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AUTOTRASPLANTES DENTALES

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1. RESUMEN

Introducción: El autotrasplante dental o trasplante de diente autólogo, consiste en trasladar un diente erupcionado o sin erupcionar, de su posición original a otro alveolo existente o creado artificialmente, en el mismo individuo. El desarrollo de otros tratamientos como la prótesis fija y los implantes supuso una reducción del uso de este tratamiento. En las últimas décadas, sin embargo, ha cobrado popularidad.

Objetivos: Evaluar la evidencia actualmente disponible sobre la tasa de éxito, y establecer las indicaciones y factores de riesgo que influyen en el pronóstico del autotrasplante dental. Asimismo, identificar posibilidades futuras en el autotrasplante dental.

Materiales y métodos: Se utilizaron las bases de datos MedLine Complete, Cochrane y Dialnet Plus. Se consultaron también libros disponibles en la Universidad Europea de Madrid, artículos, entrevistas y conferencias de la Sociedad Española de Periodoncia y Osteointegración. Se aplicaron diversos criterios de inclusión y exclusión.

Resultados: Se utilizaron 53 artículos, 2 entrevistas, una conferencia y un libro. Los artículos mostraban características diferentes en cuanto al tipo de paciente (sexo, edad), diente afectado, diente donante elegido, etc.

Conclusiones: La bibliografía estudiada mostró una elevada tasa de éxito de dicho tratamiento. Está indicado en casos de pérdida dental por traumatismo, dientes con caries y con pronóstico desfavorable, endodoncias fallidas, dientes impactados o ectópicos, y agenesia. Entre los factores de riesgo se encuentran la edad del paciente, el grado de desarrollo radicular, el tiempo que permanece el diente donante fuera del

alveolo, el estado del ligamento periodontal, y el tiempo y tipo de ferulización aplicada. El futuro del autotrasplante dental está en la ingeniería de regeneración dental.

2. ABSTRACT

Introduction: Dental autotrasplantation or autologous tooth trasplantation, consists of transferring an erupted or non-erupted tooth from its original position to another existing or artificially created socket, in the same individual. The development of other treatments such as fixed prostheses and dental implants led to a reduction in the use of this treatment. In recent decades, however, it has grown in popularity.

Objectives: To evaluate the currently available evidence on the success rate, and to establish the indications and risk factors that influence the outcome of tooth autotransplantation. Likewise, to identify future possibilities in tooth autotransplantation.

Materials and methods: The MedLine Complete, Cochrane and Dialnet Plus databases were used. Books available at Universidad Europea de Madrid, articles, interviews and conferences of Sociedad Española de Periodoncia y Osteointegración were also consulted. Several inclusion and exclusion criteria were applied.

Results: 53 articles, 2 interviews, one conference and one book were used. The articles showed different characteristics regarding the type of patient (gender, age), affected tooth, chosen donor tooth, etc.

Conclussions: The bibliography estudied showed a high success rate for this treatment. It is indicated in cases of dental loss due to trauma, teeth with cavities and with an unfavorable prognosis, failed endodontics, impacted or ectopic teeth, and agenesis. Risk

factors include the age of the patient, the degree of root development, the time the donor tooth remains outside the socket, the state of the periodontal ligament, and the time and type of splinting applied. The future of dental autotransplantation is in dental regeneration engineering.

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3. INTRODUCCIÓN

El autotrasplante dental o trasplante de diente autólogo, consiste en trasladar un diente erupcionado o sin erupcionar, de su posición original a otro alveolo existente o creado artificialmente, en el mismo individuo (1–18). Se trata de una técnica clásica, descrita por primera vez por el cirujano oral sueco Widman en 1915 (3,18).

El desarrollo de las rehabilitaciones con prótesis fija y, sobre todo, el uso de los implantes osteointegrados, supuso una gran reducción del uso de este tratamiento (19). La incorporación de los implantes dentales a la práctica clínica ha supuesto una importante mejora en la salud oral de la sociedad, al proporcionar estos buena estética, fonética y función masticatoria. Por ello, durante décadas se han considerado estos una panacea (20).

A pesar de que el índice de supervivencia de los implantes dentales es de un 79% – 98%, en la actualidad sabemos que en ocasiones estos presentan complicaciones técnicas y biológicas, con su consecuente fracaso (20–23). En el Congreso de Periodoncia y Salud Bucal celebrado recientemente en Málaga, el reconocido Dr. Jan Lindhe (24) expresaba su preocupación por el notable incremento de casos de periimplantitis experimentado en los últimos años. *"Se calcula que actualmente 1 de cada 5 portadores de un implante dental terminarán desarrollando una enfermedad periimplantaria y, fruto de ella, acabarán por precisar una nueva intervención"*, indicó. Otros estudios (20,23,24) indican que la prevalencia de mucositis y periimplantitis se sitúa en torno al 25% - 45%.

Por otro lado, el implante dental presenta ciertas limitaciones. Está contraindicado en pacientes jóvenes en edad de crecimiento esquelético y desarrollo dental. La colocación de un implante supondría el bloqueo del crecimiento alveolar y provocaría anquilosis

(10,19,25–31). Además, el proceso alveolar en el sector anterior continúa creciendo levemente a lo largo de la vida, siendo más intenso en la segunda y tercera década. El implante dental no posee ligamento periodontal por lo que no experimenta el crecimiento progresivo de los dientes adyacentes. Por consiguiente, este permanece intruido, lo que conlleva problemas estéticos y funcionales a largo plazo (3,8,11,12,14,17,19,25–28,30,32–34).

Debido a las limitaciones de los implantes y a los numerosos estudios científicos que muestran el alto porcentaje de éxito del autotrasplante, se está observando en los últimos años un incremento de interés en esta técnica clásica (1,6,25,35). Se trata de un tratamiento conservador que presenta una alta tasa de éxito cuando se realiza en pacientes bien seleccionados (1,2,25,28,34–36).

- **Indicaciones**

El autotrasplante es un tratamiento indicado en casos de pérdida dental por traumatismo, dientes con caries y con pronóstico desfavorable, endodoncias fallidas, dientes impactados o ectópicos, y agenesia (1,3,4,7–13,15–17,19,30,37–39).

El principal motivo por el que se realiza este tipo de tratamiento es por la necesidad de realizar una exodoncia de un diente con caries extensa no restaurable. El primer molar permanente es el diente más comúnmente afectado, al ser el primero en erupcionar. Su pérdida a edad temprana supone la movilización de los dientes adyacentes, desajustes oclusales y una disminución de crecimiento mandibular del lado afectado (11,14,16,19,30,35,37,40). En estos casos, estaría indicado el autotrasplante del tercer molar, ya que este es el último diente en erupcionar y por lo tanto, no suele presentar patología (10,16,37,40).

También está indicado un autotrasplante en casos de pérdida dental por traumatismo. Habitualmente esto ocurre en pacientes jóvenes, por impacto en incisivos centrales superiores (6,14,16,30–32,36,41). Un diente avulsionado se puede reimplantar en las primeras 24h, pero pasado este tiempo, o si el diente afectado no se ha recuperado, podría estar indicado realizar un autotrasplante (14,36). El primer o segundo premolar inferior suele ser el diente elegido para sustituir al incisivo central, debido a su similar tamaño mesio-distal (10,13,15,19,27,32). Sin embargo, la elección del premolar donante (primero, segundo, superior o inferior) dependerá de la clase oclusal que presente el paciente (clase I, II o III) (32). Posteriormente, se realiza una reconstrucción para darle la forma del incisivo. El espacio provocado por la extracción del premolar se podría corregir posteriormente con ortodoncia (14,15,32).

Figura 1. Secuencia de autotrasplante de premolar inferior a incisivo central (19)

Los pacientes con agenesia dental son también buenos candidatos para autotrasplante, y se les puede plantear este tratamiento como alternativa a la ortodoncia, prótesis fija o implantes. Los dientes más frecuentemente afectados son el segundo premolar inferior y el incisivo lateral superior (13,14,16,19,30,36,41,42).

Los dientes ectópicos también son susceptibles de ser autotrasplantados. Normalmente se reposicionan mediante tratamiento de ortodoncia, pero en los casos de ectopia severa, el autotrasplante podría ser un tratamiento más eficaz (10,13,14,19,39,43).

- **Contraindicaciones**

Existen ciertas contraindicaciones para realizar un autotrasplante dental: paciente con cardiopatía congénita u otras enfermedades sistémicas, paciente poco colaborador, sin disponibilidad para acudir a revisiones, higiene oral deficiente, hueso alveolar insuficiente, falta de diente donante sano, infección aguda o enfermedad periodontal crónica (1,3,7,8,10,12–14,17,18,35,40).

- **Ventajas**

Esta alternativa terapéutica proporciona una estética aceptable tanto a nivel coronal, por tratarse de su propio diente, como a nivel gingival, ya que ayuda a mantener la forma natural de la encía adherida (9,12,27,32,41). Se puede realizar en una única intervención, lo que reduce el tiempo de tratamiento. Permite un movimiento dental progresivo similar al que experimentan los dientes adyacentes, pudiendo realizarse también un tratamiento de ortodoncia. Tiene capacidad de adaptación funcional, preserva la cresta alveolar y propiocepción del ligamento periodontal (3,6,8,12,14,15,17,27,28,31–34,40,41,44,45). Provoca una mejor aceptación que la prótesis o el implante por parte de los pacientes (4,5,11,41). Además, es un tratamiento más económico, por lo que es una buena alternativa para pacientes con pocos recursos económicos (3,4,7,9,11,12,14,32,34,35,41). En la actualidad presenta un pronóstico favorable a largo plazo (2,5,6,18,28,32,40,41,44,46). Y no crea problemas de rechazo, como ocurre en ocasiones con los implantes (20–22).

- **Desventajas**

Diversos estudios indican que es frecuente encontrar reabsorción radicular (1,6,7,9,13,15,16,28,32,34,36,43,45,47,48). En ocasiones también puede observarse anquilosis, necrosis pulpar y falta de cicatrización periodontal (1,6,9,13,15,28,32,34,36,43,45–48). Es necesario que haya un diente donante sano (inexistente en muchas ocasiones) e idealmente, que no haya excesiva discrepancia de tamaño (1,10,48). Es una técnica sensible, en la que puede ocasionarse una fractura del diente donante al realizar la exodoncia. El autotrasplante supondrá la pérdida del diente donante de su alveolo (1,7,13,32,45–48). Algunos autores (7,9,10,14,15,17,18,28,35,42) indican que el resultado no es tan predecible como en otros tratamientos, aunque existe cierta controversia al respecto.

- **Factores**

Hay factores que influyen directamente en el resultado del tratamiento (9).

La edad del paciente es considerada por muchos autores como uno de los factores principales a tener en cuenta a la hora de decidir si realizar un autotrasplante dental, ya que existen numerosos estudios que indican que se obtienen resultados muy satisfactorios en pacientes jóvenes con la raíz parcialmente desarrollada, mientras que en pacientes adultos con la raíz totalmente formada existen más complicaciones (5,8,9,15,19,23,26,29,37,40,41,43–45,47). Existe sin embargo cierta controversia (1,11,12,25,26,49,50).

En cualquier caso, la mayoría de los autores (2–4,7,9,12,14,26–28,30,35) coinciden en que las probabilidades de éxito aumentan cuando se hace una buena selección del paciente y el tratamiento es realizado por un cirujano experimentado.

El grado de desarrollo radicular es considerado otro de los factores principales que comprometen el resultado final del tratamiento (4–6,8–10,13,14,19,25,29,30,36,37,42,43). Estudios muestran que en casos de autotrasplante de un diente en desarrollo, se obtiene mejor resultado cuando este presenta ½ o ¾ de la raíz formada, ya que permite la preservación de la vitalidad pulpar y la continuación de la formación de la raíz (6–10,13,14,17,19,25,27,32,34,36,40,42,43). A pesar de ello, frecuentemente se observa una menor longitud radicular por falta de desarrollo de esta (9,19). Tsukiboshi et al. (11) indican que un diente se considera adecuado para autotrasplante cuando sus raíces tienen la longitud suficiente como para ser conservadas aunque no se produzca un crecimiento radicular tras realizar el autotrasplante. Y que este debe realizarse, idealmente, cuando el diente esté en su máxima longitud pero aún con potencial de regeneración pulpar (apertura del ápice > 1mm radiográficamente) (11,23,51). También se obtienen buenos resultados al realizar autotrasplantes con dientes con la raíz completamente formada, aunque estos necesitan de tratamiento endodóntico (7,10–14,16,19,23,25,27,37,45,47,51). La literatura publicada muestra una tasa de éxito de aproximadamente 95% en dientes con ápice abierto y 90% en dientes con ápice cerrado a 5 años (23).

La ferulización también es determinante en el resultado final. Numerosos autores recomiendan realizar una ferulización semirrígida mediante alambre de ortodoncia flexible o hilo de sutura cruzada alrededor del diente. Con este último se obtienen los mejores resultados, ya que la ferulización con alambre tiende a producir reabsorción radicular (9,10,15,19,32). Otros materiales también empleados son las férulas acrílicas, el composite y el cemento quirúrgico (9,10,13,18,19,52). Existe controversia respecto al

tiempo que debe permanecer ferulizado el diente en cuestión, pero este oscila entre 1 – 6 semanas (7,10,13,15,18,23).

Figura 2. A) Ferulización con hilo de sutura (34). B) Ferulización con alambre y composite (7). C) Ferulización elástica con Peripac (18)

Existen numerosas publicaciones que demuestran que existe una mayor tasa de éxito cuando el autotrasplante se realiza en un alveolo ya existente que en uno creado artificialmente. Sin embargo, existe cierta controversia al respecto (11,12,14,16,19,49).

Estudios demuestran que se obtienen mejores resultados cuando la extracción del diente del alveolo receptor se realiza en el mismo día del autotrasplante. Cuando esto no es posible, se debe realizar idealmente en el plazo de un mes. Un periodo de tiempo más prolongado supone mayor reabsorción ósea y menor agarre del diente al hueso alveolar (11,14,16,19).

A la hora de realizar un autotrasplante, es importante también mantener un buen suministro de sangre para lograr una buena cicatrización. Este será mayor cuanto menor sea la distancia entre diente donante y lecho receptor (10,52,53). Lee et al. (53), en un estudio que realizaron mantuvieron una distancia de entre 0.93 mm y 1.19 mm, con resultados satisfactorios. No se ha encontrado más literatura al respecto, por lo que estos resultados no son concluyentes (53).

Es imprescindible realizar buenas radiografías del diente donante y de la zona receptora para conocer la cantidad y calidad de hueso disponible, así como el espacio alveolar, previo a la cirugía (13,14,17,19,36,42). En caso de que el espacio mesio-distal fuera insuficiente, sería necesario realizar previamente un tratamiento ortodóntico para crear espacio (10,13,14). Si no hubiera suficiente hueso vestíbulo-palatino, se podría optar por realizar un injerto de hueso autólogo (13,14) o trasplantar el diente donante junto con parte de hueso alveolar que lo recubre (1,19). También debemos estudiar la profundidad del alveolo y la longitud apico-coronal del diente donante. Idealmente, la cavidad del alveolo tendrá una profundidad 2mm mayor que la raíz del diente a implantar y una anchura 1mm mayor alrededor de toda la superficie de la raíz a implantar. Cuando el tamaño del lecho receptor sea insuficiente, este se aumentará mediante el uso de instrumentos rotatorios (pieza de mano y fresas redondas o cónicas de gran tamaño) y abundante irrigación con suero fisiológico (2,10,13,32,43).

Para realizar satisfactoriamente este procedimiento es necesario, por tanto, conocer al detalle la anatomía del diente donante, su longitud, y número y forma de las raíces (9,14,19,28,32,36). Mendoza-Mendoza et al. (42) explicaban la importancia de realizar radiografías periapicales ortorradiales previo a la cirugía, aunque la mayoría de autores recomiendan el uso del Cone Beam Computed Tomography (CBCT) (12,32).

El cirujano debe ser especialmente cuidadoso a la hora de realizar la exodoncia de un diente para autotrasplante (2,7,10,12,15,19,28,30,32,37,44). Por un lado, es vital no dañar la estructura del diente, ya que debe conservar las raíces y corona intactas. El cirujano hará uso de botadores y fórceps, apoyando estos únicamente en la corona del diente, sin aproximarse a la raíz (7,14,19,28,32,48). Por otro lado, es importante

conservar la mayor parte del ligamento periodontal posible del diente donante, ya que a menudo, estas fibras están ausentes en el lecho receptor (2,7,11,13,14,19,32,34,43,44). Pero mantener el ligamento periodontal prácticamente intacto no es sencillo. Una exodoncia quirúrgica, de un diente incluido por ejemplo, es más traumática que una exodoncia simple de un diente erupcionado. Ello supone mayor probabilidad de daño al ligamento periodontal, lo que a su vez implica mayor probabilidad de reabsorción radicular infamatoria (11,25,32,37,44,48).

Otro factor clave a tener en cuenta es el tiempo que permanece el diente donante fuera de la cavidad alveolar (1,2,4,7,10,13–15,17,19,23,36,37,43–45,52,53) debido a que está directamente relacionado con la supervivencia de las células del ligamento periodontal (2,10,13–15,36,37,43–45). Estudios demuestran que el ligamento periodontal se mantiene íntegro cuando el diente donante no excede los 15 - 20 minutos fuera de la cavidad alveolar. Un aumento del tiempo de exposición significa la hipoxia de las células del ligamento, con la consecuente necrosis, reabsorción radicular inflamatoria y anquilosis (1,3,4,15,17,43,44,48,53). Algunos autores recomiendan sumergir el diente donante en solución salina (4,7,10,12,13,44), en Solución Balanceada de Hanks (HBSS) (3,10,12,44) o el uso de Emdogain (16) para mantener la superficie radicular hidratada y reponer nutrientes para las células del ligamento periodontal (7,11,12,44). Emdogain es un compuesto de proteínas derivadas de la matriz del esmalte, que estimula la proliferación de odontoblastos, la diferenciación de osteoblastos inmaduros, y tiene acción antibacteriana (16). Además, en la actualidad disponemos de nuevas tecnologías que nos permiten reducir el tiempo de exposición dental extraoral (33,44).

- **Nuevas tecnologías**

En las últimas décadas la ingeniería biomédica ha experimentado gran crecimiento. Los nuevos avances tecnológicos han permitido crear técnicas de creación de modelos y prototipos mediante impresoras 3D. Estas se conocen como CARP (Computer-Aided Rapid Prototyping) y se utilizan preferentemente para la creación de férulas para cirugía guiada, restauraciones protésicas y para visualizar modelos anatómicos. Es por tanto, de gran utilidad para tratamientos de autotrasplante dental (2,12,15,19,28,43,44,51–55).

Lee et al. (53) describieron por primera vez en 2001 el uso de una réplica en 3D del diente donante para un tratamiento de autotrasplante (28,33,53). Este fue creado mediante una Tomografía Computerizada (CT), la cual emite dosis de radiación elevadas. En la actualidad, el uso del CBCT reduce considerablemente este efecto negativo (31,33). El CBCT permite visualizar con precisión la anatomía del diente donante y el alveolo receptor, para así poder elegir el diente donante más adecuado en cada caso, y determinar la necesidad de modificar el alveolo receptor (2,7,12,31,32,36,43,52).

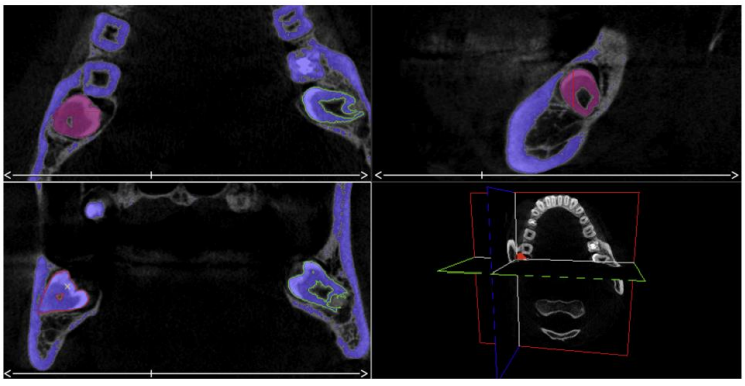

Figura 3. Separación del diente donante en el CBCT para planificación preoperatoria (40)

El uso del CBCT junto con una impresora 3D, permite crear una réplica del diente donante, lo que permite al cirujano planificar la cirugía con antelación. La réplica se utiliza también para comprobar que el diente encaja en el lecho receptor, y en caso contrario, conformar el espacio sin necesidad de tener el diente donante fuera de la cavidad oral durante un tiempo excesivo y evitando intentos repetidos de ajuste de este en el lecho receptor. Esto se traduce en un aumento en la predictibilidad de éxito del tratamiento (2,7,10,12,15,16,19,31,33,36,37,40,43,48,52–54). Algunos autores (19,36,43,44,51,53) aconsejan crear también una réplica del alveolo receptor.

La réplica del diente donante se realiza habitualmente en resina (2,10,19,43), aunque algunos cirujanos prefieren el cromo-cobalto (40,43,52,54). Ambos son materiales relativamente baratos, por lo que no supone un incremento excesivo en el coste total del tratamiento. Para pacientes alérgicos al cromo, está la opción del titanio, pero a un mayor coste (40).

Figura 4. A) Réplica en resina (19). B) Réplica en resina acrílica (16)
C) Réplica en cromo-cobalto (52). D) Polímero de almidón (53)

Otro avance de las últimas décadas es la criobiología. El objetivo de la criopreservación de tejidos vivos es el de mantener el diente donante durante un largo periodo de tiempo (12) y controlar el cese de sus funciones biológicas a una temperatura ultra baja de entre -150º y -196º (19,25). La criopreservación dental es de utilidad en casos en los que el

autotrasplante inmediato no es posible, pero se quiere realizar este en un futuro (12,45). Por ejemplo, cuando se planifica un autotrasplante pero el espacio receptor es pequeño, por lo que necesita tratamiento ortodóntico previo para aumentar el espacio (25,46). Cuando se realiza una exodoncia por falta de espacio (19,46) o al extraer un tercer molar impactado o un diente incluido, para suplir futuras pérdidas dentales (12,45).

Existe controversia en la literatura publicada respecto al efecto de la criopreservación en las células del ligamento periodontal y la pulpa dental (25,27,45,46).

También se están realizando grandes avances en el campo de la bioingeniería dental, utilizando células madre y tecnología de ingeniería de tejidos. El principal objetivo, es crear órganos capaces de sustituir órganos dañados y/o perdidos tras una enfermedad o por envejecimiento. En las últimas décadas se han realizado estudios sobre animales, los cuales proporcionan evidencia de éxito en el reemplazo de un órgano creado mediante bioingeniería. Ello pone de manifiesto el potencial de la bioingeniería, que en un futuro podrá ser aplicado en el ser humano (56,57).

- **Procedimiento clínico-quirúrgico**

Se ha descrito en numerosas publicaciones el procedimiento a seguir a la hora de realizar una cirugía de autotrasplante. Este incluye un estudio clínico y radiológico exhaustivo, planificación del tratamiento, realización de la cirugía, tratamiento endodóntico y ortodóntico en caso necesario, restauración del diente y control (11,19).

Estudio clínico y radiológico: Se analiza la anatomía del diente donante, la etapa de desarrollo de la raíz, la posibilidad de adaptación del lecho receptor y el potencial daño al diente donante al realizar la exodoncia (11).

Planificación del tratamiento: Ha de considerarse el momento adecuado de extracción del diente donante. En ocasiones, se realiza un 'autotrasplante inmediato' (10,11). Es decir, se extrae el diente del lecho receptor e inmediatamente después se trasplanta el diente donante. Pero en otras ocasiones, no es posible realizarlo el mismo día (por ejemplo, si el paciente refiere dolor por el diente afectado, o si se observa imagen radiolúcida) (11,40). En estos casos, la cirugía de autotrasplante debe realizarse entre la 2ª y 6ª semanas posteriores a la exodoncia. Demorar la cirugía supone una extensa reabsorción ósea (11). También ha de planificarse el momento a realizar la endodoncia, si esta fuera necesaria. Esta puede realizarse antes, durante o después de la cirugía (10,11).

Procedimiento quirúrgico: Tsukiboshi et al. (11) y Espona et al. (19) describen la secuencia a seguir en un autotrasplante convencional (3,11,12,19).

1. Administración de antibiótico una hora previa a la cirugía.
2. Administración de anestesia local o general.
3. En 'autotrasplante inmediato', exodoncia del diente problema previa a la exodoncia del diente donante.
4. Exodoncia diente donante, y colocación de este en su alveolo original o en solución salina.
5. Medición de longitud y diámetro de la raíz.
6. Preparación del lecho ligeramente mayor al volumen del diente donante mediante fresas quirúrgicas redondas a baja velocidad y solución salina como refrigerante.
7. Sutura del colgajo del lecho receptor previo al trasplante.

8. Colocación óptima del diente donante en el lecho receptor.
9. Ferulización.
10. Ajuste oclusal, evitando el contacto con el diente antagonista.
11. Evaluación radiográfica.

Tratamiento restaurador: Cuando el autotrasplante se lleva a cabo en el sector anterior, el diente donante requiere tratamiento restaurador (11,12,32). El material más comúnmente utilizado es el composite con técnica directa, debido a su bajo coste y su buena estética (11,19). Pero también se emplea composite con técnica indirecta o carillas de porcelana, proporcionando estos el mejor resultado estético (19,32). También los dientes autotrasplantados endodonciados del sector posterior necesitan reconstrucción, y para ello se suelen realizar overlays o coronas de disilicato de litio (1,19). La restauración suele realizarse entre 6 y 8 semanas después de la intervención, cuando se trata del sector posterior. En cuanto al sector anterior, este debe restaurarse lo antes posible (12).

Figura 5. A) Restauración indirecta con carilla de composite (12)
B) Prueba de overlay de disilicato de litio (1)

Seguimiento: Deben realizarse controles periódicos para evaluar la correcta cicatrización periodontal, el desarrollo radicular y detectar posibles complicaciones (19,32). Se debe comprobar la higiene oral, estabilidad dental, oclusión, recesiones,

bolsas periodontales y reabsorción radicular (3). Es recomendable realizar tanto exploración oral como radiológica durante mínimo 12 meses tras la cirugía (32).

Por todo lo anterior y dada la controversia existente, se propuso realizar el presente Trabajo de Fin de Grado con el fin de dar respuesta a los objetivos descritos a continuación.

4. OBJETIVOS

- **Objetivo principal**

Conocer la tasa de éxito del autotrasplante dental.

- **Objetivos secundarios**

Establecer las indicaciones del autotrasplante.

Establecer los factores más relevantes que influyen en el pronóstico.

Identificar las posibilidades futuras en el autotrasplante.

5. MATERIAL Y MÉTODOS

1. Estrategia de búsqueda

Para realizar el presente trabajo de investigación bibliográfica, se utilizaron las bases de datos MedLine Complete, Cochrane y Dialnet Plus. La búsqueda se realizó entre octubre de 2020 y febrero de 2021. Se emplearon las siguientes palabras clave: *'teeth autotransplantation', 'autogenous transplantation', 'tooth cryopreservation', 'autotransplantation CBCT', 'bioengineered tooth', 'autotrasplante dental', 'diente autólogo'.*

Se examinaron las referencias de los artículos seleccionados para identificar publicaciones válidas teniendo en cuenta los criterios de inclusión y exclusión.

Se consultaron también libros disponibles en la Biblioteca CRAI Dulce Chacón de la Universidad Europea de Madrid, artículos y entrevistas publicadas en una sociedad de reconocido prestigio como es la Sociedad Española de Periodoncia y Osteointegración (SEPA) y se asistió a una conferencia del tema en cuestión de esta misma sociedad.

2. Criterios de inclusión y exclusión

Para realizar una correcta selección de artículos se limitó el resultado aplicando unos criterios de inclusión y exclusión.

2.1. Inclusión

-Artículos de revisión bibliográfica, reportes de un caso, artículos de investigación, ensayos clínicos, meta-análisis

-Publicados en revistas y sociedades reconocidas

-Escritos en español o inglés

-Publicados entre 2000 y 2021

2.2. Exclusión

-Sin disponibilidad de texto completo

-Estudios realizados en animales

-Sin contenido relevante al tema en cuestión

*Pese a que en los criterios de exclusión se incluyen los estudios realizados en animales, debido a que la bioingeniería dental está actualmente en fase experimental en animales, se han incluido dos artículos de este campo.

6. RESULTADOS

Tras realizar la estrategia de búsqueda en cada una de las bases de datos, se obtuvieron los siguientes resultados:

MedLine Complete: 345 resultados

Cochrane: 121 resultados

Dialnet Plus: 10 resultados

Se descartaron los artículos repetidos en las distintas bases de datos, y se procedió a leer el resumen de los artículos restantes. Se eligieron para inclusión artículos de la última década mayoritariamente, y algunos artículos puntuales de la década 2000 – 2009, al tratarse estos de artículos frecuentemente referenciados y de autores de renombre en el tema en cuestión.

Del examen de las referencias de los artículos seleccionados, se agregaron otros 4 artículos.

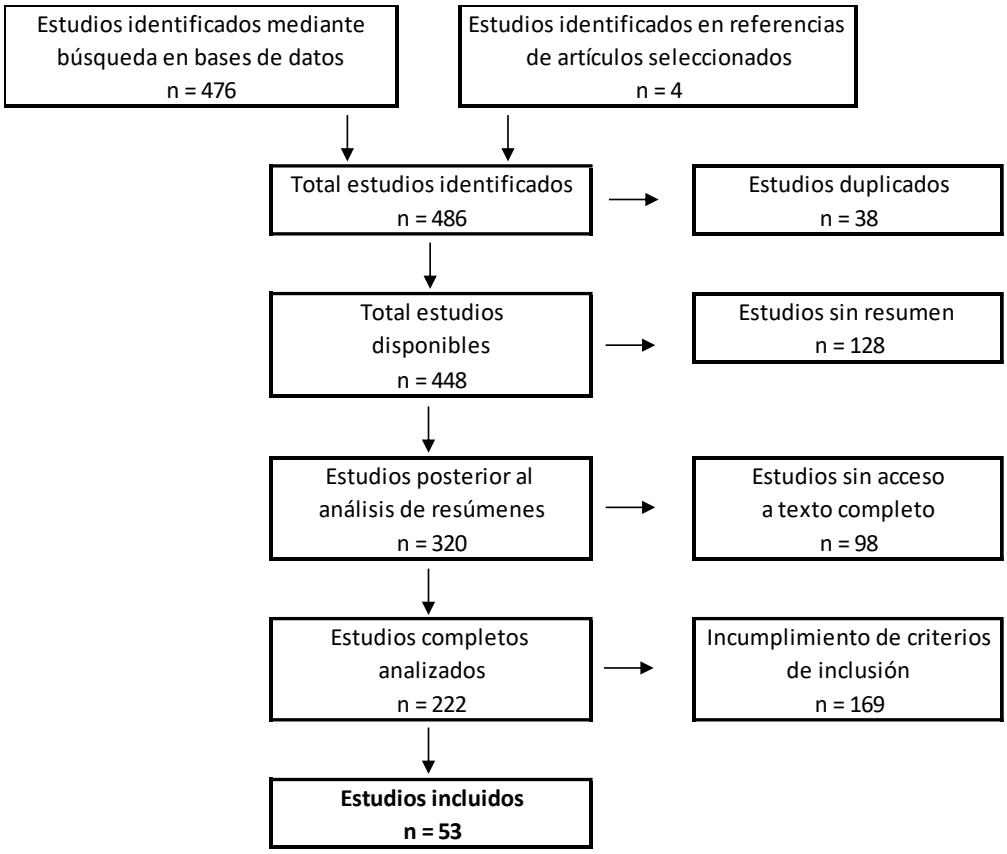

Figura 6. Diagrama de flujo de la revisión sistemática de datos publicados.

Después de aplicar los criterios de inclusión y exclusión, se seleccionaron 53 artículos, cuyas características se detallan en el Anexo (Tabla 1).

La mayoría de artículos encontrados son de revisión de literatura. Tras haber leído y analizado los diferentes artículos, se observan características diferentes en cuanto al tipo de paciente (sexo, edad), diente afectado, diente donante elegido, etc. Las características de los artículos de investigación, reportes de un caso y ensayos clínicos se detallan a continuación.

La mayoría de los artículos presentan un único caso clínico con un diente autotrasplantado. Algunos autores describen varios autotrasplantes realizados en una misma persona, por ejemplo Anitua E et al. (8). Una minoría de autores presentan tratamientos realizados a varias personas: Kang JY et al. (17) a 2 pacientes y He W et al.

(52) a 8 pacientes. Tres de los artículos describen tratamientos realizados a un número elevado de pacientes: Jang Y et al. (44) a 96 pacientes, Sugai T et al. (50) a 109 pacientes y Aoyama S et al. (47) a 259 pacientes.

La mayoría de los pacientes tratados son mujeres y el diente trasplantado presenta un desarrollo radicular completo.

El motivo por el que se realiza el tratamiento de autotrasplante es diverso, e incluye traumatismos, agenesias, dientes con caries extensa no restaurable, etc.

El tercer molar es el diente más frecuentemente autotrasplantado, seguido por el primer y segundo premolar.

Todos los dientes autotrasplantados con desarrollo radicular completo recibieron tratamiento de conductos. La mayoría de ellos se realizaron entre una y cuatro semanas posteriores a la cirugía. Únicamente Zufía J et al. (1) realizaron la endodoncia previa a la cirugía. Jang Y et al. (44) son los únicos que realizaron el tratamiento endodóntico y resección apical durante la cirugía de autotrasplante. En los dientes autotrasplantados con desarrollo radicular incompleto no se realizó en ningún caso tratamiento de conductos.

Aproximadamente la mitad de los artículos incluidos indican haber utilizado tratamiento farmacológico, coincidiendo la mayoría en la prescripción de 500mg de Amoxicilina. Jang Y et al. (44) reducen la dosis a 250mg, Mena-Álvarez J et al. (15) aumentan la dosis a 750mg, y Gupta S et al. (3) incluyen además 400mg de Metronidazol al tratamiento. Sugai T et al. (50) y Aoyama S et al. (47), en cambio, prescribieron Cefditoren Pivoxil (no indican la dosis). La otra mitad de artículos no indican haber utilizado tratamiento farmacológico.

Tan sólo cuatro autores afirman haber tenido complicaciones. Gupta S et al. (3) observaron reabsorción radicular. Jang Y et al. (44) observaron reabsorción radicular y anquilosis. Y Aoyama S et al. (47) y Sugai T et al. (50) observaron reabsorción radicular y fracaso en la cicatrización del tejido.

El periodo de seguimiento varía entre los distintos casos clínicos, desde los 6 meses a los 14 años. Verweij JP et al. (40) y Kang JY et al. (17) (en uno de los casos publicados) realizan el seguimiento más corto, de tan sólo medio año. Oh S et al. (51) también realizan un seguimiento escaso de 8 meses de duración. Por el contrario, Sugai T et al. (50), Aoyama S et al. (47), Candeiro GTM et al. (4), Plakwicz P et al. (26), Jang Y et al. (44) y Mendoza-Mendoza A et al. (42) realizaron un seguimiento de entre 5 y 14 años.

Se detallan a continuación las características principales de los artículos mencionados.

Tabla 1. Características: autores, número de pacientes, sexo, edad, patología, diente ausente, diente trasplantado y desarrollo radicular.

Autores	Nº de pacientes	Sexo	Edad	Patología	Diente ausente o patológico	Diente trasplantado	Desarrollo radicular
Anitua E et al. (4)	1	Hombre	13	Trauma	11, 12, 13	25, 35, 45	Incompleto
Aoyama S et al. (5)	259	Hombre/ Mujer	Entre 12 -73	N/A	1er molar / 2º molar	3er molar	Completo
Armstrong L et al. (2)	1	Mujer	35	Caries extensa	47	48	Completo
Ataol M et al. (3)	1	Mujer	35	Diente retenido	13	13	Completo
Candeiro GTM et al. (5)	1	Mujer	23	Caries extensa	47	48	Completo
Gupta S et al. (4)	1	Mujer	27	Pulpitis irreversible, periodontitis apical sintomática	37	38	Completo
He W et al. (4)	8	Hombre/ Mujer	Entre 23 -32	N/A	1er molar	3er molar	Completo
Intra JBG et al. (4)	1	Mujer	13	Agenesia	22	44	Incompleto
Jang Y et al. (5)	96	Hombre/ Mujer	N/A	N/A	N/A	N/A	Completo
Kaku M et al. (11)	1	Mujer	24	Fractura durante tto endodóntico	36	14	Completo

Kamio T, Kato H	1	Mujer	27	Reabsorción radicular	37	38	Completo
Kang JY et al. (5)	2	Hombre	28 // 43	Caries extensa // Periodontitis apical crónica	37// 15, 16	18	Completo
Mena-Álvarez J et al. (4)	1	Hombre	18	Diente retenido	47	48	Completo
Mendoza-Mendoza A et al. (2)	1	Hombre	10	Trauma	11	44	Incompleto
Paulsen HU et al. (2)	1	Mujer	11	Trauma	11	45	Incompleto
Plakwicz P et al. (2)	1	Mujer	19	Agenesia	12	28	Incompleto
Soram O et al. (9)	1	Mujer	17	Caries extensa, periodontitis apical sintomática	37	38	Incompleto
Sugai T et al. (7)	109	Hombre/ Mujer	Entre 11 -75	N/A	Molares, premolares e incisivo	Molares, premolares e incisivo	Completo
Verweij JP et al. (3)	1	Mujer	19	Trauma	14, 36, 37	18, 38, 48	Incompleto
Zufía J et al. (3)	1	Mujer	35	Furca, reabsorción ósea	47	48	Completo

Tabla 2. Características: autores, tratamiento quirúrgico realizado, tratamiento endodóntico y antibiótico, periodo de seguimiento, complicaciones y tasa de éxito.

Autores	Tto quirúrgico	Tto endodóntico	Tto antibiótico	Seguimiento	Complicaciones	Tasa de éxito
Anitua E et al. (4)	Preparación del lecho receptor, exodoncia del 35, trasplante en alveolo 11, ferulización. Dos meses después, siguiendo la misma secuencia, el 45 en 12 y el 25 en 13.	No	Amoxicilina 500mg	3 años	No	100%
Aoyama S et al. (5)	Exodoncia de diente donante, preparación del lecho receptor, transplante, sutura del colgajo y ferulización	Tres semanas después de la cirugía	Cefditoren Pivoxil	5 años	Reabsorción radicular, fracaso cicatrización tejido	84%
Armstrong L et al. (2)	Exodoncia del 47, exodoncia del 48, preparación del lecho receptor, trasplante y ferulización	Una semana después de la cirugía	N/A	N/A	No	100%
Ataol M et al. (3)	Colgajo mucoperióstico palatino, exodoncia del 63, exodoncia del 13, preparación del lecho receptor, trasplante, sutura del colgajo y ferulización	Una semana después de la cirugía	N/A	1 año	No	100%
Candeiro GTM et al. (5)	Exodoncia del 47, exodoncia del 48, preparación del lecho receptor, trasplante y ferulización	Tres semanas después de la cirugía	Amoxicilina 500mg	8 años	No	100%
Gupta S et al. (4)	Exodoncia del 37, exodoncia del 38, preparación del lecho receptor, eliminación interferencias oclusales extraoralmente, trasplante, sutura y ferulización	Un mes después de la cirugía	Amoxicilina 500mg, Metronidazol 400mg	1,5 años	Reabsorción radicular	100%

He W et al. (4)	Exodoncia 1er molar en cita previa. Preparación lecho receptor, exodoncia diente donante, trasplante y ferulización	Posterior a la cirugía	N/A	Entre 1 y 4 años	No	100%
Intra JBG et al. (4)	Preparación del lecho receptor, exodoncia del 44, trasplante, sutura del colgajo y ferulización	No	N/A	2,5 años	No	100%
Jang Y et al. (5)	Exodoncia, preparación del lecho receptor, exodoncia diente receptor, endodoncia, trasplante, sutura y ferulización	Durante la cirugía	Amoxicilina 250mg	12 años	Reabsorción radicular, anquilosis	68%
Kaku M et al. (11)	Exodoncia del 36, preparación del lecho receptor, trasplante de diente criopreservado y ferulización	Dos semanas después de la cirugía	N/A	3 años	No	100%
Kamio T, Kato H	Exodoncia del 37, preparación del lecho receptor, exodoncia del 38, trasplante y ferulización	Dos meses después de la cirugía	N/A	1 año	No	100%
Kang JY et al. (5)	Exodoncia, preparación del lecho receptor, exodoncia diente receptor, endodoncia, trasplante, sutura y ferulización	Cuatro semanas después de la cirugía // Dos semanas después	Amoxicilina 500mg	6 meses // 18 meses	No	100%
Mena-Álvarez J et al. (4)	Exodoncia del 47, exodoncia del 48, preparación del lecho receptor, trasplante y ferulización	Dos semanas después de la cirugía	Amoxicilina 750mg	2 años	No	100%
Mendoza-Mendoza A et al. (2)	Colgajo mucoperióstico, preparación del lecho receptor, exodoncia diente donante, trasplante, sutura y ferulización	No	Amoxicilina 500mg	14 años	No	100%
Paulsen HU et al. (2)	Exodoncia del 11, exodoncia del 45, preparación del lecho receptor, trasplante y ferulización	No	N/A	4 años	No	100%
Plakwicz P et al. (2)	Exposición del molar sin erupcionar, colgajo mucoperióstico en zona receptora, preparación del lecho receptor, exodoncia, trasplante, sutura y ferulización	No	N/A	9 años	No	100%
Soram O et al. (9)	Exodoncia del 37, preparación del lecho receptor, exodoncia del 38, trasplante, sutura y ferulización	No	Amoxicilina 500mg	8 meses	No	100%
Sugai T et al. (7)	Exodoncia de diente donante, preparación del lecho receptor, transplante, sutura del colgajo y ferulización	Tres semanas después de la cirugía	Cefditoren Pivoxil	5 años	Reabsorción radicular, fracaso cicatrización tejido	84%
Verweij JP et al. (3)	Exodocia de 14, 36 y 37, preparación de los lechos receptores, exodoncia de 18, trasplante, exodoncia de 38, trasplante, exodoncia de 48, trasplante y ferulización	No	N/A	6 meses	No	100%
Zufía J et al. (3)	Colgajo mucoperióstico en dientes 47 y 48, exodoncia del 47, preparación del lecho receptor, exodoncia del 48 y ferulización	Dos días antes de la cirugía	N/A	2 años	No	100%

7. DISCUSIÓN

El autotrasplante dental es una técnica quirúrgica que se realiza desde hace aproximadamente un siglo. Sin embargo, no es un tratamiento de elección para muchos profesionales (15,18). Ello puede ser debido a:

-Falta de formación en la Facultad de Odontología, tanto en estudios de Grado como en Postgrado.

-Falta de información sobre autotrasplantes dentales en libros de texto.

-Falta de conocimiento por parte del profesional, por lo que realiza el tratamiento mediante ortodoncia, prótesis o implantes (18).

Existen, sin embargo, algunos autores con una amplia experiencia realizando este tipo de intervención, como son Andreassen, Tsukiboshi, Plakwicz, etc. A pesar de haber publicado muchos artículos, la mayoría son de baja evidencia científica. Se trata de opiniones de expertos, que comparten su experiencia mediante reportes de casos (23).

Los distintos autores tienen diferentes criterios a la hora de realizar el tratamiento, por lo que existe cierta controversia sobre la técnica y la predictibilidad de resultados.

La edad del paciente es considerada por muchos autores como uno de los factores principales a tener en cuenta a la hora de decidir si realizar un autotrasplante dental. Afirman obtener resultados satisfactorios en pacientes jóvenes con la raíz parcialmente desarrollada, y más complicaciones en pacientes adultos con la raíz totalmente formada (8,15,19,23,26,29,41,44,47). El Dr. Plakwicz (39), en una entrevista para Best Quality Dental Centers, afirmaba que la tasa de éxito puede alcanzar el 90% en pacientes jóvenes . Otros autores, sin embargo, indican que la técnica del autotrasplante ha

progresado en la última década, y hoy en día se pueden conseguir resultados predecibles tanto en pacientes jóvenes como en adultos (1,11,12,49,50).

Igualmente, existe controversia respecto al momento idóneo para realizar el tratamiento de conductos (10,13,23). Algunos autores afirman que este puede realizarse antes, durante o después de la cirugía. Otros autores, argumentan que este se debe realizar en las 2 ó 3 semanas posteriores a la cirugía, cuando ha tenido lugar la cicatrización periodontal inicial (10,15,25).

La mayoría de los autores (3,4,14,26,35,55) coinciden en que las probabilidades de éxito aumentan cuando el tratamiento es realizado por un cirujano experimentado. El Dr. Jakobsen (29), sin embargo, discrepa. En su reciente artículo *"Autotransplantation of premolars: does surgeon experience matter?"*, investiga la influencia de la experiencia del cirujano en el resultado del tratamiento. Sus resultados concluyen que la tasa de éxito alcanza el 95% tanto en cirujanos senior como en cirujanos junior.

Numerosos autores (11,14,16,19) explican haber una mayor tasa de éxito cuando el autotrasplante se realiza en un alveolo ya existente que en un alveolo creado artificialmente. Yu et al. (49), por el contrario, afirman no existir tal diferencia. En 2017 realizaron un estudio en el que comparaban los resultados clínicos a largo plazo del autotrasplante del cordal maduro en alveolos creados artificialmente y en alveolos existentes. No observaron diferencias significativas (12,23,49).

La necesidad de ferulizar el diente autotrasplantado es otro tema controvertido entre diferentes autores (10,13,23,43). Algunos (10,13,15,23,43) consideran que la ferulización induce necrosis y reabsorción radicular, por lo que la desaconsejan. Otros (10,13,43) aconsejan la ferulización para reducir la movilidad del diente en el nuevo

lecho. Igualmente existe controversia entre el tiempo que debe permanecer el diente ferulizado y el tipo de material más apropiado (7,10,13,15,43).

Respecto a las técnicas más actuales, como la creación de una réplica del diente donante, diversos autores afirman que esta es razonablemente precisa. Sin embargo, Lee et al. (53) y Sokolowski et al. (54) en sus ensayos clínicos percibieron pequeñas discrepancias en algunos casos. Ello les supuso cierta dificultad para insertar el diente donante en el lecho receptor, lo que aumentó el tiempo extra oral del diente (12,53,54).

Otra técnica actual es la criopreservación dental. Temmerman et al. (25) afirman que la criopreservación no tiene efectos negativos sobre el ligamento periodontal, por lo que el pronóstico del tratamiento es similar al de un diente autotrasplantado y endodonciado. Autores como Kaku et al. (46), Paulsen et al. (27) y Osathanon (45), por el contrario, indican que en ocasiones el diente autotrasplantado criopreservado presenta anquilosis o reabsorción radicular debido a un daño en el ligamento periodontal ocasionado por la formación de cristales de hielo en las células de este. Según Osathanon (45), este efecto es remediable realizando una congelación lenta del diente. Respecto al efecto de la criopreservación en la pulpa dental, algunos estudios indican que la vitalidad pulpar se mantiene mientras se realice la criopreservación inmediatamente después de la exodoncia (25,46). Otros autores (25,45) afirman que la criopreservación no protege la pulpa, por lo que siempre será necesario realizar un tratamiento de conductos. La autora del trabajo no ha encontrado artículos sobre la criopreservación de dientes inmaduros.

8. CONCLUSIONES

1.La tasa de éxito del autotrasplante dental es de un 90%.

2.El autotrasplante está indicado en casos de pérdida dental por traumatismo, dientes con caries y con pronóstico desfavorable, endodoncias fallidas, dientes impactados o ectópicos, y agenesia.

3.Los factores más relevantes que influyen en el pronóstico son la edad del paciente, el grado de desarrollo radicular, el tiempo que permanece el diente donante fuera del alveolo, el estado del ligamento periodontal, y el tiempo y tipo de ferulización del diente autotrasplantado.

4.Las nuevas técnicas de bioingeniería de regeneración dental que están actualmente en desarrollo contribuirán sustancialmente en el tratamiento, al poder desarrollar órganos dentales in vitro sin necesidad de utilizar un diente del paciente.

A pesar de haber muchos artículos publicados sobre el autotrasplante dental, la mayoría son de baja evidencia científica. Se trata de opiniones de expertos, que comparten su experiencia mediante reportes de casos. La mayoría de autores presentan un solo caso clínico de un autotrasplante. Igualmente, la mayoría de los casos clínicos analizados muestran una tasa de éxito del 100%, lo que indica una falta de publicación de casos fracasados. La autora del trabajo no ha encontrado estudios comparativos entre autotrasplante dental e implante.

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10. ANEXOS

Tabla 1. Características de los 53 artículos seleccionados.

Autor	Año	Título	Revista
Armstrong L et al. (2)	2020	Autotransplantation of third molars: a literature review and preliminary protocols	British Dental Journal
Cahuana-Bartra P et al. (5)	2020	The use of 3D additive manufacturing technology in autogenous dental transplantation	3D Printing in Medicine
Czochrowska EM, Plakwicz P	2020	Guidelines for autotransplantation of developing premolars to the anterior maxilla	Seminars in Orthodontics
Dutta SR et al. (5)	2020	Risks and complications associated with dental implant failure: critical update	National Journal of Maxillofacial Surgery
Lucas-Taulé E et al. (5)	2020	Fully guided tooth autotransplantation using a multidrilling axis surgical stent: proof of concept	Journal of Endodontics
Mena-Álvarez J et al. (4)	2020	Technology at the service of surgery in a new technique of autotransplantation by guided surgery: a case report	BMC Oral Health
Plotino G et al. (6)	2020	Clinical procedures and outcome of surgical extrusion, intentional replantation and tooth autotransplantation - a narrative review	Internatinal Endodontic Journal
Xia JJ et al. (3)	2020	Autotrasplantation of third molars with completely formed roots to replace compromised molars with the computer-aided rapid prototyping	Journal of Esthetic and Restorative Dentistry
EzEldeen M et al. (8)	2019	Use of CBCT guidance for tooth autotransplantation in children	Journal of Dental Research
Kamio T, Kato H	2019	Autotransplantation of impacted third molars using 3D printing technology: a case report	The Bulletin of Tokyo Dental College
Sokolowski A et al. (7)	2019	Accuracy assessment of 3D-printed tooth replicas	International Journal of Computerized Dentistry
Tsukiboshi M et al. (2)	2019	Long-term outcomes of autotransplantation of teeth: a case series	Journal of Endodontics
Wu Y et al. (5)	2019	Autotransplantation of mature impacted tooth to a fresh molar socket using a 3D replica and guided bone regeneration: two years retrospective case series	BMC Oral Health

Ataol M et al. (3)	2018	Autogenous transplantation of an impacted maxillary canine: a case report	International Journal of Medical Dentistry
Espona J et al. (5)	2018	Autotrasplante dental. Una opción terapéutica contrastada	Revista Española de Endodoncia
He W et al. (4)	2018	Computer-aided autotransplantation of teeth with 3D printed surgical guides and arch bar: a preliminary experience	Peer Journal
Jakobsen C et al. (4)	2018	Autotransplantation of premolars: does surgeon experience matter?	International Journal of Oral and Maxillofacial Surgery
Rohof ECM et al. (4)	2018	Autotransplantation of teeth with incomplete root formation: a systematic review and meta-analysis	Clinical Oral Investigations
Oh S et al. (9)	2018	Virtual simulation of autotransplantation using 3-dimensional printing prototyping model and computer-assisted design program	Journal of Endodontics
Anitua E et al. (4)	2017	Tooth autotransplantation as a pillar for 3D regeneration of the alveolar process after severe traumatic injury: a case report	Dental Traumatology
Atala-Acevedo C et al. (5)	2017	Success rate of autotransplantation of teeth with an open apex: systemic review and meta-analysis	Journal of Oral and Maxillofacial Surgery
Becker W, Tibbetts L	2017	Has implant dentistry lost its compass?	Clinical Implant Dentistry and Related Research
Ono M et al. (14)	2017	Practical whole-tooth restoration utilizing autologous bioengineered tooth germ transplantation in a postnatal canine model	Scientific Reports
Prato GP et al. (2)	2017	A translational medicine approach to tooth transplantation	Journal of Periodontology
Verweij JP et al. (3)	2017	Replacing heavily damaged teeth by third molar autotransplantation with the use of cone-bean computed tomography and rapid prototyping	Journal of Oral and Maxillofacial Surgery
Yu HJ et al. (3)	2017	Autotransplantation of third molars with completely formed roots into surgically created sockets and fresh extraction sockets: a 10-year comparative study	International Journal of Oral and Maxillofacial Surgery
Zufía J et al. (3)	2017	Autotransplantation of mandibular third molar with buccal cortical plate to replace vertically fractured mandibular second molar: a novel technique	Journal of Endodontics

Giannobile WV, Lang NP	2016	Are dental implants a panacea or should we better strive to save teeth?	Journal of Dental Research
Jang Y et al. (5)	2016	Prognostic factors for clinical outcomes in autotransplantation of teeth with complete root formation: survival analysis for up to 12 years	Journal of Endodontics
Paulsen HU et al. (2)	2016	Tooth loss treatment in the anterior region, autotransplantation of premolars and cryopreservation	APOS Trends in Orthodontics
Plakwicz P et al. (2)	2016	Transplant vs implant in a patient with agenesis of both maxillary lateral incisors: a 9-year follow-up	American Journal of Orthodontics and Dentofacial Orthopedics
Almpani K et al. (2)	2015	Autotransplantation of teeth in humans: a systematic review and meta-analysis	Clinical Oral Investigations
Candeiro GTM et al. (5)	2015	Eight-year follow-up of autogenous tooth transplantation involving multidisciplinary treatment	Journal of Oral Science
Gupta S et al. (4)	2015	Autotransplantation	Journal of Conservative Dentistry
Kaku M et al. (11)	2015	A case of tooth autotransplantation after long-term cryopreservation using a programmed freezer with a magnetic field	The Angle Orthodontist
Intra JBG et al. (4)	2014	Autogenous premolar transplantation into artificial socket in maxillary lateral incisor site	Journal of Endodontics
Kang JY et al. (5)	2013	Autogenous tooth transplantation for replacing a lost tooth: case reports	Restorative Dentistry & Endodontics
Nimcenko T et al. (5)	2013	Tooth auto-transplantation as an alternative treatment option: a literature review	Dental Research Journal
Shahbazian M et al. (6)	2013	Validation of the cone bean computed tomography - based stereolithographic surgical guide aiding autotransplantation of teeth: clinical case - control study	Oral and Maxillofacial Radiology
Aoyama S et al. (5)	2012	Prognostic factors for autotransplantation of teeth with complete root formation	Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology
Mendoza-Mendoza A et al. (4)	2012	Retrospective long-term evaluation of autotransplantation of premolars to the central incisor region	International Endodontic Journal
Marques-Ferreira M et al. (4)	2011	Autogenous tooth transplantation: Evaluation of pulp tissue regeneration	Medicina Oral, Patología Oral y Cirugía Bucal

Mendoza Mendoza A et al. (2)	2010	Treatment of an avulsed maxillary permanent central incisor replaced by autotransplantation of a mandibular premolar: 14-year follow-up	International Endodontic Journal
Osathanon T	2010	Transplantation of cryopreserved teeth: a systematic review	International Journal of Oral Science
Sugai T et al. (7)	2010	Clinical study on prognostic factors for autotransplantation of teeth with complete root formation	International Journal of Oral and Maxillofacial Surgery
Ikeda E et al. (9)	2009	Fully functional bioengineered tooth replacement as an organ replacement therapy	Proceedings of the National Academy of Sciences of the United States of America
Temmerman L et al. (3)	2006	Toot transplantation and cryopreservation: state of the art	American Journal of Orthodontics and Dentofacial Orthopedics
Jiménez A y cols. (4)	2004	Tratamiento quirúrgico de las malposiciones dentales	Revista Española de Cirugía Oral y Maxilofacial
Peñarrocha M y cols. (2)	2003	Trasplantes dentales, una alternativa en tratamiento quirúrgico-ortodóncico de los dientes incluidos	Archivos de Odonto Estomatología
Czochrowska EM, et al. (3)	2002	Outcome of tooth trasplantation: survival and success rates 17 - 41 years posttreatment	American Journal of Orthodontics and Dentofacial Orthopedics
Tsukiboshi M	2002	Autotransplantation of teeth: requirements for predictable success	Dental Traumatology
Clokie CML et al. (2)	2001	Autogenous tooth transplantation: an alternative to dental implant placement?	Journal of the Canadian Dental Association
Lee SJ et al. (4)	2001	Clinical application of computer-aided rapid prototyping for tooth transplantation	Dental Traumatology

Tabla 2. Página principal de los 53 artículos y el libro seleccionados.

Case Report/Clinical Techniques

Autotransplantation of Mandibular Third Molar with Buccal Cortical Plate to Replace Vertically Fractured Mandibular Second Molar: A Novel Technique

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Abstract

Tooth replacement often leads to inadequate vertical volume in the recipient site bone when a tooth has been extracted because of a vertical root fracture (VRF). This case report presents the autotransplantation of a mandibular third molar (tooth #32) with the attached buccal cortical plate to replace a mandibular second molar (tooth #31) diagnosed with a VRF. After extraction of tooth #31, the recipient socket was prepared based on the size measured in advance with cone-beam computed tomographic imaging. The precise and calculated osteotomy of the cortical bone of tooth #32 allowed for the exact placement of the donor tooth in the position of tooth #31. The total extraoral time was only 25 minutes. The block was fixed to the recipient socket with an osteosynthesis screw and splinted with a double resin wire for 8 weeks. At the 6-month follow-up, the screw was removed, and the stability of the tooth and the regeneration obtained throughout the vestibular area were confirmed. At the 2-year follow-up, the transplanted tooth was asymptomatic and maintained a normal bone level. Advantages of autotransplantation over dental implants include maintenance of proprioception, possible orthodontic movements, and a relatively low cost. This case report demonstrates that an autotransplantation of a third molar attached to its buccal cortical plate is a viable option to replace teeth with a VRF. (*J Endod 2017;43:1574–1578*)

Key Words

Autotransplantation, buccal cortical plate, complete root formation, periodontal ligament, vertical root fracture

Significance

Autotransplantation can provide an alternative to dental implants in patients with inadequate bone support because of a vertical root fracture.

Autotransplantation is the transplantation of embedded or erupted teeth in the same individual from one site to another into extraction sites or surgically prepared sockets (1). Indications for tooth autotransplantation include impacted or ectopic teeth, premature and/or traumatic tooth loss, loss of teeth because of tumors or iatrogenesis, congenitally missing teeth, replacement of teeth with a poor prognosis, and/or developmental anomalies when a suitable donor tooth is available (2, 3).

Successful tooth transplantation depends on proper case and patient selection (4, 5). It depends above all on the vitality of the remaining periodontal ligament (PDL) cells in the donor root, the shape and the site of the recipient socket, and the vascularity of the recipient bed (6, 7). Since the 1990s, many studies on periodontal tissues, periodontal membrane, and dental root resorption have shown that the transplant success rate is rapidly increasing, which is giving rise to new clinical interest (3, 8, 9). It should be noted that most studies have focused on the autotransplantation of teeth with incomplete root formation (10–12), which restricts the applications of tooth autotransplantation to patients in their early 20s and younger. However, previous research has determined no substantial difference in the autotransplantation success rate between mature and immature teeth (3, 8, 9). Tsukiboshi (3) reported a 90% survival rate and an 82% success rate for 250 cases observed over 6 years; these results are similar to those obtained by Lundberg and Isaksson (8) and Mejàre et al (9). Therefore, teeth with complete root formation should be considered for use as donor teeth.

The most frequently reported complications in teeth autotransplantation include inflammatory root resorption, replacement root resorption or ankylosis (2, 3, 8, 13), pulp necrosis (9, 14), lack of periodontal healing (5, 9), and reduction of final root length (12, 15, 16). Hence, for successful tooth autotransplantation, it is essential to preserve as many viable cells as possible in the donor tooth root and promote the formation of new PDL in the recipient site. Efforts to maintain viable cells in the donor tooth facilitate the preservation of cervical root cells, which can be easily damaged during tooth extraction and allow for bone healing around the donor tooth (17).

Tooth replacement often leads to an inadequate vertical volume in the recipient site bone when a significant period has passed since tooth extraction or extraction

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CLINICAL ARTICLE

WILEY

Autotransplantation of third molars with completely formed roots to replace compromised molars with the computer-aided rapid prototyping

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Abstract

Objective: To describe a method to fabricate donor tooth replica to assist surgeons in preparation of recipient socket during tooth autotransplantation.

Materials and Methods: A total of 28 compromised molars in 27 patients were transplanted with third molars using computer-aided rapid prototyping (CARP) technique. Surgery time and extra-alveolar time were documented. Postoperatively, the distance between cervix of transplanted tooth and the alveolar wall was measured. The degree of postoperative pain experienced was assessed with visual analog scale at day 1, 3, and 7.

Results: From 28 clinical cases, the average extra-alveolar time and surgery time were 2.5 minutes (±1.3) and 44 minutes (±6.8), respectively. Postoperatively, the average distance between cervix of transplanted tooth and the alveolar wall was 0.87 mm (±0.15) at the mesial-cervix, 0.95 mm (±0.17) at the distal-cervix, 0.88 mm (±0.18) at the buccal-cervix, and 0.95 mm (±0.13) at the lingual-cervix. The value of visual analog scale score significantly decreased from day 1 to day 3.

Conclusions: CARP is a reliable technique for fabrication of tooth like surgical replicas in conventional autotransplantation.

Clinical Significance: CARP technique minimized extra-oral time, reduced iatrogenic damage, and consequently increased the survival rate of tooth autotransplantation.

KEYWORDS
digital dentistry, endodontics, laboratory technology, oral surgery, pain

1 | INTRODUCTION

Autotransplantation, a well-documented surgical procedure involving transplantation of a tooth from its original position into a surgically prepared recipient site within the same individual, has been overlooked as an alternative to replace a significantly compromised tooth.[1] In contrast to other popular oral rehabilitation alternatives such as dental implants, a successfully transplanted tooth with intact periodontal ligaments (PDLs) could stimulate new alveolar bone formation and establish a new occlusion which allows it to function like a healthy tooth.[2] Due to lack of standardized and internationally accepted success criteria, it is difficult to compare the success rate and survival rate among different studies, but tooth autotransplantation generally yields a satisfying long-term outcomes.[3] A recent study conducted by Verweij reported that the survival rate and success rate of transplanted teeth were 79% to 100% and 57% to 100%, respectively, further proving its reliability as a treatment option.[4]

The longevity of the transplanted tooth could be influenced by various factors such as case selection, atraumatic tooth removal, and vitality of PDL, among which the preservation of the healthy PDL cells and good tissue adaptation is the most critical factors to consider in the healing of autotransplanted tooth.[5,6] These factors may be ascribed to several intraoperative factors including the number of fitting attempts of the donor tooth, distance between donor tooth

Case Report

Autotransplantation

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Abstract

Autogenous tooth transplantation refers to the repositioning of autogenous teeth in another tooth extraction site or a surgically formed recipient site to replace missing teeth due to congenital deformity, grossly decayed carious teeth, mobile teeth due to periodontal disease, teeth lost due to trauma, endodontic failure or any other reason when a suitable donor tooth is available. This is a case report of autotransplantation of impacted #38 with complete root formation into the extraction site of grossly decayed, unrestorable #37 with 18 months follow-up showing excellent periapical healing and tooth stability. In autogenous tooth transplantation, even if the donor's tooth has complete root formation, a high success rate can be achieved if the cases are selected and treated properly. Chances of root resorption are there because of necrotic pulp and periodontal irritation during manipulation. However, autogenous tooth transplantation should always be considered as a good treatment modality in feasible cases.

Keywords: Autotransplantation; missing teeth; root resorption

INTRODUCTION

Tooth transplantation is the surgical repositioning of a tooth from one site to another. It is classified into autogenous, homogenous and heterogeneous transplantation. In autogenous transplantation, the tooth from one socket is inserted into another socket in the same person. In homogenous transplantation, the donor and recipient are of same species, and if the donor and the recipient are of different species, then it is called heterogeneous transplantation.[1]

Autotransplantation refers to the repositioning of an autogenous erupted or unerupted tooth from one site to another in the same individual.[2] Review of dental literature shows that one of the first descriptions of autogenic transplantation of teeth was given by a Swedish Dental Surgeon Vidman far back in 1915.[3] Impacted maxillary canines were the teeth traditionally selected for transplantation as they played a key role in dentofacial esthetics. Premolars and mandibular third molar teeth were also successfully transplanted.

Autotransplantation is indicated in traumatic tooth loss, tumors, congenitally missing teeth, teeth with bad prognosis and in case of developmental anomalies of teeth.[4] This procedure is cost effective and also results in better functional adaptation and preservation of alveolar ridge.[5] The success rate of autotransplantation varies from 74% to 100%, respectively.[6] Autotransplantation is contra-indicated in patients with cardiac anomalies, poor oral hygiene, lack of self-motivation and insufficient alveolar bone support.[5]

Autotransplantation has an important role in the replacement of missing teeth of young patients due to the contraindication of osseointegrated implants for them. The auto transplanted tooth has the capacity for the preservation of alveolar ridge and functional adaptation, which is very important and advantageous in comparison to osseointegrated implants that are stationary and do not erupt, resulting in infraoccluion.[7]

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Case Report

Eight-year follow-up of autogenous tooth transplantation involving multidisciplinary treatment

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Abstract: Although autogenous tooth transplantation is a widely reported procedure, its success is dependent on a number of factors. Here we describe the surgical technique, endodontic treatment and rehabilitation employed for a patient in whom a lower right third molar was transplanted to substitute an adjacent second molar with extensive caries. During an 8-year follow-up period, normal periodontal healing was observed and no infection, ankylosis or progressive resorption occurred. It may be concluded that transplantation of a third molar is a practicable approach for replacement of a lost permanent tooth, with restoration of esthetics and function.
(J Oral Sci 57, 273-276, 2015)

Keywords: autogenous transplantation; dental restoration; oral surgery; root canal therapy; tooth rehabilitation.

Introduction

Tooth transplantation is a means of replacing a lost or missing tooth by transfer of an existing tooth to the socket previously occupied by the missing tooth, or to a prepared socket (1). Autogenous tooth transplantation is indicated for cases of dental-alveolar trauma, extensive caries with root involvement, tooth agenesis, iatrogenic complications and cases where the patient's socioeconomic condition precludes affordable prosthetic rehabilitation (1,2).

The success of autogenous tooth transplantation depends on the integrity of the periodontal ligament, and is also influenced by surgical expertise so that the extent of trauma, as well as the period of extra-alveolar tooth exposure, are minimized. Additional factors influencing the success of tooth transplantation include absence of periodontal lesions and acute infection in the recipient socket (2,3).

Autogenous transplantation tends to be more successful when it involves teeth with completely formed roots rather than tooth germs with incomplete root formation, but it has become established as a practicable alternative to tooth loss (4). Some authors have emphasized the importance of multidisciplinary planning for achieving higher success rates in terms of esthetics and function (2-5).

Here we report a clinical case of autogenous transplantation involving a tooth with a complete root, for which a multidisciplinary approach was adopted in order to promote tooth rehabilitation, and discuss some of the important factors influencing the success of this technique.

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AUTOGENOUS TRANSPLANTATION OF AN IMPACTED MAXILLARY CANINE: A CASE REPORT

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Abstract

Maxillary canines play a vital role in dental and facial appearance, arch development and functional occlusion. When surgical exposure procedures can not be performed due to surgical or orthodontic contraindications or the patient does not accept the treatment, autotransplantation should be considered. A 35 year-old woman with a compliant of maxillary primary canine decay and impacted maxillary canine addressed the medical office. A palatal mucoperiosteal flap was elevated. The primary canine tooth and the permanent canine were gently extracted. A new socket with appropriate size and position with the permanent canine was prepared with implant surgical drills. Then, the tooth was correctly positioned and splinted. The centric and lateral mandibular movements were checked. After 1 week, root canal treatment was performed. At one-year follow-up, no clinical mobility was observed and the patient did not report any intraoral pain and discomfort.

Keywords: *autogenous transplantation, autotransplantation, impacted maxillary canine.*

1. INTRODUCTION

The term of tooth transplantation is defined as the transfer of a tooth from one site to another, in the same person or from one person to another. Autotransplantation is described as the transfer of an embedded or impacted or erupted tooth to the extraction sites or into surgically prepared sockets, in the same person [1]. The maxillary canines are the second most frequently impacted teeth after third molar teeth and also the most frequent in the anterior area [2]. This situation appears as the maxillary canines develop deep within the maxilla and the eruption path to travel is longer compared with any other tooth [3]. Various treatment options are available. Autotransplantation is one of the preferred options for an impacted maxillary canine. The reasons for autotransplantation of a canine tooth are to improve the aspect of the mouth, to complete the upper arch, to prevent drifting of other teeth and to avoid the need for fixed prosthesis [4]. After autogenous tooth transplantation, periodontal healing involves a periodontal ligament along the root surface and the alveolar part of the periodontal ligament in the socket [5]. The aim of this case report is to present the autogenous transplantation of an impacted maxillary canine tooth.

2. CASE REPORT

A 35 year-old woman was referred to the Atatürk University, Faculty of Dentistry, Department of Oral and Maxillofacial Surgery, with a chief compliant of maxillary primary canine decay. The radiological examination revealed the presence of an impacted maxillary canine (Fig. 1).

Fig. 1. Preoperative panoramic radiograph

Success Rate of Autotransplantation of Teeth With an Open Apex: Systematic Review and Meta-Analysis

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Purpose: The aim of the present study was to determine the success rate of autotransplanted permanent teeth with an open apex and to identify the most influential prognostic factors.

Materials and Methods: A systematic search of the MEDLINE, EMBASE, LILACS, and SciELO databases was conducted for January 1990 to August 2015. The study eligibility criteria were primary studies that had evaluated patients with autotransplantation with an open apex, with or without preparation of the socket, and a minimum of 12 months of follow-up. The principal outcome was the success rate of autotransplanted teeth with an open apex. Two of us independently performed the selection process and data extraction. The Effective Public Health Practice Project's Quality Assessment Tool was used for the quality assessment of the studies. The odds ratio (OR) was calculated, with the 95% confidence interval (CI).

Results: A total of 21 studies were included in the present analysis. Of the 21 studies, 10 were retrospective and 11 were prospective. All the studies were of weak methodologic quality. The overall success rate was 89.68%, the survival rate was 98.21%, and the mean follow-up period was 6 years, 3 months (standard deviation 5.81 years). Among the prognostic factors analyzed, the premolars had a lower failure risk than did the molars (OR, 0.46; 95% CI, 0.25 to 0.84). The stage of development of the root and the autotransplantation receptor site showed no statistically significant differences.

Conclusions: The overall success rate and survival were high, despite the methodologic limitations of the included studies. Further study is needed of the prognostic factors that influence the success of autotransplantation with an open apex.

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The congenital absence of permanent teeth or their loss in children and adolescents is particularly challenging because the rehabilitation must adapt to the growth and changes in the oral region.[1] Of the existing treatment alternatives for tooth replacement, autotransplantation is a therapy that has received increasing attention in recent years, because it provides a vital periodontium and continuous skeletal

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Autotransplantation of third molars: a literature review and preliminary protocols

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Key points

- Wisdom tooth autotransplantation offers a cost-effective tooth replacement method when compared to alternative techniques such as osseointegrated implants.
- Appropriate patient selection remains a key factor in the success of autotransplanted teeth.
- There is no set or defined protocol in the literature relating to the autotransplantation technique or review protocol.

Abstract

Tooth autotransplantation (the movement of a tooth from one site to another in the same person) is a technique with a history dating back many centuries. However, the use of third molars as donor teeth is perhaps less well-recognised and less documented. A review of the current literature was undertaken with particular attention to the use of the third molar as the donor tooth. The selection process, surgical procedure and follow-up pathways were summarised in the review. Appropriate patient selection was found to be a key factor in the success of the technique. Other prognostic factors were also discussed. The findings from the available literature suggest that autotransplantation is a viable and cost-effective technique. However, the literature relating to the use of third molars as donor teeth for autotransplantation is limited and there are currently no evidence-based guidelines or protocols relating to the technique. This paper discusses the literature and protocols the authors implement for autotransplantation of wisdom teeth.

Introduction

Tooth autotransplantation can be defined as the planned movement of a particular tooth from one site to another within the same patient.[1] The wider umbrella term of tooth transplantation dates back to the days of Ancient Egypt, where it has been reported that slaves were forced to donate their teeth to Pharaohs.[2] Furthermore, and perhaps closer to home, Scottish-born dentist John Hunter in the late 1700s is reported to have popularised the, now eyebrow-raising, practice of transplanting teeth into the mouths of the wealthy from poorer members of society for the right price. This practice was documented by Hunter in The Natural History of Human Teeth and was exploited by other dentists of the time.[3] These accounts, if accurate, would be examples of intra-species homogenous tooth transplantation. The method of autotransplantation was first well-documented in 1956 by Hale *et al.*, and much of the methodology remains the same today.[4] The technique is more commonly used in paediatric dentistry, typically utilising partially formed open apex premolars to replace poor prognosis or absent anterior teeth.[5]

Molar tooth autotransplantation also dates back over half a century, with specifically third molar autotransplantation providing an alternative option to replace a missing or hopeless prognosis first or second molar,* whether this is due to caries, periodontal disease or otherwise. The classical indications for autotransplantation include premature or traumatic tooth loss, impacted, ectopic or missing teeth, tumours, iatrogenic injury and those with a poor prognosis;[7] the latter being, arguably, the most common case study presented in the literature for third molars.

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Clinical technique

The clinical considerations for the technique of third molar autotransplantation can be briefly visited by describing a 35-year-old female who attended Birmingham Dental Hospital. She presented with a carious lower right second molar (47) and a mesially impacted, partially erupted, sound lower right third molar (48) with complete root formation. The suitability of both the extraction site and donor tooth were assessed and determined as appropriate (the factors to consider will be detailed later). The patient was well-motivated, medically fit, had excellent oral hygiene and an unrestored, otherwise well-maintained, dentition.

The 47 was extracted before the 48. The 48 was provisionally left *in situ* while the 47 donor socket site was prepared. This involves the removal of remaining inter-radicular bone and debris which may hinder location of the transplant. The 48 was then autotransplanted to the donor socket and the occlusion checked. Following surgery, the 48 was splinted to the adjacent tooth and the soft tissue sutured at the point of the interdental papilla. The patient was followed up with a

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CASE REPORT

WILEY Dental Traumatology

Tooth autotransplantation as a pillar for 3D regeneration of the alveolar process after severe traumatic injury: A case report

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Abstract

In dental traumatology, the loss of teeth and the supporting alveolar bone in children compromise the proper development of maxillofacial structures and also limit the solutions that can be offered. In this case report, multidisciplinary management is described of a child with a significant loss of alveolar bone and associated teeth due to a traffic accident at 8 years of age. The management involved staged teeth autotransplantation into surgically prepared sites with bone expanders, orthodontic treatment and dental implants. The 3D regeneration of the alveolar process was successfully stimulated by teeth autotransplantation. At the 4-year follow-up visit, evaluation of the autotransplanted teeth and the implants indicated a successful outcome for the patient.

KEYWORDS
autotransplantation, dental trauma, tooth

1 | INTRODUCTION

In dental traumatology, the loss of teeth and the supporting alveolar bone in children compromise the proper development of maxillofacial structures and also limit the solutions that can be offered. Bone regeneration procedures may help in restoring the bone volume; however, the absence of teeth can limit the growth and functional adaptation of the maxillofacial structures with the unwanted outcome of facial disharmony. The ankylotic healing of osseointegrated implants may result in infraocclusion.[1]

Tooth autotransplantation refers to the transfer of a tooth in the same individual from one site in the mouth to an extraction socket or a surgically prepared site.[2] The procedure is generally carried out in young patients with agenesia, dental trauma or destructive caries in molars without complete root formation.[2-4] A success rate of almost 98% has been reported when teeth are atraumatically transplanted and the extraoral time is kept to a minimum.[5-7] However, it is contraindicated in patients with cardiac anomalies, poor oral hygiene, lack of self-motivation and insufficient alveolar bone.[5-7]

When considering the above, the combination of teeth loss and alveolar bone loss limits the treatment alternatives that can be offered to patients. This case report describes the multidisciplinary management of a child with complete loss of the alveolar process and associated teeth due to a traffic accident. The management of this case involved tooth autotransplantation, orthodontic treatment and dental implants.

2 | CASE REPORT

In October 2011, a 13-year-old male patient presented with the loss of bone volume in the right maxilla together with the loss of all teeth from the upper right lateral incisor to the upper right first molar as a consequence of a traffic accident at 8 years of age. Avulsion of the upper left lateral incisor and the upper right central incisor was also reported. In the maxillofacial surgery unit of a hospital, the upper right central incisor was mistakenly replanted in the position of the upper left lateral incisor. In addition, the upper left central incisor had fractured (Figure 1). The history revealed that the upper central incisors received endodontic treatment and the upper left central incisor was also reconstructed (Figure 1).

Clinical and radiographic examination indicated that the two upper central incisors had poor prognosis as a result of root resorption and

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REVIEW

Autotransplantation of teeth in humans: a systematic review and meta-analysis

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Abstract
Objectives The aim of this investigation was to assess the currently available evidence concerning the complications and risk factors influencing the outcome of autotransplantation of teeth in humans.
Materials and methods Electronic searches were conducted to identify randomized controlled and prospective clinical trials. Risk of bias within studies was assessed with the Downs and Black tool. Random-effects meta-analyses were conducted to pool the adverse event rates and relative risks with their 95 % confidence intervals. Risk of bias across studies was assessed with the GRADE framework followed by sensitivity analyses.
Results Thirty-eight studies were included in the analysis. Reported complications included the need for extraction, failure, hypermobility, pulp necrosis, pulp obliteration, and root resorption. Pooled complication event rates varied considerably, with small studies (<100 teeth) reporting greater complication rates. The analysis of risk factors was associated with both the primary outcome (extraction need) and secondary outcomes (failure, hypermobility, pulp necrosis, pulp obliteration, root resorption). The stage of root development seems to influence both the future survival, as well as the success of the transplanted teeth. Teeth with open apex were less likely to be extracted in comparison to teeth with closed apex (3 studies; 413 teeth; relative risk 0.3; 95 % confidence interval 0.2–0.6).
Conclusions Due to the small number of the contributing studies, their methodological limitations, and the heterogeneous results reported, no firm conclusions can be drawn.
Clinical relevance Root development of the donor teeth has been established as one the most important factor related to the success of tooth autotransplantation.

Keywords Autotransplantation · Teeth · Transplantation · Root development · Pulp necrosis · Pulp obliteration · Root resorption

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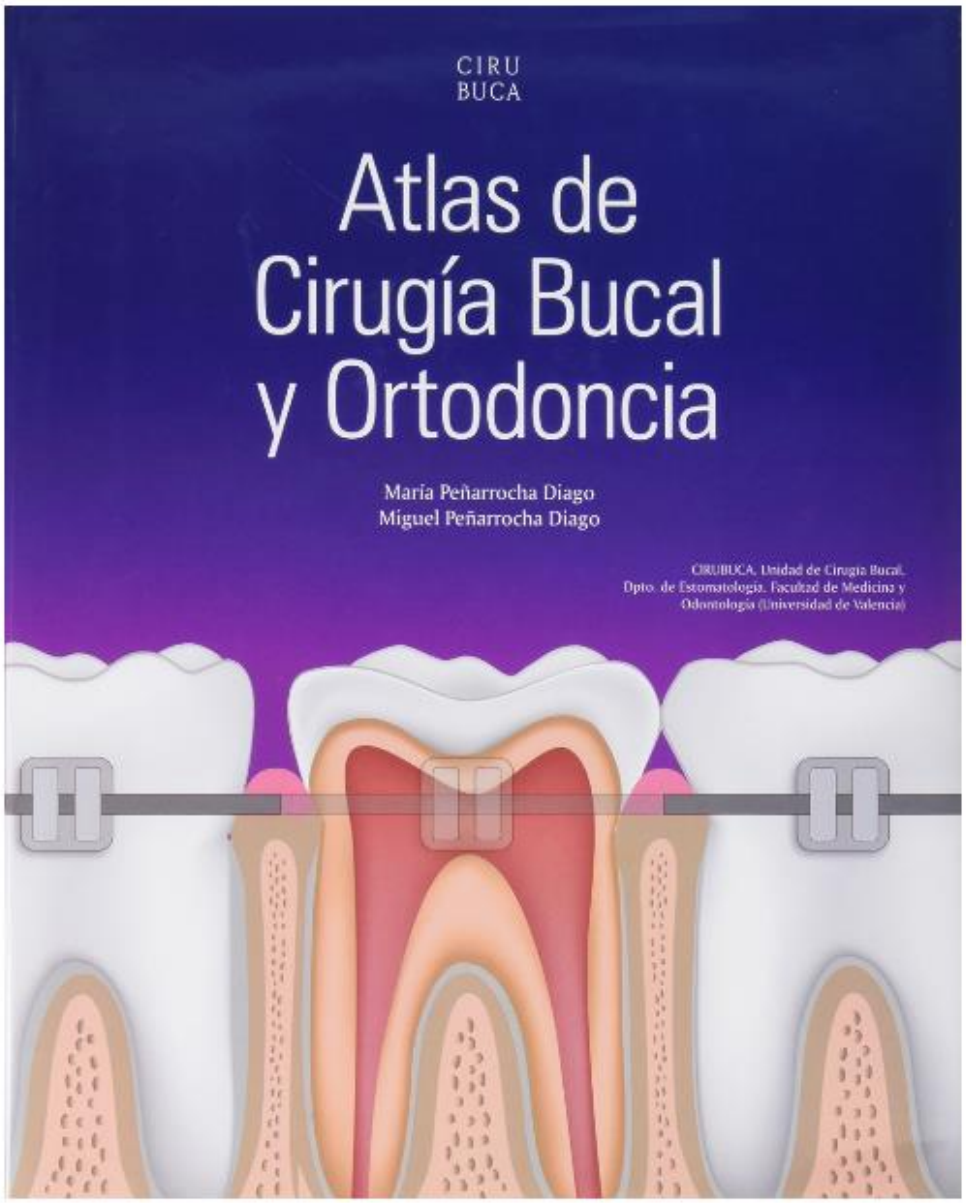
Introduction

Rationale

Autotransplantation is the transplantation of embedded in bone or erupted teeth in the same individual, from one site to another, into extraction sites or surgically prepared sockets [1]. Autotransplantation of teeth has evolved into a viable treatment option for replacing missing teeth, as successfully transplanted teeth can function like totally normal teeth [2].

Indications for tooth autotransplantation include impacted or ectopic teeth, premature and/or traumatic tooth loss, loss of teeth because of tumors or on iatrogenic grounds, congenitally missing teeth in one arch in combination with arch length discrepancy or clinical signs of tooth crowding on the opposing arch, replacement of teeth with bad prognosis, and/or developmental dental anomalies [3–25]. Autotransplantation ensures that alveolar bone volume is maintained, due to physiological stimulation of the periodontal ligament [26]. Moreover, successful tooth transplantation offers improved esthetics, arch form, dentofacial development, mastication,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Autotransplantation of teeth: requirements for predictable success

Tsukiboshi M. Autotransplantation of teeth: requirements for predictable success. Dent Traumatol 2002; 18: 157–180. © Blackwell Munksgaard, 2002.

Abstract – The aim of this article is to summarize the biologic principles required for successful autotransplantation of teeth. Indications, armamentarium, technique and prognosis will be discussed.

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Key words: autotransplantation; requirements; success

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Words associated with transplantation of teeth are 'pessimism and tragedy' for some dentists but 'hope and pleasure' for others. The difference stems from different experiences of the dentists themselves or the biases of teachers and peers with whom they have discussed the procedure. The tragedy and pessimism would have been derived from the history of homogenous tooth transplantation (1–10) or autogenous tooth transplantation performed without sound underlying biologic principle (11–18). In addition, the recent popularity of implants has resulted in transplantation being overlooked as a treatment option. However, if the clinical and experimental studies on transplantation over the last 30 years are considered, hope should replace pessimism with regard to this procedure.

Biologic principles

It is well documented that avulsed teeth recover optimal function and esthetics after replantation under ideal conditions (Fig. 1). Favorable periodontal ligament [PDL] healing is the critical factor for success whether teeth are mature or immature. Pulp regeneration can be expected in immature (developing) teeth but not in mature teeth (Fig. 2). Similar healing patterns can be expected in autotransplantation of teeth (Fig. 3). In addition, bone induction is an interesting additional benefit of transplantation (Fig. 4). Wound healing in autotransplantation of teeth is discussed below according to PDL healing, bone induction, pulp healing and root development, respectively.

PDL healing

Favorable healing of the PDL depends on how many viable cells are preserved on the root (19–44). PDL cells can be damaged mechanically during extraction or bio-chemically due to various extra-oral conditions. PDL cells are easily injured under stressful conditions such as variable pH, osmotic pressure, dehydration, etc. (45–55). If donor teeth are extracted with minimal mechanical damage to the PDL and are preserved in optimal condition extra-orally until the end of the surgical procedure, successful PDL healing should be expected.

Optimal PDL healing is seen when a (avulsed) tooth is immediately replaced into its own socket. In this situation, 'reattachment' occurs in 2 weeks between the connective tissues (PDL tissues) of the root surface and the recipient socket wall (19–27). While not quite as predictable, extremely good PDL healing is expected in the case when a donor is immediately placed into the freshly extracted recipient socket (28,29). However, PDL healing in the transplantation where the donor is placed into the newly (artificially) formed socket would need more time and the prognosis is a little poorer in comparison with the former two situations (28). The slight difference in prognosis described above suggest that although viable cells on the root surface are critical for successful healing (29), the importance of progenitor cells on the socket wall should not be overlooked (28, see Follow-up results in this article).

Another important factor to consider in regard to PDL healing is the repair of mechanically damaged

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REVIEW

Clinical procedures and outcome of surgical extrusion, intentional replantation and tooth autotransplantation – a narrative review

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Abstract

Plotino G, Abella Sans F, Duggal MS, Grande NM, Krastl G, Nagendrababu V, Gambarini G. Clinical procedures and outcome of surgical extrusion, intentional replantation and tooth autotransplantation – a narrative review. *International Endodontic Journal.*

Surgical extrusion is defined as the procedure in which the remaining tooth structure is repositioned at a more coronal/supragingival position in the same socket in which the tooth was located originally. Intentional replantation is defined as the deliberate extraction of a tooth and after evaluation of root surfaces, endodontic manipulation and repair, placement of the tooth back into its original position. Tooth autotransplantation is defined as the transplantation of an unerupted or erupted tooth in the same individual, from one site to another extraction site or a new surgically prepared socket. The advent of titanium implant rehabilitation has reduced the use of these treatments in day-by-day clinical practice; however, the re-emerging trend to conserve and preserve natural sound tissues has led to a rediscovery of these treatments. All three distinct surgical methods are closely related, as they act to treat teeth that cannot be predictably treated using other more conventional procedures in endodontics, periodontics and restorative dentistry. Furthermore, these procedures share the same treatment approach and include the atraumatic extraction of a tooth, visual inspection of the tooth/root and its subsequent replantation. The clinical procedures for surgical extrusion, intentional replantation and tooth autotransplantation treatment have undergone several changes in recent years, and currently, there are no clear clinical treatment protocols/guidelines available. The clinician should be aware of the outcome of these treatments. Hence, the aim of this narrative review is to provide the background, clinical procedures and outcomes of surgical extrusion, intentional replantation and tooth autotransplantation.

Keywords: intentional replantation, review, surgical extrusion, tooth autotransplantation.

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Artículo de Revisión

Trasplantes dentales, una alternativa en el tratamiento quirúrgico-ortodóncico de los dientes incluidos

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RESUMEN

Los trasplantes dentales son una alternativa de tratamiento de los dientes incluidos, que se encuentran en una posición desfavorable, a la metodología ortodóncica clásica. Las principales ventajas de realizar un trasplante son la posibilidad de mantener o restaurar el volumen de hueso alveolar y de reponer el diente perdido, sin alterar los dientes vecinos. Cuando en la zona receptora del trasplante no hay espacio suficiente en sentido mesiodistal, se debe ampliar con métodos ortodóncicos. En la manipulación quirúrgica se debe tener cuidado en no dañar el ligamento periodontal. Algunos autores aconsejan hacer la endodoncia durante la cirugía; otros, la posponen algunas semanas después y otros sólo la realizan ante signos clínicos y radiológicos de patología. El diente trasplantado se feruliza entre 1-6 semanas. Los datos de porcentajes de éxito varían según distintos autores entre un 44% y un 100%. Las complicaciones más frecuentes son: la pérdida de soporte óseo, la movilidad, las caries, las reabsorciones radiculares, la infección postoperatoria, la falta de cicatrización periodontal y la necrosis pulpar.

PALABRAS CLAVE

Trasplantes dentales; Ortodoncia; Cirugía.

ABSTRACT

Dental transplant is considered an alternative treatment to included teeth which are unfavorably located. Absent teeth could be replaced by them using a traditional orthodontic procedure. Main advantadges are: to keep or to restore alveolar bone volume and to replace a lost tooth without damaging adjacent teeth. When there is not enough mesiodistal distance in the receiver's space, we will create it using orthodontic methods. No damage must be done to the periodontal ligament during surgical treatment. Some authors recomend endodontic treatment during surgical procedure, or a few weeks later and others only in presence of clinical and radiographic pathologic signs. Between 1 and 6 weeks

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Tooth auto-transplantation as an alternative treatment option: A literature review

Tatjana Nimčenko,[1] Gražvydas Omerca,[1] Vaidas Varinauskas,[1] Ennio Bramanti,[2] Fabrizio Signorino,[2] and Marco Cicciù[3]

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Abstract

Go to:

Rapidly evolving implantation and alveolar ridge reconstruction techniques created a new area in modern dentistry where tooth loss is no longer a problem. Endless variations of implant's length, diameter, surface, and design along with autogenous, alogenous, aloplastic, or xenogenous bone substitutes made it possible to recreate physiological occlusion, esthetic and masticatory function. However, none of nowadays technologies in implant dentistry have the potential to adapt to a growth and development changes of a child's jaw. Therefore, patient's young age is a restriction for implantation and a particular challenge for a dentist willing to restore missing tooth. Thus, tooth auto-transplantation can be a good choice for treatment. The objective of this review is to underline the biologic principles required for successful auto-transplantation of teeth. Limits, indications, technique, and prognosis will be analyzed.

Keywords: Autologous, auto-transplantation, tooth transplantation

INTRODUCTION

Go to:

Dental auto-transplantation or autogenous transplantation is defined as the movement of one tooth from one position to another, within the same person.[1,2] This could involve the transfer of impacted, embedded, or erupted teeth into extraction sites or into surgically prepared sockets.[2] The procedure itself is not a new invention, and the earliest reports of tooth transplantation involve slaves in ancient Egypt who were forced to give their teeth to their pharaohs.[3,4] Eventually, allotransplantation, transplantation of a tooth from one individual to another, was abandoned because of histocompatibility and replaced with auto-transplantation.[3]

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Technology at the service of surgery in a new technique of autotransplantation by guided surgery: a case report

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Abstract

Go to:

Background

The aim of this case report was to use a surgical technique for autotransplantation of tooth using virtually planned 3D printed surgical templates for guided osteotomy preparation of the recipient of donor tooth.

Case presentation

An 18-year-old male patient received autotransplantation of the right mandibular third molar to replace an included right second molar. This procedure was based on guided implant surgery methods by superimposition of DICOM files and 3D data sets of the jaws. In order to design a 3D-printed template with the aid of a fully digital workflow; the third molar was conserved in PRGF during the surgical procedure and the tooth socket was prepared with a template and the help of a 3D-printed donor tooth copy in order to prevent iatrogenic damage to the donor tooth. This template and replica were manufactured using 3D-printing techniques. The transplanted tooth was placed in infra-occlusion and fixed with a suture splint and root canal therapy was performed 15 days later. The intervention was be accomplished by performing preplanned virtual transplantations with guided osteotomies to ensure accurate donor tooth placement in the new recipient site. The 24 months follow-up showed physiological clinical and radiologic results compatible with healing periradicular tissues.

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Autogenous tooth transplantation: Evaluation of pulp tissue regeneration

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Abstract

Objective: The aim of this study was to assess the pulp survival that occur in transplants of autologous teeth, by comparing two surgical techniques: the conventional technique (autotransplantation for newly formed alveoli), and an alternative technique, (autotransplants for alveoli in the initial phase of healing). In each surgical techniques were applied, randomly, either saline solution or Emdogain®.

Study Design:The study group comprised 26 patents, in which 28 teeth were transplanted to recipient sockets prepared mechanically. Of the 28 teeth transplanted, 4 were intentional replants, and of the remainer, 11 had the apex closed and 13 open. The mean age at the time of transplantation was 22.34±8.14 years (mean ± SD). The transplantation were performed by the same operator, with the informed consent of the patient and authorized by the ethical committee of the hospital. Clinical and radiological examinations were performed during 24 to 65 months (48±12.96; MED±SD), from 10 days, 1 month, 3 months, 6 months and annually to 5.6 years.

Results: Only two transplanted teeth were lost, due persistent apical periodontitis, and one transplanted patient with open apex missed the treatment. In the teeth with pulp, we needed to perform root canal therapy in 9. In the 73% of the teeth with closed apex, we needed to perform root canal treatment, with no statistically significant difference found among closed apex and root canal therapy (p=0.083). In only 8% of the teeth with open apex did we need to perform root canal treatment, with an association between open apex and root canal therapy (p=0.0002). The overall success rate was 98% with significant difference for losses (p=0.0001).

Conclusions: Although not a frequent procedure, it was concluded that autotransplanted teeth, performed with appropriate surgical care had a good prognosis, and can render a very useful service to the patients.

Key words: *Autogenous tooth transplantation, pulp tissue regeneration, root canal treatment.*

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Autogenous tooth transplantation for replacing a lost tooth: case reports

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The autogenous tooth transplantation is an alternative treatment replacing a missing tooth when a suitable donor tooth is available. It is also a successful treatment option to save significant amount of time and cost comparing implants or conventional prosthetics. These cases, which required single tooth extraction due to deep caries and severe periodontal disease, could have good results by transplanting non-functional but sound donor tooth to the extraction site. (*Restor Dent Endod* 2013;38(1):48-51)

Key words: Autotransplantation; Surgical procedure

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Introduction

Autogenous tooth transplantation or autotransplantation is a surgical movement of a tooth from its original location to another site in the mouth within the same person.[1] It can be applied in cases like traumatic tooth loss, impacted or ectopic positioned teeth, congenitally missing tooth, large endodontic lesions, and localized severe periodontitis which does not show promising prognosis.[2]

Autotransplantation is an alternative to dental implant or it is better than implant treatment, because it can save time, provide faster healing, function, and esthetic advantages. Moreover, it also have advantages of maintaining unique sensory system and promoting proper healing of the periodontal environment to sound tissue.[3]

However, several complications, such as root resorption, ankylosis, loss of the autotransplanted tooth, or fracture during the extraction, can be occurred.[4,5] Especially, insufficient nutrition to the root surface of an autotransplanted tooth could be an explanation for the high rates of root resorption or loss of tooth transplant.[4]

The purpose of this article was to report two cases of successful autotransplantation for replacing lost teeth. The first case is transplantation of the third molar to periodontally healthy socket. The second case is transplantation of the second molar to periodontally involved socket.

Case reports

Case 1

A 28 year old male visited the Department of Conservative Dentistry at Chonnam National University Dental Hospital for treatment of mandibular left second molar.

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Artículo Clínico

Tratamiento quirúrgico de las malposiciones dentales

Surgical treatment of dental malpositions

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Resumen: Presentamos los resultados obtenidos tras 17 años de experiencia en el tratamiento quirúrgico de las malposiciones dentales. Se incluyen los autotrasplantes de molares incluidos, autotrasplantes de caninos retenidos y reubicación de incisivos, caninos o premolares mal posicionados; 81 piezas dentales en total, de los cuales 60 dientes corresponden a autotrasplantes y 21 a reubicaciones, obteniendo un alto porcentaje de éxito. Se explica en detalle las indicaciones, técnica quirúrgica y resultados, concluyendo en que a la vista de los mismos, la manipulación quirúrgica de dientes retenidos sanos tiene un alto porcentaje de éxito a largo plazo.

Palabras clave: Autotrasplante dental; Reubicación dental; Dientes retenidos.

Abstract: *We present the results obtained during our 17 years of experience in surgical treatment of dental malpositions. We include the autotransplantation of embedded molars, autotransplantation of retained canines and the repositioning of malpositioned incisors, canines and premolars; A total of 81 teeth, 60 autotransplanted and 21 repositioned, with a large degree of success. Detailed explanation is given regarding the surgical indications, techniques and results. In view of this, a conclusion is reached regarding the high, long-term success rate of surgical manipulation of embedded, healthy teeth.*

Key words: *Dental autotransplantation; Dental repositioning; Embedded teeth.*

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Autotrasplante dental. Una opción terapéutica contrastada

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RESUMEN

El autotrasplante dental es una técnica clínica clásica que desde su protocolización por la escuela escandinava en los años 50 del pasado siglo permite obtener de forma predecible excelentes resultados. Si bien la introducción de los implantes dentales llevó a un cierto ostracismo a los autotrasplantes, progresivamente se ha ido reincorporando al armamentario clínico habitual como excelente método para reponer dientes ausentes. El índice de fracasos es bajo cundo se sigue un protocolo clínico estricto, que en los últimos tiempos incorpora el uso de réplicas 3D para minimizar el tiempo extraoral del diente donante. El momento ideal para realizar un autotrasplante se da cuando el diente donante tiene formado entre 2/3 y ¾ de la raíz, lo que permite que esta complete su desarrollo y mantenga la vitalidad pulpar. No obstante, es también posible realizar autotrasplantes de dientes con ápice cerrado, si bien en estos casos es imperativo realizar el tratamiento de conductos. El comportamiento de un diente autotrasplantado es idéntico al de cualquier otro diente, permite el crecimiento del hueso, e incluso movimientos ortodóncicos. En caso de pérdida de dientes en sector estético en pacientes jóvenes el autotrasplante es la opción de elección siempre que sea posible disponer de un diente donante.

Palabras clave: Autotransplante, avulsión, CBCT, endodoncia, tomografía.

INTRODUCCIÓN

En una revisión de la literatura realizada el 30 de abril de 2018, con los términos "teeth autotransplantation" o" tooth autotransplantation" o" tooth transplantation" en el título, hemos encontrado 410 artículos referenciados en PubMed, entre los años 1934 y 2018, de los cuales 21 corresponden a los años 2017 y 2018 (con sólo 4 meses transcurridos de este último año). Vemos así que el autotrasplante dental es una técnica clínica clásica contrastada por la literatura, y a la vez parece que de moda, y merece ser por ello revisada y comentada.

El autotrasplante dental consiste en extraer un diente de su posición original para colocarlo en una zona edéntula(Kvint et al., 2010, Schwartz et al., 1985, Czochrowska et al., 2002a), sea ésta un alveolo postextracción o un lecho receptor tallado en el hueso del mismo individuo(Natiella et al., 1970). Es una técnica que gozó de amplio predicamento en los siglos XVIII y XIX, si bien con éxito relativo, pero que la escuela escandinava protocolizó hacia los años 50 del pasado siglo, permitiendo obtener buenos resultados de forma predecible. La técnica de autotrasplante se ideó como opción terapéutica ante la pérdida de dientes por traumatismos, caries o agenesias, pero la prótesis fija sobre dientes y, sobre todo, los implantes dentales, redujeron el uso de este tratamiento por parte de los clínicos.

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Editorial

Are Dental Implants a Panacea or Should We Better Strive to Save Teeth?

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Keywords: peri-implantitis, oral implants, implant dentistry, periodontitis, tooth maintenance, function

Dental implants have become an important treatment for the replacement of teeth lost due to disease, injury, or congenital tooth agenesis (Adell et al. 1990). Over the past 30 years, the incorporation of dental implants into everyday clinical dental practice has resulted in major improvements in oral health of our patients through enhancements in function, esthetics, and phonetics. In this month's issue of the *Journal*, we highlight new evidence on the biological complications of dental implants and the great challenges associated with predictable implant therapy. These adverse outcomes associated with implants have come to the forefront of discussion groups in periodontology, oral surgery, prosthodontics, and implant dentistry relating not only to prosthetic (technical) failure but also persistent infections surrounding implants. A recent systematic review based on a European consensus conference revealed that the prevalence of peri-implant mucositis and peri-implantitis ranges from 19% to 65% (Derks and Tomasi 2015). This month, results from one of the largest studies performed in Sweden show that peri-implantitis and peri-implant mucositis are common biological complications of implant therapy (Derks et al. 2016) that may jeopardize the longevity of reconstructions on implants. Tarnow (2016) comments on how far we have come in implant dentistry while at the same time recognizing the influence on success of implant placements by generalists, specialists, and different implant configurations/surfaces. One finds that reconstructive therapy of peri-implantitis lesions is unpredictable as yet when compared to surgical resection, as evidenced by recent investigations and systematic reviews (Khoshkam et al. 2013; Carcuac et al. 2016; Jepsen et al. 2016).

A trend affecting clinical practice over the past 2 decades has been the reduced emphasis to "save compromised teeth." In fact, studies have demonstrated that those with less training in periodontology and implant dentistry generally apply reduced efforts in addressing tooth retention (Lang-Hua et al. 2014). It is noted that less trained individuals are often recommending tooth extraction versus retention. As such, many teeth are being condemned at early stages given the expediency that lends itself to quickly rid a problematic tooth and provide a new tooth replacement implant. It is not unusual for many practitioners to recommend tooth extraction with modest tooth-associated ailments such as caries, need for endodontic therapy, or periodontal involvement. There are many scenarios where patients are advised to get rid of the compromised tooth and get the "newer, better" implant. It has recently been advocated that practice patterns should change to retain more teeth given the excellent long-term track record of successful therapy for tooth preservation (Axelsson and Lindhe 1981; Lindhe and Pacey 2014). It is acknowledged that in many clinical situations, advanced diseases such as caries and periodontitis render teeth hopeless, requiring implant prosthetic solutions to rehabilitate patients. Most all dental implant systems are susceptible to peri-implant biological complications (Derks et al. 2015). These complications result in very difficult to treat options, including local mechanical therapy and antibiotics, resective surgery, regeneration, or, in a large number of cases, removal. The erroneous belief of implants yielding a better long-term prognosis has now clearly been rejected in several comparative studies and systematic reviews. Teeth even compromised because of periodontal disease or endodontic problems may have a longevity that surpasses by far that of the average implant (Carnevale et al. 1998; Hardt et al. 2002; Lang and Zitzmann 2012; Salvi et al. 2014; Klinge et al. 2015).

This dialogue can be a call to action to revisit the long history of success of tooth maintenance to preserve the natural dentition without the rush to extract teeth and replace with implants. We do a disservice to our patients and ourselves without carefully weighing the advantages and disadvantages of such options in providing the optimal oral health care delivery to our patients. We have been trained to preserve teeth. Let us face the challenge. If we select an "early removal of compromised teeth" paradigm, the dental profession will lose most of its expertise in preserving a functional dentition for a lifetime.

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EDITORIAL

WILEY

Has implant dentistry lost its compass?

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What has happened to many patients undergoing implant dentistry? Over the past few years there has been a dramatic increase in implant complications. There are instances of screw loosening, implant and/or abutment fractures, implant surface exposure, and retained cement following crown insertion. Additionally, we all too frequently observe unrepairable results, usually related to either incorrect implant positioning or restorative deficiencies. Too many implants are being placed into allogenic bone with apparently minimal to no contact with host bone. Are these problems inevitable or are they the result of too many clinicians now placing implants? Do dentists placing implants understand the dynamics of implant dentistry and the biologic basis necessary for successful implant outcomes?

It is almost 50 years since dentistry was exposed to the research and teachings of Professor P-I Branemark, and Drs. Ulf Lekholm, Ragnar Adell, and Tomas Abrektsson. Their Implant survival rates were very high as were long-term success rates. In the early days, surgical aspects of implant dentistry were often limited to oral surgeons and periodontists. Implant placement and restorative protocols were very conservative. Diagnosis and treatment was primarily limited to fully edentulous maxillae and mandibles, implants were "buried" from 4 to 6 months following placement, implants were threaded and manufactured of commercially pure titanium. Within a short time after introduction of the Branemark system, Straumann introduced a highly researched and biocompatible implant system. A few other systems were on the market and dental implants were introduced to the profession and public as a fantastic, predictable method for replacement of missing teeth. Implants were subsequently used to replace missing single teeth, restore partially edentulous patients and placed immediately following tooth extraction. Guided tissue regeneration was introduced to repair or enhance bony jaw defects and an unending list of so-called biomaterials was introduced to enhance, fill, repair or regenerate bone lost to trauma or periodontal diseases. The number of so called new bone "enhancers" is seemingly unending.

Over time more and more commercial companies have introduced varying types, shapes, and sizes of implants. Each implant having its own "unique" reported specific virtue and all at a wide range of cost. There are now estimated to be over 700 types of dental implants on the market. Most have not lived up to the early implant systems rigor of long-term survival and success rate documentation. The early implant protocols are now seemingly ignored or forgotten. There have been seemingly undocumented concepts to decrease healing time, shorten the interval between implant placement and loading and eventually the idea of immediate implant placement and immediate loading became popular. How did the idea of rushing to implant restoration evolve? Where did the pressure to restore early evolve from? The patients? The profession? Why are patients and clinicians in such a hurry to have a final implant supported restoration that they are willing to forgo even a discussion of the risks involved.

Commercialization of dental implant technology is not necessarily bad, but what is questionable is the level of training or lack thereof provided in short term "weekend courses." Additionally, efforts teaching the rigors of surgical and restorative implant dentistry in webinars needs scrutiny. Adequate diagnosis and treatment planning are necessarily the required basis for dental implant placement, restoration, and maintenance. Short term "weekend courses" cannot devote adequate time to wound healing, bone biology and repair, flap management, diagnosis, number of implants necessary to successfully restore patient's complications, correction of problems, and ultimately, when not to place implants. These skills and concepts require time, understanding, experience, and study, usually best provided in formal university based postgraduate specialty training programs. Where is the evidence and data to support socket grafting, not to mention the wide variety of grafting materials? More long-term studies are needed to convincingly justify implant placement in the various array of grafting materials. In our opinion, it does not convincingly exist.

Computerized implant planning software is a marvelous addition to implant dentistry. Restorative dentists and prosthodontists must be a key part of the team and will help minimize implant problems through careful treatment planning. Such treatment planning is primarily indicated when multiple teeth are missing, requiring several implants to properly restore the patients to proper function and esthetics. Restorative dentists must be involved with preplanning and plan execution. At the end of the day, this is a restoratively driven treatment and not a surgical one.

All too often the maintenance aspect of implant treatment is forgotten. It is imperative that patients with dental implants receive periodic routine periodontal maintenance similar to those

Review Article

Risks and complications associated with dental implant failure: Critical update

ABSTRACT

Risks and complications have been identified with dental implant failure though there is continuous innovation in implant systems and various interceptive treatment modalities. The success rate of dental implants has increased over a period of years as a treatment option for the rehabilitation of missing teeth. The dental implants are designed that best suits the various types of bone. Endosseous implants fail due to many reasons. Different reasons for the implant failure and their contributing factors have been discussed in this review article. A better understanding of the factors responsible for the implant failure will provide clinical decision-making and may enhance the field of implant dentistry. This article summarizes the factors causing implant failure. This paper presents the results of a survey of dentists practicing implant dentistry and updates regarding their knowledge of risk factors that they consider to be important for predicting dental implant failure.

Keywords: Dental implant, osseointegration, osteoradionecrosis, peri-implantitis, periodontitis

INTRODUCTION

The replacement of missing teeth by titanium dental implants is currently the gold standard in dental rehabilitation.[1,2] Different statistically analyzed factors associated with implant failure are age and sex,[3] smoking,[4] systemic diseases,[5,6] maxillary implant location, quantity and quality of bone,[7] and implant surface treatments and characteristics.[8] Immunological[9] and genetic factors[10] have also been reported to be associated with early implant failure. Periodontitis and cigarette smoking are associated with an increased rate of implant failure. It decreases the vascularity of local tissues and interrupts in healing, chemotaxis, and systemic immunity. Overall failure rates have been reported as 11% for smokers as compared to 5% for nonsmokers. Mellado-Valero *et al.*[11] found more failures in diabetic patients during the 1st year of functional loading. The failure of dental implant is seen in irradiated bone, excessive temperature elevation in bone during placement, leading to necrosis of the supporting bone around the implant[12] [Table 1 and Figure 1].

Age factor

Age is considered as one of the important prognostic factors in implant success. Older patients are more prone to altered systemic health conditions, have poor local bone conditions and potentially longer healing times.[13] Moy *et al.*[14] studied that advanced age increases the risk of implant failure. Patients older than 60 years have an adverse outcome in two folds. Brocard *et al.*[15] studied cumulative success rates in a long-term follow-up study and concluded that patients older than 60 years hwwad less implant survival than usual. Implant submersion continues throughout adult life, and its rate varies with age. This process is much more conspicuous

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REVIEW ARTICLE

Tooth transplantation and cryopreservation: State of the art

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Autotransplantation of teeth is useful and has many indications in dentistry. Cryopreservation of teeth creates new possibilities—eg, when autotransplantation is needed, but the recipient site is too small and orthodontic treatment is needed to gain space for the transplant. This review article examines the reactions of various dental tissues after autotransplantation vs after autotransplantation with cryopreservation. Various subjects will be discussed, including periodontal healing, pulp reactions, and root development after autotransplantation with and without cryopreservation. (Am J Orthod Dentofacial Orthop 2006;129:691-5)

According to Thilander et al,[1] the use of implants to replace missing front teeth causes an important amount of marginal bone loss after 10 years. Moreover, continuous eruption (even after active growth) of the neighboring teeth by abrasion can result in a different vertical gingival level of the implant. Therefore, autotransplantation, if possible, could be a more appropriate alternative treatment.

The reactions of dental tissues after autotransplantation are well described by Andreasen et al.[2-5] According to Andreasen and Schwartz,[6] teeth transplanted with incomplete and complete roots had a more than 90% survival rate after observation periods of 1 to 13 years. Czochrowska et al[7] reported long-term outcomes of tooth transplantation 17 to 41 years posttreatment. The survival rate was 90%; the success rate was 79%. They concluded that long-term survival and success rates for teeth autotransplanted when the roots were partly developed are at least as good as the results obtained with other treatment modalities for missing teeth.

Cryobiology has existed for several decades. The aim of cryopreservation of living tissues is "controlled reversibility of the cessation of all biologic functions"[6] at an ultra low temperature (−196°C).

Bartlett and Reade[8] were among the first scientists to experiment with cryopreservation of tooth material. They extracted tooth germs from rats, preserved them at −196°C, and transplanted them, after thawing, in the rats' eyes. They saw that the dental structures developed well, meaning that the cells in these tissues survived the freezing process.

Cryopreservation of teeth creates new possibilities—eg, when autotransplantation will be carried out but the recipient site is too small and orthodontic treatment is needed to gain space for the transplant.[6] Although there might be limited indications for this procedure, it has many advantages in specific situations compared with other treatment modalities.

Several animal experiments on cryopreservation and autotransplantation have been carried out,[9-12] but many questions remain about dental-tissue reactions after cryopreservation and transplantation.

In this review, the reactions of various dental tissues after autotransplantation vs after autotransplantation with cryopreservation will be explained.

- Periodontal healing after autotransplantation with and without cryopreservation.
- Pulp reactions after autotransplantation with and without cryopreservation.
- Root development after autotransplantation with and without cryopreservation.

PERIODONTAL HEALING AFTER AUTOTRANSPLANTATION

Periodontal healing is an important factor in determining success after autotransplantation.[13] It is generally known that if a tooth has a healthy and undamaged periodontal ligament (PDL), the success rate after transplantation is optimal.

Damage to the PDL can cause various types of root resorption: surface, replacement, and inflammatory. The degree of root development and the amount of

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CLINICIAN'S CORNER AJO-DO

Transplant vs implant in a patient with agenesis of both maxillary lateral incisors: A 9-year follow-up

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Introduction: Agenesis of a maxillary lateral incisor occurs in about 2% of the population. Treatment options should adapt to natural biologic changes in a lifelong perspective. **Methods and results:** A young woman with bilateral agenesis of the maxillary lateral incisors was treated with transplantation of a developing maxillary third molar on one side and a dental implant on the contralateral side, after orthodontic space opening. The periodontal examination, including bacterial testing of the transplant, the implant, and the control central incisor, was performed 9 years after the treatment. A radiologic assessment was also performed. The transplanted tooth did not differ from a natural incisor, except for the pulp obliteration, and the total bacteria count was higher at the implant site. The periodontal tissues around the implant showed progressive signs of recession. **Conclusions:** Both tooth transplants and dental implants for replacing missing maxillary incisors can be effective in the long term. This report supports natural tooth substitution rather than implant placement for dental agenesis in the anterior maxilla. (Am J Orthod Dentofacial Orthop 2016;149:751-6)

Agenesis of a maxillary lateral incisor is the second most common tooth agenesis, excluding third molars, and occurs in 1.55% to 1.78% of the population, with a higher incidence of bilateral agenesis.[1] The treatment options for replacement of congenitally missing maxillary incisors include dental implants, canine substitution usually after orthodontic space closure, and tooth-supported restorations.[2-4] The patient's age, dentofacial morphology, profile, crowding, and preferences determine the treatment decisions, which have lifelong consequences.

Dental implants have been reported to favorably substitute for congenitally missing maxillary lateral incisors[5]; recently, implants with narrow diameters or custom-made abutments were introduced to fulfill the anatomic and esthetic demands.[6,7] Autotransplantation of developing teeth is also documented as a predictable treatment modality for missing teeth,[8] including missing maxillary incisors.[9,10] However, no articles in the literature have compared the effectiveness of tooth transplantation and dental implants when replacing missing maxillary incisors. This report is the first to document the long-term outcome after transplantation of a developing third molar and the use of a dental implant to substitute for both congenitally missing lateral incisors in the same patient.

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CASE DESCRIPTION

In 2001, a 19-year-old woman sought orthodontic treatment because she was dissatisfied with the esthetics of her smile; her complaint was related primarily to the congenital absence of both maxillary lateral incisors (Figs 1 and 2). The clinical examination and the analysis of study models showed spacing in the anterior maxilla, a Class I molar relationship on the right side, a Class II molar relationship on the left side (Fig 3), and a 3-mm maxillary midline shift to the right side. We also recorded Class IB according to the Palacci-Ericson classifications[11] of the vertical dimensions of tissue loss (Class I, intact or slightly reduced papillae; Class II, limited loss of papillae [less than 50%]; Class III, severe

Case Report

Tooth loss treatment in the anterior region: Autotransplantation of premolars and cryopreservation

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Abstract

Avulsed and lost anterior teeth are common in young people. Using autotransplantation, it is possible to move problems in dental arches to regions where they are easier to solve orthodontically. Transplantation of premolars with three-quarter root formation or full root formation with wide open apical foramina provides the best prognosis for long-term survival. This article describes the use of autotransplantation and orthodontic treatment, together with cryopreservation, in connection with complicated trauma in the anterior region of an 8-year-old female child.

Key words: Anterior region, autotransplantation, cryopreservation, Tooth loss

INTRODUCTION

Autotransplantation of teeth has become a predictable treatment approach for certain orthodontic conditions, namely aplasia of premolars and malformation or tooth loss of permanent incisors. In conventional orthodontics, tooth movements are usually limited to relatively small distances in sagittal, vertical, and transverse dimensions. Including tooth transplantation in the orthodontic equipment, tooth movement is no longer limited to short distances in a quadrant of the dental arch, but wider freedom is achieved to place the tooth exactly where needed, may it be the contralateral side in the dental arch or the opposing jaw. The periodontium is the key for bone induction and bone modeling in the recipient area, and the tooth will normally erupt in a similar manner as a contralateral, nontransplanted tooth in its normal area.

However, transplantation of teeth is more traumatic to the pulp and periodontium than conventional orthodontics. Donor teeth with wide open apices and a single root canal are recommended as grafts of choice for long-term survival. The surgical procedure is thus an essential key to the successful outcome of this treatment selection and outcome.

However, orthodontists are generally the most competent professionals to identify available donor teeth; because overall occlusal status must be assessed, the orthodontist should be considered a key person in planning, referring, and coordinating treatment that includes transplantation of teeth. With autotransplantation, it has become possible to move problems in the dental arches to regions where they are easier to solve orthodontically.

The survival of transplanted premolars has been studied postoperatively for more than 30 years. A prerequisite for the use of this method is, however, a thorough knowledge of the prognosis. Thus, the stage of root development of transplants has been found to be of great importance. Transplantation at 3/4–4/4 root development of transplants

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CASE REPORT/CLINICAL TECHNIQUES

Fully Guided Tooth Autotransplantation Using a Multidrilling Axis Surgical Stent: Proof of Concept

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ABSTRACT

Introduction: Digital technology has been progressively introduced into tooth autotransplantation to enhance both treatment planning and surgery. The aim of this report was to describe a novel protocol for fully guided tooth autotransplantation. **Methods:** This report includes 10 consecutive patients treated with a complete virtual planning and a multidrilling axis surgical guide in combination with the computer-aided rapid prototyping model. **Results:** All transplanted teeth fulfilled the criteria for success over a mean follow-up duration of 13.1 months. No signs of progressive root resorption or pain were found during follow-up. One case required minimal adjustment of the surgical stent to allow correct seating, whereas a second case could not be performed fully guided because of limited mouth opening. **Conclusions:** Our protocol for fully guided tooth autotransplantation is a viable option that involves minimal bone preparation in a short surgical time. Future research should focus on further investigation of the benefits of this novel protocol in a larger sample. *(J Endod 2020;46:1515–1521.)*

KEY WORDS

Computer-aided rapid prototyping model; guided surgery; tooth autotransplantation; virtual planning

SIGNIFICANCE

Digital technology has been steadily incorporated into tooth autotransplantation to improve both treatment planning and surgical outcome. This novel protocol for fully guided tooth autotransplantation can be beneficial for patients, offering a predictable and minimally invasive approach to this technique.

Tooth autotransplantation is an accepted and predictable procedure for the replacement of unrestorable teeth[1,2]. In contrast to dental implants, the transplant adapts to the eruption of adjacent teeth and developmental changes in the oral region and can be orthodontically moved.[3–6] Therefore, it is considered the ideal treatment for tooth replacement in growing patients[3,7,8]. Furthermore, given the regenerative potential of the periodontal ligament (PDL), the transplant itself stimulates regeneration of the attachment apparatus, leading to re-establishment of a normal alveolar process and preservation of the gingival architecture[9].

Since Slagsvold and Bjercke[10] established a tooth autotransplantation protocol at the University of Oslo in the 1960s, the predictability of this treatment has been confirmed by several long-term follow-up studies[11–15]. Predictors of survival of the transplanted tooth are chiefly related to preservation of the PDL cells in the donor tooth[5,8,11]. Tooth manipulation during surgery and its extraoral time may damage the PDL surface, leading to postoperative complications, such as root resorption and attachment loss[16]. Hence, this procedure requires gentle extraction and handling of the donor tooth during surgery.

Digital technology has been progressively introduced into this therapy to enhance both treatment planning and surgery. Lee et al[17] first described the use of computer-aided rapid prototyping (CARP) models in tooth autotransplantation, which allow the clinician to prepare the recipient site without the need of the donor tooth itself, thereby minimizing further complications. For its part, surgical planning software enables the design and manufacture of a 3-dimensional (3D)-printed surgical template for guided preparation of the recipient socket during surgery, as used in dental implants.

Some authors have proposed the use of multiple surgical templates for preparation of the recipient socket during tooth autotransplantation. However, to the best of our knowledge, no protocols include fully guided socket remodeling with a single and milled surgical template. The aim of this case series was to present a new protocol for tooth autotransplantation based on full virtual planning and a milled, sleeveless, multidrilling axis surgical guide in combination with the CARP model.

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Clinical Paper
Oral Surgery

Autotransplantation of premolars: does surgeon experience matter?

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C. Jakobsen, K. Stokbro, E. Kier-Swiatecka, J. Ingerslev, J.J. Thorn: Autotransplantation of premolars: does surgeon experience matter?. Int. J. Oral Maxillofac. Surg. 2018; 47: 1604–1608.

Abstract. Autotransplantation of premolars is a well-established method to rehabilitate aplasia of premolars. Nevertheless, with the introduction of titanium implants, not all surgical units offer this procedure. The aim of this study was to examine the predictability of autotransplantation of premolars on orthodontic indication as suggested by Andreasen et al., when performed by surgeons with or without prior experience of this procedure. A prospective protocol was implemented in 2001. All patients treated with autotransplantation of premolars during the years 2001–2015 were recalled to evaluate the long-term status of the teeth. The state of root development, need for endodontic treatment, presence of an apical pathology or ankylosis, and tooth loss were recorded. The results were divided into two groups according to the surgeon's experience: senior surgeons with prior training and experience in the procedure and junior surgeons without prior experience. A total of 89 teeth (66 patients) were treated. The mean observation time was 10.1 years (range 1.0–15.1 years). The long-term survival rate was 95%. No statistically significant difference between the results of the two groups of surgeons was found. Autotransplantation of premolars on orthodontic indication could be adopted successfully in the hospital setting regardless of surgeon experience.

Key words: autotransplantation; transplantation of teeth; premolar; tooth transplant.

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Autotransplantation of teeth is a well-described procedure and is preferable to the use of dental implants in young patients. Since the first reports by Slagsvold and Bjercke almost 50 years ago[1,2], several protocols for this procedure have been proposed in relation to the type of donor tooth, surgical technique, and handling of the donor tooth prior to transplantation[3–7]. New emerging technology has enabled further development of the treatment protocol, keeping the treatment current and evolving to use platelet-rich plasma and rapid prototyping for printed transplantation models[8,9].

Two recent systematic reviews with meta-analyses found a survival rate of more than 90%[10,11]. Furthermore, it was

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Autogenous Premolar Transplantation into Artificial Socket in Maxillary Lateral Incisor Site

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Abstract

Introduction: Autogenous transplantation of a natural tooth to another site has significant advantages over dental implants, particularly in cases of agenesis, accidental tooth loss, or poor prognosis for the maintenance of tooth function. **Methods:** This report describes a case of autogenous premolar transplantation into an artificial socket in the site of a missing maxillary lateral incisor in a 13-year-old girl. Clinical examination and radiography revealed tooth agenesis (#4, #10, #13, and #20) and microdontia (#7). The occlusion and skeletal maxillomandibular relations were normal. **Results:** Tooth #29 was chosen for transplantation into the site of tooth #10 because of its size, stage of root formation, and possible closure of the spaces created by agenesis. **Conclusions:** Autogenous transplantation is a feasible alternative to dental implants in cases of tooth agenesis or tooth loss because of trauma. Autotransplantation was indicated in this case because it ensures the natural (facial) growth of the alveolar process and preserves the function of periodontal tissues. A multidisciplinary approach (ie, combining techniques from different dental specialties) was important for treatment success. Clinical and radiographic follow-up confirmed that the transplanted premolar was esthetically comparable with the lateral incisor and that root development and pulp canal obliteration were complete. *(J Endod 2014;40:1885–1890)*

Key Words

Agenesis, autogenous tooth transplantation, pulp regeneration, root canal treatment, tooth transplantation

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Current rehabilitation strategies include autogenous transplantation to replace missing teeth or teeth with a poor prognosis (1, 2). Tooth transplantation has been a well-established procedure in dental practice for many years, and immature third molars have recently been used to replace carious first molars (1–6).

Teeth may be absent because of several reasons (eg, agenesis [the absence of teeth because of abnormal tooth germ development]) and dental trauma. Also, in some cases, teeth may require replacement because of a poor long-term prognosis for the maintenance of tooth function (5). Tooth autotransplantation is especially indicated to replace missing teeth in children and adolescents because autotransplanted teeth continue to participate in the normal development of the alveolar bone (6). On the contrary, osseointegrated dental implants are contraindicated in this group of patients because of their potential interference with the growth of the alveolar process. Other clinical situations that may benefit from autogenous transplants include partial agenesis, especially of lateral incisors and premolars, and impacted teeth (3, 6).

Some of the criteria used to classify a transplant as successful are the absence of progressive root resorption, the presence of normal hard and soft periodontal tissues adjacent to the transplanted tooth, and a crown-to-root ratio <1 (7). Positive outcomes depend on the integration of treatment protocols used in different specialties, such as endodontics, orthodontics, surgery, implants, and operative dentistry, as well as on careful planning and accurate techniques (5–8).

Autogenous tooth transplantations tend to be more successful when the roots are incompletely formed (9). The correct selection of cases, assessment of root development stage and recipient socket, and adoption of safety protocols are all essential to ensure success (9–12).

This report describes the autogenous transplantation of a mandibular premolar into an artificial socket in the site of a missing maxillary lateral incisor (tooth #7) in an adolescent patient.

Case Report

Clinical and radiographic examination of a 13-year-old girl who sought orthodontic care revealed multiple agenesis (teeth #4, #10, #13, and #20) and microdontia (tooth #7) (Fig. 1*A–E*). The occlusion and skeletal maxillomandibular relations were normal. The treatment plan was to perform autotransplantation of tooth #29 into the site corresponding to tooth #10 because of its size, stage of root formation, and the possibility of closing spaces left by other missing teeth.

The plan was carefully discussed and accepted, and all steps, benefits, and risks were explained to the patient and her parents, who provided written informed consent. Fixed appliances were placed in both arches and spaces distributed in the maxillary arch. Teeth #5 and #12 were moved distally using a strategy similar to the segmented arch technique, and titanium-molybdenum alloy T-loop springs were connected to a palatal bar (Fig. 2*A–D*) (13). Tooth #6, originally impacted, erupted spontaneously, and space was opened between teeth #9 and #11.

The recipient site was defined after the maxillary arch was leveled using a rectangular stainless steel arch wire that bypassed the site of tooth #10. The size of the recipient site was defined according to computed tomographic images showing the exact dimensions of tooth #29, which was selected for transplantation. At the time of treatment, the root of the transplanted tooth showed three quarters of its final root length.

Use of CBCT Guidance for Tooth Autotransplantation in Children

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Abstract

Tooth autotransplantation (TAT) offers a viable biological approach to tooth replacement in children and adolescents. The aim of this study was to evaluate the outcome of the cone-beam computed tomographic (CBCT)–guided TAT compared to the conventional TAT protocol and to assess the 3-dimensional (3D) patterns of healing after CBCT-guided TAT (secondary aim). This study included 100 autotransplanted teeth in 88 patients. Each experimental group consisted of 50 transplants in 44 patients (31 males and 19 females). The mean (SD) age at the time of surgery was 10.7 (1.1) y for the CBCT-guided group. This was 10.6 (1.3) y for the conventional group. The mean (SD) follow-up period was 4.5 (3.1) y (range, 1.1 to 10.4 y). Overall survival rate for the CBCT-guided TAT was 92% with a success rate of 86% compared to an 84% survival rate and a 78% success rate for the conventional group ($P > 0.005$). The following measurements were extracted from the 3D analysis: root hard tissue volume (RV), root length (RL), apical foramen area (AFA), and mean and maximum dentin wall thickness (DWT). Overall, the mean (SD) percentage of tissue change was as follows: RV gain by 65.8% (34.6%), RL gain by 37.3% (31.5%), AFA reduction by 91.1% (14.9%), mean DWT increase by 107.9% (67.7%), and maximum DWT increase by 26.5% (40.1%). Principal component analysis (PCA) identified the mean DWT, RV, and maximum DWT as the parameters best describing the tissue change after TAT. Cluster analysis applied to the variables chosen by the PCA classified the CBCT group into 4 distinct clusters (C1 = 37.2%, C2 = 17.1%, C3 = 28.6%, C4 = 17.1%), revealing different patterns of tissue healing after TAT. The CBCT-guided approach increased the predictability of the treatment. The 3D analysis provided insights into the patterns of healing. CBCT-guided TAT could be adopted as an alternative for the conventional approach. (Clinical trial center and ethical board University Hospitals, KU Leuven: S55287; ClinicalTrials.gov Identifier: NCT02464202)

Keywords: CAD, computed tomography, digital imaging/radiology, tooth regeneration/transplantation, periodontal ligament (PDL), clinical outcomes

Introduction

Tooth autotransplantation (TAT) offers a viable biological approach to tooth replacement in children and adolescents after traumatic dental injuries (TDIs), agenesis, developmental anomalies, or specific orthodontic problems (Czochrowska et al. 2000; Zachrisson et al. 2004; Paulsen et al. 2006). TDIs have a relatively high prevalence (15.2%), with children being the most affected (Petti et al. 2018). The treatment options available (e.g., implant placement) are limited by the ongoing dentoalveolar development (Sharma and Vargervik 2006), while orthodontic tooth alignment is challenging unless skeletal anchorage is applied (Kanavakis et al. 2014; Becker et al. 2018). TAT allows for periodontal healing and enables preservation of the alveolar ridge, maintaining the possibility of function and growth (Andreasen, Paulsen, Yu, and Schwartz 1990; Czochrowska et al. 2000; Kallu et al. 2005; Denys et al. 2013). To enhance outcome predictability of the TAT procedure, a low-dose cone-beam computed tomographic (CBCT)–guided surgical planning and transfer technique has been developed, involving donor tooth selection and tooth replica fabrication (Shahbazian et al. 2010; Shahbazian et al. 2013).

The primary aim of this study was to evaluate the outcome of the CBCT-guided TAT compared to the conventional TAT protocol, and the secondary aim was to assess the 3-dimensional (3D) patterns of healing after CBCT-guided TAT.

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A supplemental appendix to this article is available online.

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Guidelines for autotransplantation of developing premolars to the anterior maxilla

Ewa Monika Czochrowska, and Paweł Plakwicz

Loss of a permanent maxillary central incisor in a young patient is a therapeutic challenge for dental professionals. Autotransplanted developing premolars replacing missing maxillary incisors provide predictable long-term results and assure bone preservation during growth. Moreover, they can be successfully transformed to the morphology of the missing incisors. which is very important since these teeth are placed centrally in the esthetic zone. Comprehensive interdisciplinary treatment planning is necessary, combining a thorough evaluation of the occlusion and the profile, existing indications for premolar removal, space conditions, and the optimal match between the donor tooth and the recipient site. Orthodontic space management before and after surgery is often needed to create favorable conditions for donor accommodation, and to establish both normal occlusion and a good esthetic result. Monitoring of pulpal and periodontal healing and root development after transplantation of developing premolars is mandatory during follow-up appointments. (Semin Orthod 2020; 26:61–72) ***© 2020 Elsevier Inc. All rights reserved.***

Introduction

One of the most important indications for tooth autotransplantation is traumatic loss of maxillary incisors in young patients. Upon the loss of an upper anterior tooth, patients and parents are usually very alarmed and seek expert help with the main request to explain all possible treatment options, and to select the best solution for the individual situation. Gaining informed consent after a thorough discussion with patients and parents/guardians about potential complications and alternative solutions must precede the initiation of any treatment.

Autotransplanation of developing premolars has been reported to be a successful long-term treatment alternative in growing patients with congenitally missing or traumatically lost teeth.[1-5]

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The advantages of this method include immediate replacement of a missing tooth, good adaptation of the transplanted tooth to growth changes, and normal response to orthodontic forces. These features are very important in children and young adolescents for whom dental implants are generally contraindicated.[6-8] Transplanted developing premolars have a good potential for long-term preservation of hard and soft periodontal tissues.[3,9] Orthodontic mesialization of lateral incisors, which is another viable alternative to replace a missing central incisor in a young patient, is a long and complex treatment after the eruption of all permanent teeth.[10] Moreover, tooth width at the gingival level is usually more favorable for premolars than for lateral incisors, which is an important factor for satisfactory esthetics of the restoration to resemble the missing central incisor.[10,11]

Developing premolars have good surgical access, which facilitates their gentle removal - a crucial predictor for successful outcome.[12-14] In addition, premolars are frequently extracted for orthodontic purposes, which is another reason why they can serve as tooth replacements in case of need.[15] When tooth transplantation is

Validation of the cone beam computed tomography–based stereolithographic surgical guide aiding autotransplantation of teeth: clinical case–control study

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Objective. To compare the outcome of cone beam computed tomography (CBCT)–based surgical planning and transfer technique for tooth autotransplantation versus conventional autotransplantation.

Study Design. The study material comprised 40 pediatric subjects in whom 48 teeth were transplanted following a case–control design. While the study group (mean age 11 years) underwent CBCT imaging for surgical planning and transfer via stereolithographic tooth replica fabrication, the historical control group (mean age 12 years) was subjected to conventional autotransplantation.

Results. The CBCT-based preoperative planning and the use of a tooth replica decreased the extra-alveolar time and reduced the number of positioning trials with the donor tooth. In the control group, 6 patients showed 1 or more complications, while this was noticed for only 2 study patients.

Conclusion. CBCT-based surgical planning of tooth autotransplantation may benefit from a shorter surgical time, while being a less invasive technique, causing fewer failures than a conventional approach. (Oral Surg Oral Med Oral Pathol Oral Radiol 2013;115:667-675)

The reported prevalence of traumatic dental injuries varies considerably among countries.[1-4] Overall, it has a relatively high prevalence[5] with a subsequent social and psychological impact on children (Figure 1). A large national survey in the USA indicates that 1 of 4 adults has experienced traumatic dental injuries.[6] The extent of such a traumatic injury to permanent teeth can vary from crown or root fracture to avulsion.[7] Avulsion of teeth occurs in 0.5%-3% of the traumatic injuries in the permanent dentition.[8,9] Replantation is the treatment of choice in the majority of avulsed teeth. Although it may initially save the avulsed teeth, it is important to realize that some of the replanted teeth have lower chances of long-term survival and may even be lost or extracted at a later stage.[10]

Replacement of permanent teeth in children is challenging considering that alveolar bone growth is ongoing. A study of the use of implants in growing children suggests that when a single tooth is missing, implants should be withheld until completion of dentoalveolar development.[11] This implies that treatment approaches should consider both growth and developmental changes in the craniofacial area to ensure the potential for long-term management of missing teeth.

This could be realized through autotransplantation of teeth, which is a biological approach to tooth replacement in young children. It enables preservation of the alveolar ridge and allows for periodontal healing, thus preserving the adaptability to function and growth.[12,13] There are various factors that may influence the outcome of this procedure. Case selection, atraumatic tooth removal, and vitality of periodontal ligament are key objectives for a successful tooth autotransplantation.[13-16]

Statement of Clinical Relevance

Tooth autotransplantation is a viable option for tooth replacement in young patients and may become even a more predictable procedure when using stereolithographic tooth replica and guides.

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2018 MEETING OF THE WORLD CONGRESS ON DENTAL TRAUMATOLOGY

Long-term Outcomes of Autotransplantation of Teeth: A Case Series

SIGNIFICANCE

Autotransplantation of teeth can be a beneficial, long-term treatment alternative for patients who have teeth with a poor prognosis or missing teeth.

ABSTRACT

The aim of autotransplantation of teeth (ATT) is to replace a lost tooth with a functional tooth within the same patient. Although it has recently become more of a recognized and viable treatment approach in dentistry, the long-term outcomes are still not well-documented. The principal author (M.T.) has performed more than 1000 ATTs for reasons such as treating missing teeth, deep caries, poor endodontic results, and periodontitis over the past 30 years in private practice. During the course of private practice, 2 separate analyses were performed on a total of 319 cases with follow-up ranging from 2–26 years. The results showed a tendency toward higher success rates in younger patients; the success rate was highest in ATTs performed on immature teeth (about 95%), about 90% in patients younger than 30 years of age and approximately 80% in patients older than 30. The failures were most often caused by replacement resorption (ie, ankylosis-related resorption). The purpose of this case series was to show successful long-term outcomes of ATT as well as to provide clinical insights and describe tendencies noted over the course of 30 years of performing ATTs. *(J Endod 2019;45:S72–S83.)*

KEY WORDS

Autotransplantation of teeth; pulp revascularization; reattachment; root resorption

Autotransplantation of teeth (ATT) has been performed for centuries, but its popularity has varied over the years because of unpredictable results[1–9]. However, with recent advancements in technology and better biological understanding, ATT has become more predictable. Yet, many clinicians are still not confident about this technique, in part because of the lack of studies on the long-term outcomes of these cases.

The principal author (M.T.) has performed more than 1000 ATTs since 1987 in general private practice. Almost all of the cases were carefully recorded with photographs and radiographs in a standardized manner, and many were followed long-term. Here, the authors provide a case series showing long-term successful outcomes of ATT and general observations and tendencies noted throughout 30 years of performing ATTs in private practice.

Case 1

The patient was a 16-year-old female at the initial examination. Her chief complaint was with the mandibular right second premolar, which erupted ectopically on the lingual aspect (Fig. 1*A*). Extraction of the tooth was indicated, but a congenitally missing tooth (the mandibular left second premolar) was observed on the contralateral side, which had been restored with a fixed bridge (Fig. 1*B*). The root development of the mandibular right second premolar was around stage 4, which is considered an ideal stage as a donor tooth for ATT. After discussion of the risks, benefits, and options, transplantation of the premolar into the aplasia site was performed.

After anesthesia of the donor and recipient sites, the bridge was sectioned, and the approximate recipient socket was formed. The donor tooth was extracted (Fig. 1*C*) and tried in the socket. This case was performed 25 years ago, and the techniques used then have changed over the years. A more contemporary way of ATT therapy includes cone-beam computed tomographic (CBCT) analysis and preparing 3-dimensional replicas to reduce the extraoral time and the potential damage to the periodontal ligament (PDL) of the donor tooth. In this case, the adjustment of a recipient socket was made until the donor tooth could be placed into the appropriate position (Fig. 1*E*). The gingival flap was closed tightly around the transplant. The donor tooth was splinted with the suture strings, and the wound was covered

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Autogenous Tooth Transplantation: An Alternative to Dental Implant Placement?

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• **Deirdre M. Yau**, B.Sc., DDS •

• **Laura Chano**, DDS •

Abstract

Autogenous tooth transplantation, or autotransplantation, is the surgical movement of a tooth from one location in the mouth to another in the same individual. Once thought to be experimental, autotransplantation has achieved high success rates and is an excellent option for tooth replacement. Although the indications for autotransplantation are narrow, careful patient selection coupled with an appropriate technique can lead to exceptional esthetic and functional results. One advantage of this procedure is that placement of an implant-supported prosthesis or other form of prosthetic tooth replacement is not needed. This article highlights the indications for autogenous tooth transplantation using 3 case reports as examples. A review of the recommended surgical technique as well as success rates are also discussed.

MeSH Key Words: *tooth/transplantation; tooth loss*

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This article has been peer reviewed.

The earliest reports of tooth transplantation involve slaves in ancient Egypt who were forced to give their teeth to their pharaohs.[1] However, allotransplanta tion — transplantation of a tooth from one individual to another — was eventually abandoned because of problems of histocompatibility and replaced with autotransplantation. Autogenous tooth transplantation, or autotransplantation, is the surgical movement in one individual of a vital or endodontically treated tooth from its original location in the mouth to another site.[2] Autogenous tooth transplantation was first well documented in 1954 by M.L. Hale. The major principles of his technique are still followed today.[3] The science of autotransplantation has progressed, as evidenced by the high success rates reported in studies over the past decade.[1,4-8] These studies demonstrate that autotransplantation is a viable option for tooth replacement for carefully selected patients.

Indications

While there are many reasons for autotransplanting teeth, tooth loss as a result of dental caries is the most common indication, especially when mandibular first molars are involved. First molars erupt early and are often heavily restored. Autotransplantation in this situation involves the removal of a third molar which may then be transferred to the site of an unrestorable first molar.[2] Other conditions in which transplantation can be considered include tooth agenesis (especially of premolars and lateral incisors), traumatic tooth loss, atopic eruption of canines, root resorption, large endodontic lesions, cervical root fractures, localized juvenile periodontitis as well as other pathologies.[2,9-11] Successful transplantation depends on specific requirements of the patient, the donor tooth, and the recipient site.

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CASE REPORT

Treatment of an avulsed maxillary permanent central incisor replaced by autotransplantation of a mandibular premolar: 14-year follow-up

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Abstract

Mendoza Mendoza A, Solano Reina E, Segura-Egea JJ. Treatment of an avulsed maxillary permanent central incisor replaced by autotransplantation of a mandibular premolar: 14-year follow-up. *International Endodontic Journal*, **43**, 818–827, 2010.

Aim To present the 14 year follow-up of a case in which an avulsed permanent maxillary central incisor was replaced by autotransplantation of a mandibular premolar.

Summary A mandibular premolar (Moorrees' stage 3) was transplanted into the space left by an avulsed permanent maxillary central incisor after a delay of 3 months. Recall examination 14 years after transplantation revealed a normal periodontal architecture with absence of infection, ankylosis or progressive resorption. The transplantation of a premolar is seen as a promising method to replace a lost permanent tooth and to restore aesthetics and function.

Key learning points

- Autotransplantation is a viable option for the treatment of a missing tooth or for replacement of avulsed and traumatized tooth when a donor tooth is available.
- Autotransplantation is a therapeutic option for the substitution of missing anterior teeth in young patients who also need orthodontic treatment.

Keywords: autotransplantation, avulsion, orthodontics, tooth injuries.

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Introduction

Since the report of Slagsvold & Bjercke (1967), numerous studies (Slagsvold & Bjercke 1974, 1978, Andreasen 1981, Kristerson 1985, Andreasen *et al.* 1988, Tsurumachi & Kakehashi 2007, Sonmez *et al.* 2008) have confirmed that autotransplantation is a widely accepted method for the treatment of orthodontic problems with premolar or incisor

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BMC Oral Health

RESEARCH ARTICLE Open Access

Autotransplantation of mature impacted tooth to a fresh molar socket using a 3D replica and guided bone regeneration: two years retrospective case series

Ye Wu[1], Jiaming Chen[1], Fuping Xie[1], Huanhuan Liu[1], Gang Niu[1] and Lin Zhou[2*]

Abstract

Background: The aim of this study was to evaluate the clinical outcome of autotransplantation of mature third molars to fresh molar extraction sockets using 3D replicas.

Methods: Ten patients underwent teeth autotransplantation with or without GBR. We observed the mobility, percussion, radiography examination, the probing depth and the masticatory function of the transplanted teeth during 2 years following up, which were transplanted into fresh molar sockets by using 3D replicas, and GBR when it is necessary.

Results: The average extra-oral time of donor tooth had been shortened to 1.65 min when used the 3D replica. Some probing depth of the transplanted tooth were deeper than 3 mm at 4 or 5 weeks temporarily. And one patient felt slight sensitive when chewing with soft food at 4 weeks, then disappeared. The clinical examination of the autotransplantation teeth during 1 year follow-up showed no sign of failure.

Conclusions: The tooth autotransplantation using 3D replica with or without GBR is an effective method which can reduce the extra-oral time of the donor teeth and may result in less failure.

Keywords: Tooth autotransplantation, Mature impacted tooth, 3D replica model, Guided bone regeneration

Background

The tooth autotransplantation is a predictable method to replace a tooth that needs to be extracted due to caries, trauma, or tooth fracture. Since it was first introduced by Fauchard in his book, Le Chirurgien Dentiste, in 1728, the clinical protocol had been developed for hundreds of years [1–3]. Its brief process is that the donor tooth (mostly an impact tooth or a supernumerary tooth) is extracted for the insertion of a prepared recipient socket [4]. Compared to dental implant, the tooth autotransplantation is a better way to restore missing teeth for its proprioception, the vital periodontium, preservation of alveolar bone volume and the papilla [5], and also better than a fixed bridge.

Many previous studies have demonstrated that third molars, premolars, impacted teeth and supernumerary teeth can be a donor tooth in the clinical practice [6–8]. The incidence of the extraction of the compromised molars is much higher than in other teeth, especially in young Chinese range from 25 to 30 years old. The transplantation of a third molar to replace compromised first or second molar has more practical value. The survival rates of tooth autotransplantation with incomplete root formation after 1, 5 and 10 years were 97.4, 97.8 and 96.3% respectively [9]. However, some studies showed that the estimated 10-years success rate of a transplanted premolar with mature root was 81.6% which is much higher than that of a molar, with a 33.8% 10-years success rate [10]. Many factors affect the success of tooth autotransplantation, such as the stage of root development, surgical trauma, the recipient site (local inflammation, alveolar bone volume and quality), the surgery procedure (stabilization method, use of intraoperative

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REVIEW

Autotransplantation of teeth with incomplete root formation: a systematic review and meta-analysis

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Abstract

Objectives The objective of this systematic review and meta-analysis was to determine the rates of survival and success and the complications related to autotransplantation of teeth with incomplete root formation. Additionally, we attempted to identify the prognostic factors that influence the outcome of tooth autotransplantation.

Materials and methods A literature search for all data published until July 2016 was conducted. Inclusion and exclusion criteria were specified. Risk of bias was assessed with the Newcastle checklist. Meta-analysis was performed by using the DerSimonian-Laird random effect model. The 1-, 5-, and 10-year survival rates and the weighted estimated survival, success, and complication rates per year were calculated.

Results Thirty-two studies were included for analysis. The survival rates reported after 1, 5, and 10 years were 97.4, 97.8, and 96.3%, respectively. The annual weighted estimated survival rate (98.2%), success rate (96.6%), and complication rates in terms of ankylosis (2.0%), root resorption (2.9%), and pulp necrosis (3.3%) were analyzed. No firm conclusions could be drawn with respect to the prognostic factors due to insufficient evidence of high quality.

Conclusion The survival and success rates of autotransplantation of teeth with incomplete root formation were high (> 95%), with a low rate of complications (< 5%).

Clinical relevance Current evidence from the literature on autotransplantation of teeth with incomplete root formation shows favorable survival and success rates and low complication rates, indicating it is a reliable treatment option.

Keywords Tooth autotransplantation · Incomplete root formation · Success rate · Survival rate · Systematic review · Meta-analysis

Introduction

Tooth autotransplantation is a treatment option in cases with tooth loss due to trauma, caries, periodontitis, or endodontic problems and in cases with tooth impaction or agenesis [1–25]. Unlike osseointegrated dental implants, successfully autotransplanted teeth ensure a vital periodontium, continuous eruption, preservation of alveolar bone volume and the interdental papilla, and the possibility of tooth movement by orthodontic or physiological forces [2, 16, 19, 26]. Another advantage of autotransplantation over dental implants is that it can be performed in growing subjects, in whom the incidence of tooth loss due to trauma is relatively high [27, 28]. The longevity and prognosis of autotransplanted teeth are comparable to those of dental implants [29, 30]. However, complications such as inflammatory and replacement root resorption [18, 22, 30, 31], ankylosis [16, 31, 32], pulp necrosis [3–9, 11–15, 33], and compromised periodontal healing [6, 11, 15, 24] may undermine the clinical outcome of tooth autotransplantation.

During the late twentieth century, Andreasen published a series of studies on autotransplantation. In his first study, he reported the standard surgical procedures, which are still being

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Replacing Heavily Damaged Teeth by Third Molar Autotransplantation With the Use of Cone-Beam Computed Tomography and Rapid Prototyping

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This article describes the autotransplantation of third molars to replace heavily damaged premolars and molars. Specifically, this article reports on the use of preoperative cone-beam computed tomographic planning and 3-dimensional (3D) printed replicas of donor teeth to prepare artificial tooth sockets. In the present case, an 18-year-old patient underwent autotransplantation of 3 third molars to replace 1 premolar and 2 molars that were heavily damaged after trauma. Approximately 1 year after the traumatic incident, autotransplantation with the help of 3D planning and rapid prototyping was performed. The right maxillary third molar replaced the right maxillary first premolar. The 2 mandibular wisdom teeth replaced the left mandibular first and second molars. During the surgical procedure, artificial tooth sockets were prepared with the help of 3D printed donor tooth copies to prevent iatrogenic damage to the actual donor teeth. These replicas of the donor teeth were designed based on the preoperative cone-beam computed tomogram and manufactured with the help of 3D printing techniques. The use of a replica of the donor tooth resulted in a predictable and straightforward procedure, with extra-alveolar times shorter than 2 minutes for all transplantations. The transplanted teeth were placed in infraocclusion and fixed with a suture splint. Postoperative follow-up showed physiologic integration of the transplanted teeth and a successful outcome for all transplants. In conclusion, this technique facilitates a straightforward and predictable procedure for autotransplantation of third molars. The use of printed analogues of the donor teeth decreases the risk of iatrogenic damage and the extra-alveolar time of the transplanted tooth is minimized. This facilitates a successful outcome.

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Autotransplantation of teeth is a valuable single-tooth replacement therapy in young patients with missing teeth.[1] The procedure is ideally performed when root development of the donor tooth is 50 to 75%, because in these cases the transplanted teeth usually function as normal teeth with a good long-term outcome.[2] However, autotransplantation of third molars to replace teeth with a poor prognosis is rarely

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Conflict of Interest Disclosures: None of the authors have a relevant financial relationship(s) with a commercial interest.

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ORIGINAL ARTICLE

Outcome of tooth transplantation: Survival and success rates 17-41 years posttreatment

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The literature contains no follow-up studies of transplanted teeth with mean observation times exceeding 10 years. This article describes long-term outcomes, including gingival and periodontal conditions, and the patients' attitudes about treatment and outcome. The material comprised all accessible patients in the files of the Department of Orthodontics, University of Oslo, Norway, on whom treatment had been performed at least 17 years ago (n = 28). Established clinical criteria were used to assess tooth mobility, plaque and gingival indexes, and probing pocket depth. Standardized radiography was used to evaluate the presence of pathology, pulp obliteration, and root length. Similar recordings were obtained from the in situ tooth contralateral to the initial position of the grafted tooth. Criteria for determining treatment success were established. All patients responded to questions about their treatment using visual analogue scales. The mean age at surgery was 11.5 years, and the mean observation period was 26.4 years (range, 17-41 years). Of the 33 teeth transplanted in the 28 patients, 3 teeth were lost after 9, 10, and 29 years, respectively. Therefore, the 30 teeth in the 25 patients we examined yielded a survival rate of 90%. The success rate was 79% because 2 transplants had ankylosed, and 2 others failed to fulfill the proposed criteria. The patients generally responded very favorably regarding their perception of the treatment. Their only hesitation was related to some discomfort during surgery. It was concluded that survival and success rates for teeth autotransplanted when the root is partly developed compare favorably in a long-term perspective with other treatment modalities for substituting missing teeth. (Am J Orthod Dentofacial Orthop 2002;121:110-9)

Missing teeth in children are a particular challenge. The replacement should preferably adapt to growth and developmental changes in the oral region. Furthermore, the substitute should have the potential for long-term, even lifelong, survival. In this perspective, few, if any, studies are available.

Of the alternative replacement means, autotransplantation of developing premolars[1,2] is a treatment modality that has received increasing attention in recent years. This is because transplanted teeth also have the capacity for functional adaptation[3,4] and preservation of the alveolar ridge.[5,6] Andreasen et al[7] reported survival rates of more than 90% in a comprehensive study, but only a few of their transplants had an observation period of more than 10 years. So far, Schwartz et al[8] presented the longest mean observation time of 10 years with a range of 1 to 25 years (1 tooth) for transplanted teeth. However, even longer follow-up periods are needed to document the applicability of tooth transplantation for lifelong survival in children and adolescents.

More than 4 decades ago, the method for autotransplantation of immature premolars was developed by Drs Slagsvold and Bjercke,[2-4] and they reported successful results in publications from the University of Oslo about 30 years ago. The files of their patients are still available. Because this material comprises transplantations performed according to a strict protocol, it represents an opportunity for a truly long-term follow-up study of transplanted teeth. The purposes of this study were to evaluate the long-term survival and success rates of transplanted teeth and to compare them with natural in situ teeth. An additional objective was to examine the patients' own assessments of the treatment process and outcome.

MATERIAL

The transplantation files until 1980 (when Dr Slagsvold passed away) comprised 63 patients; of these, 28 persons with a total of 33 transplanted teeth could be found and were willing to participate (44%). Three patients had each lost 1 transplanted tooth before this study. Therefore, 30 transplanted teeth in 25

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CLINICAL ARTICLE

Retrospective long-term evaluation of autotransplantation of premolars to the central incisor region

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Abstract

Mendoza-Mendoza A, Solano-Reina E, Iglesias-Linares A, Garcia-Godoy F, Abalos C. Retrospective long-term evaluation of autotransplantation of premolars to the central incisor region. *International Endodontic Journal*, **45**, 88–97, 2012.

Aim This retrospective case-series study aimed to examine the long-term outcomes of autogenously transplanted premolars.

Methodology Twelve patients in whom donor premolars were used to replace maxillary central incisors lost by trauma were clinically and radiologically monitored. Standardized clinical and radiographic records were systematically obtained during the follow-up period of 14 years, to determine the influence of specific clinical criteria on the overall success rate of transplantation.

Results The success rate of premolar autotransplantation in the maxillary central incisor area was 80% after 14 years follow-up. The highest success rate occurred in those teeth transplanted with two-thirds of full root development. Complete pulp obliteration was positively related to autotransplant viability, followed by root formation in the bony crypt.

Conclusions Autotransplantation of donor teeth, at the stage of ½ to ¼ of their expected root length, can provide a successful treatment solution for over 14 years.

Keywords: bicuspid/transplantation, incisor trauma, long-term follow-up, oral surgery, orthodontics, tooth autotransplant.

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The use of 3D additive manufacturing technology in autogenous dental transplantation

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Associated Data

▸ Data Availability Statement

Abstract

Go to:

Background

In medicine and dentistry, 3D technology allows the virtual planning and printing of surgical replicas of anatomical structures that can facilitate certain transplant procedures. In dentistry, 3D technology is useful in autogenous tooth transplantation.

Case presentation

We present a clinical case of an ectopic mandibular second premolar, describing the preoperative planning with dental replicas and the autotransplantation surgery. 3D prints of the surgical replica of the tooth to be transplanted was made using an Objet30 Prime® Printer, PolyJet. Clinical controls performed at 3, 6 and 12 months indicated the satisfactory evolution of the transplanted tooth.

Conclusion

3D additive manufacturing technology allows the preparation of a new recipient socket with the aid of a surgical replica of the tooth to be transplanted, thus minimizing handling and extraoral time.

Keywords: Tooth autotransplantation, Additive manufacturing, Dental ectopy, Polyjet 3D, Dental replica

Prognostic Factors for Clinical Outcomes in Autotransplantation of Teeth with Complete Root Formation: Survival Analysis for up to 12 Years

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Abstract

Introduction: Tooth autotransplantation is a treatment option that has the potential to restore masticatory function and esthetics to edentulous spaces resulting from extracted teeth. The purpose of this study was to investigate the prognostic factors and clinical outcomes for autotransplanted teeth with complete root formation. **Methods:** Patients who had received tooth autotransplantation in the Department of Conservative Dentistry, Yonsei University Dental Hospital, Seoul, Korea, from July 2001 to August 2010 were electronically searched, and a total of 105 cases of autotransplanted teeth met the inclusion criteria. Tooth survival, inflammatory root resorption (IRR), ankylosis, and related prognostic factors were assessed by using the survival analysis that was based on clinical and radiographic examination. **Results:** The cumulative tooth survival rate was 68.2% at 12 years after the tooth autotransplantation. According to the Cox proportional hazard regression analysis, patient age, donor position, and extraoral time were significantly associated with tooth survival ($P < .05$). Donor extraction type was significantly associated with IRR ($P < .05$), and transplantation timing and initial stability were significantly associated with ankylosis ($P < .05$) **Conclusions:** Patients less than 45 years of age, maxillary donor teeth, and an extraoral time of less than 15 minutes were associated with significantly higher tooth survival. Surgical extraction of the donor tooth was associated with a significantly higher incidence of IRR. Immediate transplantation after the extraction of the recipient site's tooth and low initial stability were associated with a significantly lower incidence of ankylosis (*J Endod 2016;■:1–8*)

Key Words

Autotransplantation, computer-aided rapid prototyping model, extraoral time, periodontal ligament, survival analysis

Tooth autotransplantation is a treatment option that has the potential to restore masticatory function and esthetics to edentulous spaces resulting from extracted teeth by repositioning the patient's own teeth to another recipient site in the same patient (1, 2). By using the patient's own teeth, tooth autotransplantation exhibits a number of advantages compared with other treatment options (ie, dental implants or fixed partial prostheses), such as greater resistance to occlusal loading, maintenance of the periodontal ligament (PDL) and surrounding bone, and potential for better esthetics (1, 3, 4).

After its first reported clinical application in 1950 (2), the success rate of tooth autotransplantation has gradually increased because of advances in diagnostic and surgical techniques, such as computer-aided rapid prototyping (CARP) models. By applying preoperatively fabricated CARP models, the extraoral time is significantly reduced, and the suitability between the donor tooth and the recipient site is improved (5). Consequently, recent clinical studies report high success rates with tooth autotransplantation (6, 7).

However, it should be noted that most studies have focused on autotransplantation using teeth with incomplete root formation (7–9), which restricts the application of tooth autotransplantation to patients in their early 20s and younger (10). Therefore, to expand the potential therapeutic applicability of tooth autotransplantion, teeth with complete root formation could be considered for use as donor teeth. However, in the field of autotransplantation of teeth with complete root formation, there is currently a lack of clinical evidence regarding its clinical outcome and prognostic factors. One problem is that most studies use a relatively short follow-up period (ranging from 16.4–35.6 months on average) (7, 11, 12), which reduces the ability to assess the long-term predictability. When considering that the cumulative survival of tooth autotransplantation changes over time (11, 12), a longer follow-up period is required to properly assess the influence of related prognostic factors.

In addition, most studies analyzed the prognostic factors related only to tooth survival, but other clinical outcomes, such as inflammatory root resorption (IRR) and

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REVIEW

Transplantation of Cryopreserved Teeth: A Systematic Review

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Abstract

The aim of this article was to examine the research articles regarding biological and mechanical properties of cryopreserved teeth for potential use in tooth transplantation.

A systematic review of literatures was performed by Pubmed searching with assigned key words from January 1, 1990 to June 8, 2009. All articles were examined for inclusion criteria. Secondary search was conducted by hand-search through references of included articles from primary search.

A total of 24 articles were obtained from both primary and secondary search and used as fundamental articles in this review. Periodontal ligament tissues of cryopreserved teeth were able to maintain their biological properties resulted in a satisfactory healing of periodontium. Dental pulp tissues, however, may be compromised by limitation of permeability of cryopreservative agent into pulp cavity. Therefore, an endodontic treatment of transplanted cryopreserved teeth was recommended. Cryopreserved teeth had comparable mechanical properties to those of normal teeth. Importantly, the success of cryopreserved tooth transplantation treatment in orthodontic patients was reported.

The cryopreserved teeth for tooth banking have a potential clinical application for treatment of missing teeth. Case selection, however, is critical for treatment success. More studies and data regarding masticatory function and periodontal healing of transplanted cryopreserved teeth are needed.

Keywords cryopreservation, transplantation, teeth

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Introduction

Recently, methods have been reported in a number of studies for growing biological teeth in the laboratory to replace missing teeth (Ohazama *et al*., 2004; Yen and Sharpe 2006; Ferreira *et al*., 2007; Duailibi *et al*., 2008; Abukawa *et al*., 2009; Zhang *et al*., 2009). Cells isolated from tooth buds seeded on biodegradable scaffolds are able to form tooth-like structures containing dentin-pulp complex, enamel and cementum (Young *et al*., 2002). The sequential seeding of epithelial and mesenchymal cells has been used to improve the ability to control morphology of bioengineered teeth. Upon transplantation of the bioengineered tooth in extracted socket, reinnervation and revascularization have been observed in the dental pulp of bioengineered teeth (Nakao *et al*., 2007). The eruption and function of bioengineering molar tooth germ in oral cavity was recently reported (Ikeda *et al*., 2009). These data strongly suggest the potential for tooth replacement using biological engineered teeth. The success observed in these studies, however, is still limited by the lack of embryonic cell source and the difficulty in engineering complex tooth morphology (*e.g*., molar teeth).

In addition to conventional prosthetic and dental implants, autotransplantation is an alternative treatment for treating missing teeth. Case selection plays a crucial role, however, in the success of transplantation. A seventy-nine percent success

Case Report

A case of tooth autotransplantation after long-term cryopreservation using a programmed freezer with a magnetic field

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ABSTRACT

This case report describes the treatment of a skeletal Class III malocclusion with autotransplantation of a cryopreserved tooth. To gain an esthetic facial profile and good occlusion, extraction of bimaxillary premolars and surgical therapy were chosen. The patient had chronic apical periodontitis on the lower left first molar. Although she did not feel any pain in that region, the tooth was considered to have a poor prognosis. Therefore, we cryopreserved the extracted premolars to prepare for autotransplantation in the lower first molar area because the tooth would probably need to be removed in the future. The teeth were frozen by a programmed freezer with a magnetic field (CAS freezer) that was developed for tissue cryopreservation and were cryopreserved in −150°C deep freezer. After 1.5 years of presurgical orthodontic treatment, bilateral sagittal split ramus osteotomy was performed for mandible setback. Improvement of the facial profile and the occlusion were achieved in the retention phase. Six years after the initial visit, the patient had pain on the lower left first molar, and discharge of pus was observed, so we extracted the lower left first molar and autotransplanted the cryopreserved premolar. Three years later, healthy periodontium was observed at the autotransplanted tooth. This case report suggests that long-term cryopreservation of teeth by a CAS freezer is useful for later autotransplantation, and this can be a viable technique to replace missing teeth. (*Angle Orthod.* 2015;85:518–524.)

KEY WORDS: Autotransplantation; Cryopreservation; Programmed freezer; Magnetic field

INTRODUCTION

Autotransplantation of teeth is useful procedure for recovering occlusal function by replacing missing teeth. Unnecessary wisdom teeth and teeth extracted for orthodontic treatment are mainly used as donor teeth. Autotransplanted teeth can regenerate the alveolar bone of the socket through the osteoinduction ability of periodontal ligament (PDL) cells.[1,2] This treatment is reliable and associated with good outcomes.[3] However, sometimes patients may not have an available donor tooth because it was previously extracted. To solve this problem, teeth cryopreservation systems have been developed. Many clinical

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Prognostic factors for autotransplantation of teeth with complete root formation

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Objectives. The aim of the present study was to evaluate the factors affecting the prognosis of the autotransplantation of teeth with complete root formation.
Study Design. A total of 259 transplanted teeth were studied. The significance of each of the prognostic factors was examined in 2 ways, first in a univariate analysis and then in a multivariate analysis. The comprehensive risk combining these factors that remained after multivariate analysis was calculated.
Results. Among 259 transplanted teeth, 27 (10.4%) were judged as unsuccessful cases. In the multivariate analysis, history of root canal treatment of donor tooth, multirooted, maxillary tooth as a donor, and duration of tooth absence at recipient site remained significantly associated with unsuccessful transplantation. Multifarious combination of the significant prognostic factors can decrease the comprehensive risk.
Conclusions. Minimizing the comprehensive risk by combining significant prognostic factors improved the prognosis of autotransplantation of teeth with complete root formation. (Oral Surg Oral Med Oral Pathol Oral Radiol 2012;114(suppl 5): S216-S228)

Many recent studies have reported on the development of tissue-engineered teeth[1-3]; however, it appears that there are still many difficulties in the clinical application of tissue-engineered teeth for replacement of missing teeth owing to the complexities of dental morphology and function. Conventional prosthetic treatment, dental implants, and tooth autotransplantation are considered as solutions for occlusal problems after tooth loss. In particular, tooth autotransplantation is a promising procedure for occlusal rehabilitation, as the transplanted tooth can function as a normal tooth following successful transplantation.[4] A large number of clinical studies on immature tooth transplantation have evaluated root development, pulpal healing, and root resorption after autotransplantation.[5-8] Autotransplantation of teeth with complete root formation is indicated for replacement of 1 or more teeth lost as a result of dental caries or periodontitis in adult patients and successful autotransplantation of teeth with complete root formation has been reported.[9-12] However, autotransplantation of teeth with complete root formation sometimes fails; therefore, the main factors affecting prognosis of tooth autotransplantation in adult patients should be investigated.

Since 1994, the authors have performed more than 50 autotransplantations of teeth with complete root formation annually at Niigata University Medical and Dental Hospital, and have evaluated their prognosis and prognostic factors.[13,14] We reported that the major causes for unsuccessful autotransplantation of teeth with complete root formation were failure of initial healing and replacement root resorption with periodontal inflammation. Furthermore, pocket depth and a history of root canal treatment of donor teeth appeared to increase the risk of unsuccessful transplantation statistically.[14] It is still not clear how these factors influence the prognosis of tooth autotransplantation, however,

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Commentary

A Translational Medicine Approach to Tooth Transplantation

Giovanpaolo Pini Prato,* Giliana Zuccati,* and Carlo Clauser*

The autogenous tooth transplantation approach to replace missing teeth has been in use for a long time. Different surgical techniques have been developed to improve prognosis and longevity of transplanted teeth with complete root formation. Many factors reportedly affected short- and long-term success of the procedure: complications such as ankylosis and root resorption up to the tooth exfoliation have occurred frequently. Several studies have appeared on this issue over the years. However, outcomes of transplantations have not yet been conclusively determined as no randomized clinical trials have been published on this issue, and their effectiveness has been evaluated only in observational studies. On the other hand, interesting information from specific experimental studies on the healing pattern of the interface between the root surface and alveolar bone in the replantation/transplantation model, and from nonrelated studies dealing with mechanically induced periodontal trauma, has been available and potentially useful since the 1970s to 1980s. However, this information has not been incorporated into clinical literature regarding tooth autotransplantation. This commentary aims to show how information from related and unrelated experimental models was translated to a clinical setting and led to a novel approach, successfully applied, in the autotransplantation of a multirooted tooth with completed root formation. J Periodontol 2017;88:519-525.

KEY WORDS

Oral surgical procedures; orthodontics; periodontal ligament; translational medicine; transplantation.

TRANSLATIONAL MEDICINE

Translational medicine, a rapidly growing discipline in biomedical research, may help in making clinical decisions when conclusive clinical evidence is not yet available. Translational medicine is defined as "effective translation of the new knowledge, mechanisms, and techniques generated by advances in basic science research into new approaches for prevention, diagnosis, and treatment of disease, essential for improving health."[1] It would be a tremendous waste not to "translate efficiently the scientific discoveries of the past generation into tangible human benefit."[2] The National Institutes of Health has made translational research a priority, funding about 60 centers in the United States with a budget of $500 million per year; at least two journals (*Translational Medicine* and the *Journal of Translational Medicine*) are devoted to the issue. Sung et al.[2] indicated that several factors, such as "high costs, slow results, lack of funding, regulatory burdens, fragmented infrastructure, incompatible databases, and a shortage of qualified investigators and willing participants" have contributed to generating two major obstacles. These obstacles, so-called "translational blocks," have prevented or avoided the translation of basic science discoveries into clinical studies (T1) and clinical studies into medical practice and health decision-making in systems of care (T2).[3] Therefore, the main goal of translational medicine is to allow and accelerate translation of discoveries from the "bench to the bedside," overcoming roadblocks to improve the global health care system significantly.

This commentary aims to describe how a clinical case of molar autotransplantation in a 23-year-old woman, treated in 1996 on the basis of previous periodontal experimental studies, was fully successful after 20 years. This offers a positive ante litteram example of translational medicine in periodontics.

LITERATURE

What Was Known in the 1970s to 1990s

Many technical/surgical approaches had been published with detailed descriptions of site preparation,

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Clinical Paper
Oral Surgery

Autotransplantation of third molars with completely formed roots into surgically created sockets and fresh extraction sockets: a 10-year comparative study

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H. J. Yu, P. Jia, Z. Lv, L. X. Qiu: Autotransplantation of third molars with completely formed roots into surgically created sockets and fresh extraction sockets: a 10-year comparative study. Int. J. Oral Maxillofac. Surg. 2017; 46: 531–538.

Abstract. The aim of this study was to analyze and compare the long-term clinical outcomes of mature third molar autotransplantation in surgically created sockets and fresh extraction sockets with regard to survival and functional success rates. A total of 65 third molars with completely formed roots were autotransplanted in 60 patients (average age 33.1 years). Thirty-six of the teeth were autotransplanted into surgically created sockets with or without guided bone regeneration (GBR; delayed autotransplantation), while 29 were autotransplanted into fresh extraction sockets (immediate autotransplantation; control group). All patients underwent annual clinical and radiographic examinations (average follow-up 9.9 years, range 7–13 years). The survival rates for the control, GBR, and no GBR groups were 93.1%, 95.2%, and 80.0%, respectively, with no significant differences among the groups. There were no statistically significant differences among the groups with regard to the frequency of inflammatory root resorption or root ankylosis. Age did not influence the clinical outcomes. These results suggest that the autotransplantation of third molars with completely formed roots is effective in both surgically created and fresh extraction sockets and provides a high long-term success rate if cases are selected and treated appropriately.

Key words: tooth autotransplantation; complete root formation; guided bone regeneration; third molars; extraction socket.

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Clinical Paper
Oral Surgery

Clinical study on prognostic factors for autotransplantation of teeth with complete root formation

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T. Sugai, M. Yoshizawa, T. Kobayashi, K. Ono, R. Takagi, N. Kitamura, T. Okiji, C. Saito: Clinical study on prognostic factors for autotransplantation of teeth with complete root formation. Int. J. Oral Maxillofac. Surg. 2010; 39: 1193–1203.

Abstract. Autotransplantation is often performed to replace a missing tooth, but tooth autotransplantation has been reported in fewer teeth with complete root formation than those with incomplete root formation. The aim of this prospective study was to evaluate the factors that affect the prognosis of autotransplantation of teeth with complete root formation. 109 patients with 117 transplants were studied. Of the 117 transplants investigated, 14 (12%) failed during the observation period. The overall 1-year survival rate was 96%; the 5-year survival rate was 84%. The major causes of failure were unsuccessful initial healing and replacement root resorption with periodontal inflammation. Factors significantly associated with unsuccessful transplantation, in single factor analysis, were age 40 years or more, molar tooth as donor, probing pocket depth to 4 mm or more, history of root canal treatment, multi-rooted teeth and fixation with sutures. Pocket depth of 4 mm or more and history of root canal treatment appeared to increase the risk of unsuccessful transplantation in multivariate analysis. It is suggested that the pocket depth of the donor tooth and history of root canal treatment are related to the healing of paratransplantal tissue and root resorption.

Keywords: Tooth autotransplantation; Complete root formation; Prognostic factor

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Tooth autotransplantation is a viable option for replacing a missing tooth because the transplanted tooth can function as a normal tooth when tooth transplantation is successful. The prognosis of an autotransplanted tooth is influenced by pre- and per-operative conditions, which are recognized as prognostic factors. A large number of clinical studies on tooth autotransplantation have been conducted, but most of them reported the transplantation of teeth with incomplete roots and focused on factors such as the developmental and eruption stage of the donor tooth, root development, pulpal healing and root resorption of the transplanted tooth[6,8,12,15–17,19].

The autotransplantation of teeth with complete root formation necessitates endodontic treatment within 3–4 weeks to avoid pulp infection followed by periradicular inflammation and subsequent inflammatory root resorption because revascularization of the pulp is not normally expected after tooth transplantation[10,24]. The prognostic factors for the autotransplantation of teeth with complete root formation should be investigated dif-

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Virtual Simulation of Autotransplantation Using 3-dimensional Printing Prototyping Model and Computer-assisted Design Program

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Abstract

This case report describes an innovative virtual simulation method using a computer-aided rapid prototyping (CARP) model and a computer-aided design (CAD) program for autotransplantation of an immature third molar.A compromised left mandibular second molar (#18) was extracted and replaced by autotransplantation using an immature left mandibular third molar (#17). In order to minimize the surgical time and injury to the donor tooth, a virtual 3-dimensional (3D) rehearsal surgery was planned. Cone-beam computed tomographic images were taken to fabricate the 3D printing CARP model of the donor tooth and tentative extraction socket. Subsequently, both CARP models were scanned with an intraoral scanner (CEREC Omnicam; Dentsply Sirona, Bensheim, Germany) followed by superimposition and virtual simulation of osteotomy preparation of the recipient alveolus using the CAD analysis program. During the surgery, the extraction socket was precisely prepared according to the predetermined location and dimensions via virtual simulation rehearsal surgery using CAD analysis. The donor tooth was atraumatically transplanted into the prepared socket. The follow-up examination revealed that the root developed with a normal periodontal ligament and lamina dura.Virtual simulation using a 3D printing CARP model and a CAD program could be clinically useful in autotransplantation of an immature third molar by ensuring an atraumatic and predictable surgery. (*J Endod* 2018;44:1883–1888)

Key Words

Autotransplantation, computer-aided design, computer-aided rapid prototyping, immature third molar, virtual simulation

Significance

Using a computer-aided design program and 3D printing prototyping models, autotransplantation can be virtually simulated before surgery. This new virtual simulation technique could be a clinically feasible option for minimally invasive and predictable endodontic surgery.

Since its introduction in the 1980s, computer-aided design/computer-aided machining (CAD/CAM) technology in restorative dentistry has been extended to various dental fields, such as the fabrication of trays for indirect bonding of orthodontic brackets, guided implant surgery, and surgical guides for orthognathic surgery (1–3). Furthermore, the accuracy of optical impressions using intraoral scanners and the precision of the dental milling process have improved over decades (4). Recently, 3-dimensional (3D) printing and CAD/CAM technology have been applied in the endodontic field for various tasks such as navigation of a calcified canal for anatomic anomalous teeth (5) and guided osteotomy in endodontic microsurgery (6).

The clinical application of a computer-aided rapid prototyping (CARP) model for autotransplantation was first introduced in 2001 using 3D computed tomographic (CT) image acquisition followed by fabrication of a 3D printing copy model (7). This technique allowed surgeons to simulate the contour of the recipient bone using the actual-sized CARP models of donor teeth and recipient alveolar bones preoperatively. Using CARP models for autotransplantation has an advantage of minimized extra-alveolar time and trauma to the donor tooth, thereby increasing the success rate of the surgery (8). The survival rates for the conventional autotransplantation technique using teeth with mature roots vary from 59%–81% at 4 years and 59.6% at 10 years (9–11). CARP models improve survival rates for teeth with mature roots to 88.1% and 68.2% at 3 and 12 years, respectively (8). This improvement is more pronounced when donor teeth with immature roots are used (12).

Several clinical trials and case reports have described autotransplantation using a CARP model (7, 12–14). However, there are no reports regarding the clinical application of 3D printing and CAD technology for treatment planning for endodontic surgery through virtual simulation. This study describes a novel method of virtual 3D rehearsal simulation for treatment planning before autotransplantation surgery of immature third molar teeth using 3D printing models and a CAD analysis program.

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Computer-aided autotransplantation of teeth with 3D printed surgical guides and arch bar: a preliminary experience

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ABSTRACT

Background/Aim: Autotransplantation of teeth is a method to restore the missing teeth and computer-aided techniques have been applied in this field. The aim of this study was to describe a novel approach for computer-aided autotransplantation of teeth and to preliminarily assess its feasibility, accuracy, and stability.
Methods: Eight wisdom teeth with complete root formation of eight adult patients were autotransplanted. Individual replicas of donor teeth with local splints, surgical templates, and arch bars were virtually designed and fabricated using three-dimensional printing, these were then applied in the autotransplantation surgeries. Clinical and radiological outcomes were observed, the extra-alveolar time, success rate, and 1-year survival rate were analyzed, and accuracy and stability of this approach were evaluated.
Results: The extra-alveolar time of donor teeth were less than 3 min. The average follow-up duration was 2.00 ± 1.06 years. All autotransplanted teeth showed normal masticatory function. Ankylosis was found in one patient, and the overall success rate was 87.5%, whereas the 1-year survival rate was 100%. Linear differences between the designed and the immediate autotransplanted positions at crowns and apexes of the donor teeth were 1.43 ± 0.57 and 1.77 ± 0.67 mm, respectively. Linear differences between immediate and the stable positions at crowns and apexes of the donor teeth were 0.66 ± 0.36 and 0.67 ± 0.48 mm, respectively.
Conclusion: The present study illustrated the feasibility, clinical satisfied accuracy, and stability of a novel approach for computer-aided autotransplantation of teeth. This new approach facilitated the surgical procedure and might be a viable and predictable method for autotransplantation of teeth.

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Additional Information and Declarations can be found on page 10

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Subject Dentistry
Keywords Autotransplantation of teeth, Computer-aided surgical simulation, Surgical guide, Three-dimensional printing

INTRODUCTION

As a valuable method for restoring missing teeth, autotransplantation of teeth has been used in clinical practice for over 60 years (*Cross et al., 2013*; *Jang, Lee & Kim, 2013*).

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Clinical application of computer-aided rapid prototyping for tooth transplantation

Lee S-J, Jung I-Y, Lee C-Y, Choi SY, Kum K-Y. Clinical application of computer-aided rapid prototyping for tooth transplantation. Dent Traumatol 2001; 17: 114–119. © Munksgaard, 2001.

Abstract – The maintenance of healthy periodontal ligament cells in the donor tooth is one of the most important factors for successful tooth transplantation. This is achieved by minimizing the extra-oral time during the surgical procedure. If a duplicate form of donor tooth could be obtained before extraction, it would be possible to precontour the recipient alveolar bone compatible with the donor tooth, and thereby reduce the extra-oral time of the donor tooth. We obtained a three-dimensional image with the real dimensions of the donor tooth from a CT Highspeed Advantage™, allowing a life-sized resin model of the tooth to be fabricated. From 22 clinical cases, we achieved an average total transplantation time of 7.7 min. The average distance between the transplanted root surface and the alveolar bone from 12 available cases was 0.87 mm at the mesial cervix, 0.91 mm at the mesial apex, 0.98 mm at the distal cervix and 1.16 mm at the distal apex on the postoperative radiographs. Clinical data indicate that computer-aided rapid prototyping may be of value in minimizing the extra-oral time and possible injury to transplanted tooth during the process of autotransplantation.

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Key words: autotransplantation; computer aided-rapid prototyping; donor tooth; extra-oral time; resin model

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Autotransplantation is a viable option for the treatment of a missing tooth or for replacement of avulsed and traumatized tooth when there is a donor tooth available. The presence of intact and viable periodontal ligament cells on the root surface of the donor tooth is the most critical factor in the healing of autotransplanted tooth (1). The extra-oral time of the donor tooth significantly affects the viability of periodontal ligament cells and, therefore, extended extra-oral time of the donor tooth results in severe damage to the periodontal ligament cells and subsequent root resorption (2). Another important factor in autotransplantation is the distance between the recipient site tissue and the root surface of the transplanted tooth. Optimal contact with the recipient site can improve blood supply and nutrition to the periodontal ligament cells, and thereby increase the success rate of the autotransplantation procedure (3).

The purpose of this study was, firstly, to minimize the extra-oral time and, secondly, to achieve optimal contact between the donor tooth and the recipient site in the autotransplantation procedure using computer-aided rapid prototyping.

Material and methods

Material

A total of 22 patients (13 males and 9 females) aged between 27 and 58 years were included in this study. All patients were in good health with no known systemic diseases. Patients were informed about the potential benefits and risks of the procedure and the other treatment options such as conventional prosthodontics or implants, and consent was obtained in all cases.

Methods

Pre-surgical procedures

Pre-examination of the donor tooth and the recipient site. A careful pre-examination was first made of the donor tooth

Armin Andreas Sokolowski, Alwin Alan Sokolowski, Julian Kammerhofer, Corina Theresia Madreiter-Sokolowski, Michael Payer, Martin Koller, Norbert Jakse, Walther Alfred Wegscheider

Accuracy assessment of 3D-printed tooth replicas

Abstract

Aim: The production of individual tooth replicas has two applications in dental practice: tooth autotransplantations and dental root analogue implants. These applications require a particularly high degree of precision. The purpose of this study was to establish and evaluate a method for fabricating individual 3D-printed tooth replicas.

Materials and methods: 10 patients requiring extraction of a wisdom tooth and a preoperative cone beam computed tomography (CBCT) scan were included; exclusion criteria were intraoperative fragmentation or fracture of the tooth. 3D Slicer 4.6.2 was used for tooth segmentation and model generation based on CBCT data. The tooth replicas were manufactured by selective laser melting (SLM). The extracted teeth and 3D-printed replicas were scanned and tested for surface deviations in CloudCompare 2.8.1.

Results: The mean absolute surface deviation between the 3D-printed teeth and the corresponding extracted teeth ranged from 0.13 to 0.25 mm, with standard deviations of 0.10 to 0.21 mm; 95% of the measured surface points deviated less than 0.474 mm; the surface area was reduced by -6.0% and the volume by -3.4%. The root mean square was 0.238 mm and the mean maximum absolute surface deviation was 0.927 mm. The SLM technique showed a high precision with a mean absolute deviation of 0.045 mm and a standard deviation of 0.04 mm.

Conclusion: 3D-printed tooth replicas with a very high accuracy could be produced based on CBCT data. The described method is suitable for manufacturing tooth replicas for use in tooth autotransplantations or for fabricating root analogue implants.

Keywords: *3D printing, rapid prototyping, selective laser melting, tooth replicas, cone beam computed tomography, autologous tooth transplantation, root analogue implants, implantology*

Introduction

The term 3D printing refers to a wide range of rapid prototyping techniques developed in recent years that are indispensable in many areas of industrial production technology and biomedical engineering.[1,2] 3D printers represent the most important subclass of additive manufacturers and are used for the production of models and prototypes, especially for workpieces that require only small quantities. The technology is therefore particularly well qualified for the manufacturing of dental workpieces, including 'biomodels' for the visualization of anatomical structures, templates for guided surgery, and the production of individual dentures such as 3D-printed implants and prosthetic restorations.[3,4] The production of individual and precise tooth replicas has two concrete applications in everyday dental practice: tooth autotransplantations and dental implantology using dental root analogue implants.[5,6] Several published studies have proposed different methods for using prefabricated replicas as a template during tooth transplantations, thereby saving the original donor tooth from repeated fitting attempts at the recipient site; this reduces extraoral time and further increases the success rate of tooth transplantations.[6-13] The possibility of producing patient-specific root analogue implants by means of the metal laser sintering technique offers new treatment possibilities after tooth extractions.[5,14] The first successful case reports show promising clinical results; however, this technology-sensitive method requires a particularly high degree of precision in the production process of the root analogue implants.[15-17]

The purpose of this study was to establish and evaluate a method for fabricating an individual 3D-printed tooth replica to simplify the surgical procedure and improve the clinical outcome of tooth autotransplantations. Furthermore, the precision of rapid prototyping a tooth analogue based on CBCT data is analyzed with regard to dental root analogue implants.

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Case Report

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Autotransplantation of Impacted Third Molar Using 3D Printing Technology: A Case Report

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Abstract

Here, we describe a case of autotransplantation of a mandibular horizontally impacted third molar using a 3-dimensional (3D) model based on limited cone-beam computed tomography (CBCT) images for diagnosis, 3D morphological evaluation, preoperative treatment planning, and surgical simulation. A 27-year-old woman visited this hospital for conservative treatment of the mandibular left second molar. Intraoral radiography and CBCT images revealed a C-shaped root canal in the mesial root, and compressive resorption of the distal root due to impingement of the crown of the horizontally impacted lower left third molar. Extraction was therefore planned. Multiple tooth-jaw bone 3D models for preoperative diagnosis were fabricated using a low-cost desktop 3D printer and surgical simulation of autotransplantation performed. The autotransplantation was then performed accordingly. Cone-beam computed tomography images and 3D models were extremely useful in obtaining a stereoscopic understanding of the morphology of the transplanted tooth and its surrounding anatomical structures. At the one-year postoperative recall, the patient was able chew with the transplanted tooth without pain, and no significant abnormalities were detected on intraoral radiographs, indicating a successful postoperative clinical course. Our experience of using 3D models fabricated based on CBCT images using a desktop 3D printer for preoperative diagnosis and surgical simulation suggests that this technique is useful in tooth autotransplantation.

Key words: Autotransplantation — 3D printing — Desktop 3D printer — Computer-aided manufacturing

Introduction

Three-dimensional (3D) models can be checked both visually and tactually, making it easier to grasp positional relationships within the structure represented than with a 3D display on a computer monitor. In the oral and maxillofacial field, such 3D models are used

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Fully functional bioengineered tooth replacement as an organ replacement therapy

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ABSTRACT

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Current approaches to the development of regenerative therapies have been influenced by our understanding of embryonic development, stem cell biology, and tissue engineering technology. The ultimate goal of regenerative therapy is to develop fully functioning bioengineered organs which work in cooperation with surrounding tissues to replace organs that were lost or damaged as a result of disease, injury, or aging. Here, we report a successful fully functioning tooth replacement in an adult mouse achieved through the transplantation of bioengineered tooth germ into the alveolar bone in the lost tooth region. We propose this technology as a model for future organ replacement therapies. The bioengineered tooth, which was erupted and occluded, had the correct tooth structure, hardness of mineralized tissues for mastication, and response to noxious stimulations such as mechanical stress and pain in cooperation with other oral and maxillofacial tissues. This study represents a substantial advance and emphasizes the potential for bioengineered organ replacement in future regenerative therapies.

Keywords: regenerative therapy, transplantation

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Practical whole-tooth restoration utilizing autologous bioengineered tooth germ transplantation in a postnatal canine model

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Abstract

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Whole-organ regeneration has great potential for the replacement of dysfunctional organs through the reconstruction of a fully functional bioengineered organ using three-dimensional cell manipulation *in vitro*. Recently, many basic studies of whole-tooth replacement using three-dimensional cell manipulation have been conducted in a mouse model. Further evidence of the practical application to human medicine is required to demonstrate tooth restoration by reconstructing bioengineered tooth germ using a postnatal large-animal model. Herein, we demonstrate functional tooth restoration through the autologous transplantation of bioengineered tooth germ in a postnatal canine model. The bioengineered tooth, which was reconstructed using permanent tooth germ cells, erupted into the jawbone after autologous transplantation and achieved physiological function equivalent to that of a natural tooth. This study represents a substantial advancement in whole-organ replacement therapy through the transplantation of bioengineered organ germ as a practical model for future clinical regenerative medicine.

RESPONSABILIDAD SOCIAL

El presente trabajo cumple con los criterios de sostenibilidad medioambiental y económica.

La realización de un tratamiento de autotrasplante dental supone una disminución del uso de materiales como la resina, porcelana, zirconio y titanio (comúnmente utilizados en prótesis e implantología). Además supone una reducción significativa en el costo para el paciente.