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TRABAJO DE FIN DE GRADO

Grado en Odontología

REHABILITACIÓN MEDIANTE IMPLANTES CORTOS A NIVEL MANDIBULAR EN CASOS DE ATROFIAS SEVERAS

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Resumen

Propósito: Los implantes cortos tienen la desventaja de aumentar la proporción corona-implante, lo que hace que los odontólogos sean reacios a su uso. El siguiente estudio evalúa la viabilidad de los implantes cortos en las mandíbulas atróficas, comparándolos con los implantes estándares colocados en un hueso regenerado quirúrgicamente.

Métodos: El estudio de varios artículos científicos ha sido diseñado para analizar la tasa de éxito, la tasa de fracaso, las complicaciones, la pérdida ósea peri-implante y la influencia de la proporción corona-implante aumentada de los implantes cortos.

Resultados: 613 implantes (383 cortos y 230 estándares) fueron colocados en 290 pacientes cuya edad media era de 56,2 años. Los implantes cortos tienden a ser definidos por implantes de longitud inferior o igual a 8 mm. Las tasas de éxito encontradas en el sector posterior de las mandíbulas atróficas para los implantes cortos y los implantes estándares en un hueso regenerado quirúrgicamente son respectivamente, 95,20% y 98,50%, a los 4,5 años. No hubo diferencia significativa acerca de la estabilidad primaria de los implantes. Los implantes estándares tuvieron 57 casos de complicaciones mientras que los implantes cortos presentaron solo 20. La perdida ósea peri-implante es menos llamativa a largo plazo en el grupo de los implantes cortos.

Conclusiones: Los implantes cortos ofrecen a los pacientes un tiempo de tratamiento, una morbilidad y una incidencia de complicaciones reducidos. Su tasa de éxito es buena así que representan una alternativa terapéutica fiable cuando el hueso mandibular residual es insuficiente para la colocación de un implante estándar. El aumento de la proporción corona-implante permite estimular la osteogénesis al nivel coronal del implante y reducir la pérdida ósea peri-implante. Los estudios publicados a largo plazo son alentadores acerca de la viabilidad de esta técnica.

Palabras claves: Implantes cortos, Mandíbula atrófica, Tasa de éxito, Complicación, Hueso regenerado.

Abstract

Purpose: Short implants have the disadvantage of increasing the crown-to-implant ratio, which makes dentists reluctant to use them. The following study evaluates the relevance of short implants in atrophic mandibles compared to standard implants placed in surgically regenerated bone.

Methods: A literature review was done to analyze the success rate, failure rate, complications, implant marginal bone loss and the influence of the increased crown-to-implant ratio of short implants.

Results: 613 implants (383 shorts and 230 standards) were placed in 290 patients whose average age was 56.2 years. Short implants tended to be defined by a length being less than or equal to 8 mm. The success rates found in the posterior sector of atrophic mandibles for short implants and in the standard implants in surgically regenerated bone are respectively 95.20% and 98.50% after 4.5 years. There was no significant difference in the implant's primary stability. Standard implants had 57 complications while short implants had only 20. Peri-implant bone loss is less frequent in the long term for the short implant group.

Conclusions: Short implants offer patients a reduced treatment time with less morbidity and fewer complications. Their success rate is high and they are a good therapeutic alternative when residual bone does not allow the placement of a standard implant. The increased crown-to-implant ratio stimulates osteogenesis at the coronal level of the implant and reduces peri-implant bone loss. The published long-term studies are encouraging when it comes to the viability of this technique.

Keywords: Short implant, Atrophic mandible, Success rate, Complication, Regenerative bone.

En primera instancia, agradezco a mi tutor de trabajo y profesor en la Universidad Europea de Madrid por haber sugerido la realización de este trabajo y por su constante disponibilidad para que este último fuera lo más interesante posible.

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1) Introducción

1.1 Evolución en implantología

Los implantes dentales vivieron una evolución tremenda desde su creación, cuya fecha es imposible determinar con exactitud, ya que arqueólogos consiguieron encontrar trazas de implantes dentales desde las civilizaciones antiguas Mayas y Egipcianas.

Existen varios precursores de los implantes dentales como Greenfield y su conocido implante de iridio y oro en forma de cesta. Sin embargo, el mundo de la implantología evolucionó de golpe gracias a los estudios de Brånemark en los años 1950. Los implantes pasaron de un uso exclusivo en la parte anterior de la mandíbula a un uso rutinario a lo largo de las crestas alveolares. Con los años la longitud de los implantes se redujo, convirtiendo los implantes dentales de 16 milímetros (mm) en obsoletos(1).

<u>Figura 1:</u> Implante en cesta de Greenfield. Imagen sacada del libro *Implantes cortos* de Tomasetti BJ y Ewers R.

La colocación de un implante de longitud estándar representa un tratamiento seguro con resultados predecibles y una tasa de éxito a largo plazo de 98%(1). A pesar de ello, su colocación puede estar comprometida por las reabsorciones óseas verticales y longitudinales que tienen lugar en los maxilares(2)(3)(4). En 1998, Cawood y Howell mostraron que la pérdida ósea vertical al nivel mandibular es muy llamativa desde los primeros momentos. Durante el primer año, la altura del cuerpo de la mandíbula sufre una atrofia de 4 a 6 mm. A pesar de ello, los años siguientes la

perdida disminuye a 0,4 mm al año[5]. Otros autores hablan de una pérdida del 22% del hueso alveolar en sentido horizontal y vertical durante los seis primeros meses[6]. Para solucionar este problema, se descubrieron técnicas quirúrgicas avanzadas como la transposición del nervio dentario inferior o las regeneraciones óseas mediante xeno o autoinjertos[7], cuyas tasas de éxito aumentan con el tiempo[8]. Estas técnicas, usadas desde 40 años en las mandíbulas[3], se conocen como la regeneración ósea guiada, el injerto en bloque (que sea de tipo onlay o inlay), la distracción osteogénica y el uso de factores de crecimiento[1][3][4][7][9][10][11][12].
En cambio, la composición del hueso mandibular (tipo 2-3, según la clasificación de Lekholm y Zarb, que se define como una capa bastante gruesa de hueso compacto y un núcleo homogéneo y favorable de hueso esponjoso) y la presencia de inserciones musculares en su parte interna como puede ser la del músculo milohioideo confiere a la regeneración ósea mandibular una cierta morbilidad y una tasa de éxito reducida[9]. Además, se vio que las regeneraciones óseas extensas tenían un pronóstico comprometido en virtud a la cantidad reducida de sangre que llegaba a los extremos de la regeneración[5]. Es evidente que la colocación de membranas colágenas reabsorbibles ayuda a mejorar el resultado, aunque no resulta suficiente en un gran de número de casos[7].

Gracias a la constante voluntad de simplificar y mejorar la calidad de los tratamientos ofrecidos a los pacientes, surgió una alternativa terapéutica a las cirugías citadas, cuyo nombre es el implante corto[8]. Este avance en la implantología sigue al movimiento de la Odontología mínimamente invasiva[1] y responde a la demanda poblacional de desarrollar tratamientos con morbilidad, coste y tiempos reducidos[2].

Aunque fueron considerados menos efectivos por muchos profesionales de la odontología que los implantes largos[13][14], los estudios actuales muestran una gran mejora acerca de sus tasas de éxito. Este progreso se debe sobre todo a la evolución, durante los últimos años, del diseño y del tratamiento de la superficie de los implantes[2][12][15][16].

Los implantes cortos pasaron de tener unas superficies mecanizadas lisas a unas rugosas. Este cambio es clave para lograr una estabilidad primaria satisfactoria[17], que representa, según Brånemark, un requisito para que un implante se osteointegre correctamente[5].

Los implantes estándares representaban también la mejor opción terapéutica en vista a su capacidad de mantener una baja proporción corona-implante que aseguraba una mayor disipación de las fuerzas oclusales y una mayor longevidad a los implantes[2][12][14]. Sin embargo, los inconvenientes que existen al disminuir la longitud intraósea de los implantes, consiguen ser corregidos con el aumento de la microrugosidad de la superficie del implante[2][14][18].

Estas novedades permitieron mostrar que los implantes cortos merecían ser estudiados con más profundidad y que la costumbre de los implantólogos a lograr el menor ratio corona-implante posible en sus tratamientos, no era necesario[4][19].

1.2. Definición y clasificaciones

Un implante aloplástico dental es un material extraño al organismo, no metabolizable, que se inserta quirúrgicamente en un alvéolo natural, artificial o subperióstico y que reacciona con el hospedador para restaurar una función perdida.

No existe todavía un consenso que defina los implantes en función de su longitud o de su diámetro[(3)(10)(12)(14)(18)(20)(21)]. Cada autor y cada marca comercial entiende por implante corto, un implante de longitud diferente. En función de los autores, un implante puede ser considerado corto en cuanto su longitud no exceda 6, 7, 8 o 10 mm[(11)(12)(21)].

Aunque no exista una definición aceptada por la mayoría de los autores, es interesante apreciar que en los artículos más recientes, tienden a considerar un implante corto, cuando este último mide 8 mm o menos[(12)(14)].

La definición de un implante corto evoluciona con los años. Una clasificación, hoy en día obsoleta, era propuesta por S. Al-Johany y cols en 2016. Esta misma clasifica a los implantes en función de su longitud (distancia entre la parte más apical del implante y el cuello, sin tomar en cuenta el tamaño de la cabeza del implante) y de su diámetro (anchura del cuello del implante). Con respecto a los artículos más recientes, esta clasificación, disponible en la Tabla 1, ya no es válida puesto que habla de implantes cortos cuando miden entre 6 y 10 milímetros de longitud[(21)].

Tabla 1: Clasificación obsoleta de los implantes cortos según su tamaño.

Clasificación según la longitud	Clasificación según el diámetro
Ultra corto: ≤ 6 mm Corto: > 6 mm a < 10 mm Estándar: 10 mm a < 13 mm Largo: ≥ 13 mm	Ultra fino: < 3 mm Fino: de 3 mm a < 3,75 mm Estándar: de 3,75 a < 5 mm Ancho: ≥ 5 mm

Existen también clasificaciones para poder hablar con mucha claridad de las mandíbulas atróficas en función de la altura del cuerpo de la mandíbula en mm(5):

- Clase I: de 16 a 20 mm
- Clase II: de 11 a 15 mm
- Clase III: inferior o igual a 10 mm

1.3 Características de los implantes cortos

El diseño de los implantes cortos es considerado clave para obtener resultados clínicos fiables a corto y largo plazo(14)(17). Las siguientes características permiten aumentar la estabilidad primaria del implante y repartir más homogéneamente las fuerzas y por consiguiente poder reducir su longitud(13).

1.3.1 Cuello

El cuello del implante corto suele ser liso para conferir un mejor ajuste supra gingival con la prótesis y una mejor adaptación a los tejidos blandos. Además, permitirá reducir la adhesión de la placa bacteriana(1).

1.3.2 Cuerpo

a. Longitud y diámetro

Aumentar el diámetro del implante corto permite disipar las fuerzas oclusales al nivel de la cresta ósea lo que no se consigue con un implante de mayor longitud, dado que las fuerzas no llegan hasta la parte más apical del implante(13).

Además, permitirá aumentar la superficie de contacto entre las dos superficies. La cantidad de interfase hueso-implante, medible mediante tomografía micro computada, es igual entre un implante corto ancho (4,5 x 6 mm) que un implante estándar (3,5 x 10 mm)(17).

b. Diseño

Al disminuir la longitud de los implantes, fue importante encontrar soluciones acerca de su diseño para conservar una alta interfase entre el implante y el hueso, que son las siguientes:

- Distancia inter-rosca disminuida(1)(13).
- Roscas de formas diferentes: en V, invertidas o cuadradas(17).

  Las roscas cuadradas están conocidas por ser las que aumentan en mayor medida la superficie de contacto entre el implante y el hueso(13).
- Roscas más profundas(13).

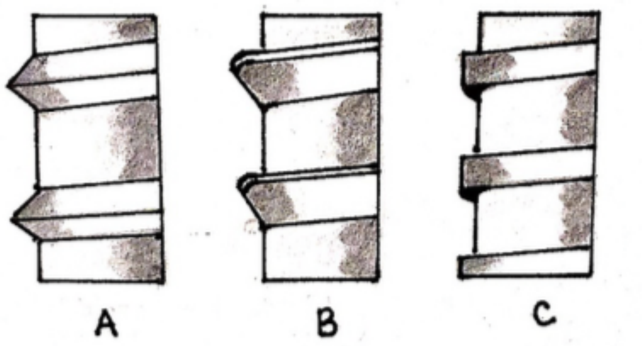


Figura 2: Los diferentes diseños de roscas en los implantes cortos. (A) Rosca en V (B) Rosca invertida (C) Rosaca cuadrada. Imagen sacada de Short implants: new horizon in implant dentistry de Jain N, Gulati M, Garg M, Pathak C.

1.3.3 Tipos de conexión

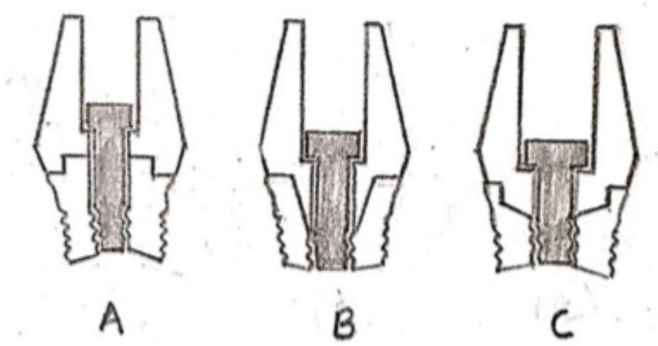


Figura 3: Los tipos de conexiones protésicas en los implantes cortos. (A) Conexión externa (B) Conexión cono morse (C) Conexión interna. Imagen sacada de Short implants: new horizon in implant dentistry de Jain N, Gulati M, Garg M, Pathak C.

La conexión de tipo cono morse ha demostrado tener menos perdida ósea peri-implante que la conexión externa. Además, puede incluso llegar a potenciar la formación de hueso alrededor del cuello del implante[12]. Estas ventajas son seguramente debido a la disminución de micromovimentos entre el pilar y el implante que confiere esta conexión[12].

1.3.4 Tipo de colocación del implante

Los implantes cortos siguen dos tipos de métodos de colocación:

- El diseño Tissue level, en el cual el cuello del implante se localiza por debajo de los tejidos blandos.
- El diseño Bone level, en el cual encontramos el cuello del implante al nivel del hueso[22].

1.3.5 Tratamiento de la superficie

Los tratamientos de superficies, aditivos o sustractivos, permiten crear nano rugosidades y poros que aumentan la superficie de contacto hueso-implante[13][18][23]. Permiten disminuir la longitud de los implantes y aumentar la capacidad de los osteoblastos a adherirse, proliferar y diferenciarse alrededor del implante[23].

Las técnicas aditivas (TPS, Titanio con hidroxiapatita) presentaron complicaciones biológicas como, por ejemplo, el aumento de la perdida ósea peri-implante.

Se desarrollaron entonces las técnicas sustractivas siguientes[23]:

- Superficie modificada con fluoruro (Osseospeed, Astra Tech) que es la precursora de los implantes con titanio nano-modificado. Este tratamiento de superficie consiste en obtener una capa de óxido de titanio superficial mezclada con flúor[23].
- Superficie anodizada (TiUnite, Nobel Biocare) tratada primero mediante grabado con ácido fosfórico. Estudios demostraron la obtención de una

superficie con fósforo que facilita la osteointegración gracias a su topografía y su química(23).

La novedad es la superficie Ti Ultra (Nobel Biocare) que presenta una superficie con más rugosidades y poros a medida que nos acercamos del ápice.

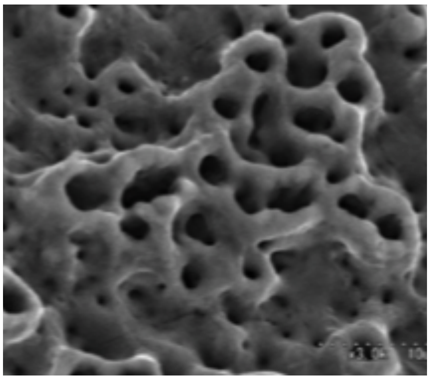


Figura 4: Superficie con poros típicos (trampa para pulpos) de los implantes anodizados observado mediante microscopio electrónico (ME). Imagen sacada del libro de Wennerberg A, Albrektsson T y Jimbo R.

- Superficies de Titanio tratadas mediante grabado por una sucesión de tres ácidos diferentes (Osseotite, Zimmer Biomet). El titanio será tratado mediante aplicación de ácido hidrofluorídrico cuyo meta es conferir la topografía macroscópica; y ácido hidroclorídrico y sulfúrico para conseguir la topografía nanométrica(23).

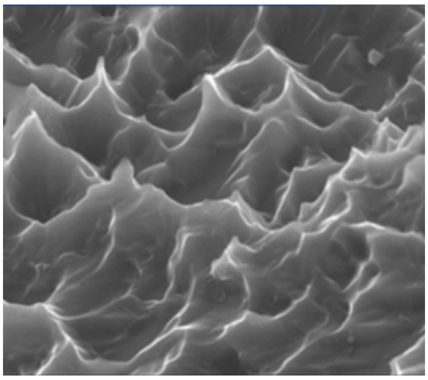


Figura 5: Superficie de implante sometida a un grabado mediante tres ácidos. Imagen sacada del libro Implant surfaces and their Biological and Clinical Impact de Wennerberg A, Albrektsson T y Jimbo R.

- Superficie Sandblasting Large-grit, Acid-etched (SLA) y superficie SLA activa (Straumann) que permite obtener la osteointegración más rápidamente.

  Este tratamiento es realizable tanto en el Titanio como en la aleación de Titanio-Zirconio (ZLA).

  El chorro de arena confiere la macrotextura mientras que el grabado ácido le da la microtextura al implante[(1)(23)].

  Este tratamiento de superficie permite reducir el tiempo de espera para la restauración protésica.
- Superficie T3 (Zimmer Biomet) que consiste en chorrear y grabar con ácido el Titanio.

1.4 Secuencia clínica

1.4.1 Historia clínica

Colocar un implante en una mandíbula atrófica es una manera para el odontólogo de rehabilitar la función masticatoria del paciente. Para eso, el implantólogo no tiene que enfocarse únicamente en la calidad del reborde alveolar del paciente, sino que es muy importante tratar al paciente como un todo y analizar sus posibles patologías sistémicas mediante una anamnesis rigurosa. Al tratarse de tratamientos costosos, es fundamental preguntar al paciente sobre sus expectativas (al nivel funcional y estético, tiempo de tratamiento…). Si en esta fase, ya es difícil encontrar un acuerdo entre las dos partes acerca del plan de tratamiento, la satisfacción del paciente después del tratamiento se podrá ver reducida.

1.4.2 Estudio de modelos, fotografías y radiografías

La Cone Beam Computed Tomography (CBCT) ofrece, hoy en día, la mejor visión de los rebordes alveolares y de sus estructuras ajenas como el nervio alveolar inferior, tanto en sentido horizontal como vertical[13].

Mediante CBCT, podremos analizar la anatomía del hueso mandibular y observar la cantidad de hueso remanente por debajo de la inserción del milohioideo.

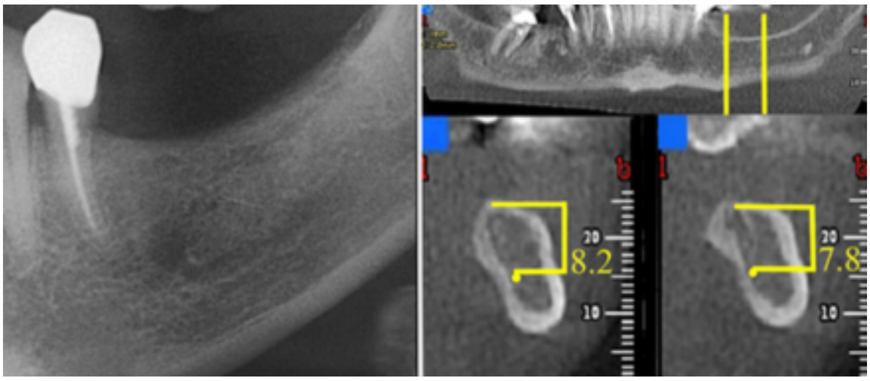


Figura 6: Radiografías del sector posterior de la mandibula atrófico. (A) Radiografía ortopantomografía (B) CBCT. Imagen sacada del artículo del F. Pieri y cols publicado en el International Journal of Oral and Maxillofacial Surgery.

1.4.3 Planificación y consideraciones quirúrgicas

La colocación de un implante resulta ser el acontecimiento de un largo proceso de planificación para poder rehabilitar con una prótesis sobre el futuro implante.

La exploración clínica y radiológica mediante CBCT permiten al clínico hacer un plan de tratamiento detallado incluyendo el número exacto de implantes necesarios y sus ubicaciones correspondientes, tanto en sentido vestíbulo-lingual como mesio-distal.

En el sector posterior de la mandíbula, el hueso residual entre el implante y el conducto dentario inferior tiene que ser de mínimo 2 mm.

La mandíbula tiene la gran ventaja de presentar en su cara interna la inserción del músculo milohioideo que le permite conservar su hueso a este nivel. No obstante, será fundamental verificar el estado del hueso por debajo de esta inserción, a consecuencia de que puede encontrarse atrófico en profundidad. Esta atrofia, invisible clínicamente, es la que obligará al clínico en ciertos casos, a colocar un implante corto aunque el proceso de reabsorción ósea vertical no se encuentre todavía muy avanzado[24].

1.4.4 Técnica quirúrgica

Preparación del campo estéril y del paciente

En esta fase se puede sacar sangre del paciente, si disponemos de un personal capacitado para ello. Se activará el plasma y se usará posteriormente para ayudar a la cicatrización de los tejidos.

Figura 7: Valoración del reborde alveolar posterior de la mandibula antes de empezar la cirugía. Imagen sacada del articulo de F. Pieri y cols.

Anestesia

Exposición del campo operatorio

Existen varios tipos de incisiones en función de lo que queremos conseguir.

Para obtener un campo operatorio amplio, la primera incisión posible sería la incisión crestal con descarga vestibular.

Otro tipo de incisión posible en este caso es la incisión en H cuya ventaja es la posibilidad de trasladar la encía queratinizada residual a zonas con defectos.

Despegamiento del colgajo mucoperióstico

El despegamiento se realizará a espesor total con la ayuda de un periostótomo para poder visualizar bien el hueso. Permite a la higienista quirúrgica, retraer bien el colgajo y así aumentar el campo de vista para el cirujano[(25)].

Osteotomía

La osteotomía consiste en el paso de una secuencia de fresa de diámetros diferentes hasta conseguir un alvéolo artificial requerido para el implante elegido.

En esta parte, la irrigación mediante suero fisiológico es imprescindible para no enfrentarse a un sobrecalentamiento óseo. El micromotor se programará a 1200 revoluciones por minuto (rpm)[(24)].

El siguiente protocolo de fresado tiene que ser respetado para colocar un implante corto:

- Marcar la posición del implante en la superficie de la cresta ósea con una fresa redonda de osteotomía[(25)].
- Con la ayuda de la fresa lanceolada, se perforará la cortical ósea consiguiendo la angulación deseada.

- Después de haber verificado la correcta angulación del primer fresado, se procederá a la siguiente fase del fresado con una fresa de 2 mm de diámetro consiguiendo una osteotomía a la longitud del implante elegido(24)(25).
- Se colocará el pin de paralelización para verificar la angulación y la profundidad de la preparación.
- Poco a poco se aumentará el diámetro de las fresas hasta llegar al diámetro aconsejado por el fabricante en función del tipo (de 1 a 4) de hueso en el cual estamos.

El fresado para la posterior colocación de un implante corto implica, en función de las marcas comerciales, el uso de una fresa especifica, la fresa de perfil corta. Esta fresa se pasa a 1200-1500 rpm y permitirá adaptar la parte coronal del implante al hueso(25).

Colocación del implante

La colocación del implante, mojado en el plasma del paciente si posible, se hará sin irrigación y a baja velocidad (normalmente torque de 30 Ncm) hasta que se encuentre a uno o dos milímetros de su posición final. La ubicación final se conseguirá mediante el uso de la llave de torque manual(24).

En las mandíbulas con atrofias severas, es de especial importancia no usar un torque excesivo para reducir el estrés mecánico ejercido sobre el hueso y de hecho el riesgo de fractura mandibular(5).

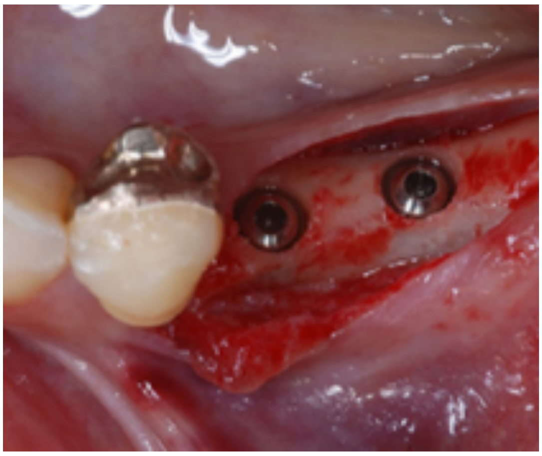


Figura 8: Dos implantes cortos colocados en el sector posterior de la mandibula (4 x 6 mm). Imagen sacada del artículo de F. Pleri y cols.

Sutura

La sutura dependerá del tipo de incisión elegida usando hilo reabsorbible de 0000[24].

1.4.5 Rehabilitación protésica

En implantología existen tres técnicas clasificadas según la posterior carga protésica.

- Colocación en tres fases o dos fases quirúrgicas[16]: asegura una estabilidad primaria óptima y una buena osteointegración reduciendo los micro movimientos perjudiciales. En este caso hablamos de un implante submucoso o sumergido.
- Colocación en dos fases o una fase quirúrgica[16], llamada también técnica con carga diferida: se deja el implante y su tapón de cicatrización transmucoso. Esta técnica se hace únicamente cuando se consiguió un torque suficiente. La restauración protésica se realizará después de 3 meses.

- Colocación en una fase o carga inmediata: la prótesis provisional se coloca el mismo día de la colocación del implante.

Los autores aconsejan colocar los implantes cortos usando la técnica de dos pasos quirúrgicos para dejar al implante un tiempo suficiente de 2 a 4 meses para osteointegrarse en la mandíbula. Pese a lo cual, en el maxilar es necesario prolongar esta fase hasta 4 o 6 meses[13].

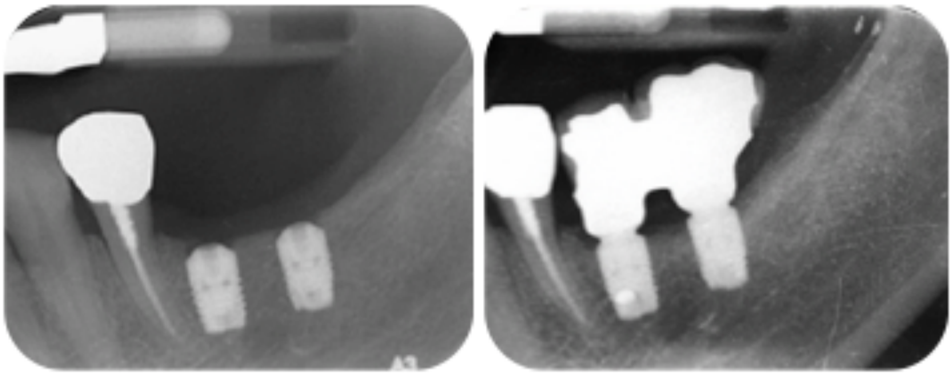


Figura 9: Control radiográfico de los implantes.

(A) Radiografía periapical post-cirugía (B) Radiografía periapical a los 5 años.

Imagen sacada del artículo F. Pieri y cols.

1.5 Indicaciones y contraindicaciones

Las indicaciones y contraindicaciones para colocar un implante corto son similares a las de los implantes estándares excepto que el implante corto será indicado en mandíbulas con poca cantidad de hueso en las cuales colocar un implante de longitud estándar resulta imposible sin técnicas quirúrgicas invasivas.

Los implantes cortos serán indicados para:

- Pacientes que exigen una prótesis fija o que son intolerantes a las prótesis removibles y sus materiales[1].
- Personas cuya cirugía de regeneración ósea están contraindicadas por causas medícales, anatómicas o financieras[19].
- Pacientes con atrofias severas debido a cirugías tumorales de cabeza y cuello en las cuales las regeneraciones verticales son contraindicadas[14].
- Reposición dentaria unitaria o múltiple en los maxilares edéntulos y atróficos de pacientes mayores si no presentan una condición sistémica que lo impida[1][14][19].
- Cantidad de hueso que permite mantener 2 mm de hueso entre la base del implante y el conducto alveolar inferior[19].

Algunos pacientes no pueden ser sujetos a cirugías de este tipo de forma absoluta como puede ser un paciente con enfermedad sistémica o inmunológica no controlada (ASA III)[1][24], con historia de tratamiento por bifosfonatos orales más de tres años o bifosfonatos intravenosos[1][5] o aún un paciente con una atrofia ósea demasiado severa para la colocación de un implante extra corto (4 mm)[3].

Otras patologías pueden conferir al paciente una contraindicación relativa como por ejemplo un paciente con higiene oral deficiente[1], fumador o bebedor[24], bruxista, fóbicos[24], un paciente con metabolismo ósea alterado (osteoporosis)[24], con cicatrización dificultada (diabetes, tratamiento mediante quimioterapia o radioterapia)[24].

1.6 Ventajas e inconvenientes

Tabla 2: Ventajas e inconvenientes de los implantes cortos.

Ventajas	Desventajas
98,3% éxito a los 10 años(14)	Riesgo de fracturas mandibulares(5)
Menos invasivo, doloroso, largo y costoso que las cirugías de regeneración ósea(1)(3)(7)(8)(9)(10)(11)(12)(13)(14)(16)(26)	Resultado poco estético (corona protética excesivamente larga)(3) con proporción corona-implante aumentada(13)
Morbilidad reducida visto que las técnicas quirúrgicas de regeneración ósea no son necesarias(7)(13)(17)(19)(26)	Riesgo de complicaciones asociadas a una cirugía (sangrado, infección, daño del nervio alveolar inferior)(13)(14)(19)
Preparación ósea rápida que limita el sobrecalentamiento del hueso(13)(17)(19)	Carga inmediata complicada debido a la falta de estabilidad primaria(14)
Inserción del implante simplificada en pacientes con abertura bucal reducida(13)	Estabilidad primaria favorable difícil a conseguir en los huesos de baja calidad (tipo 3 y 4)(13)

1.7 Complicaciones

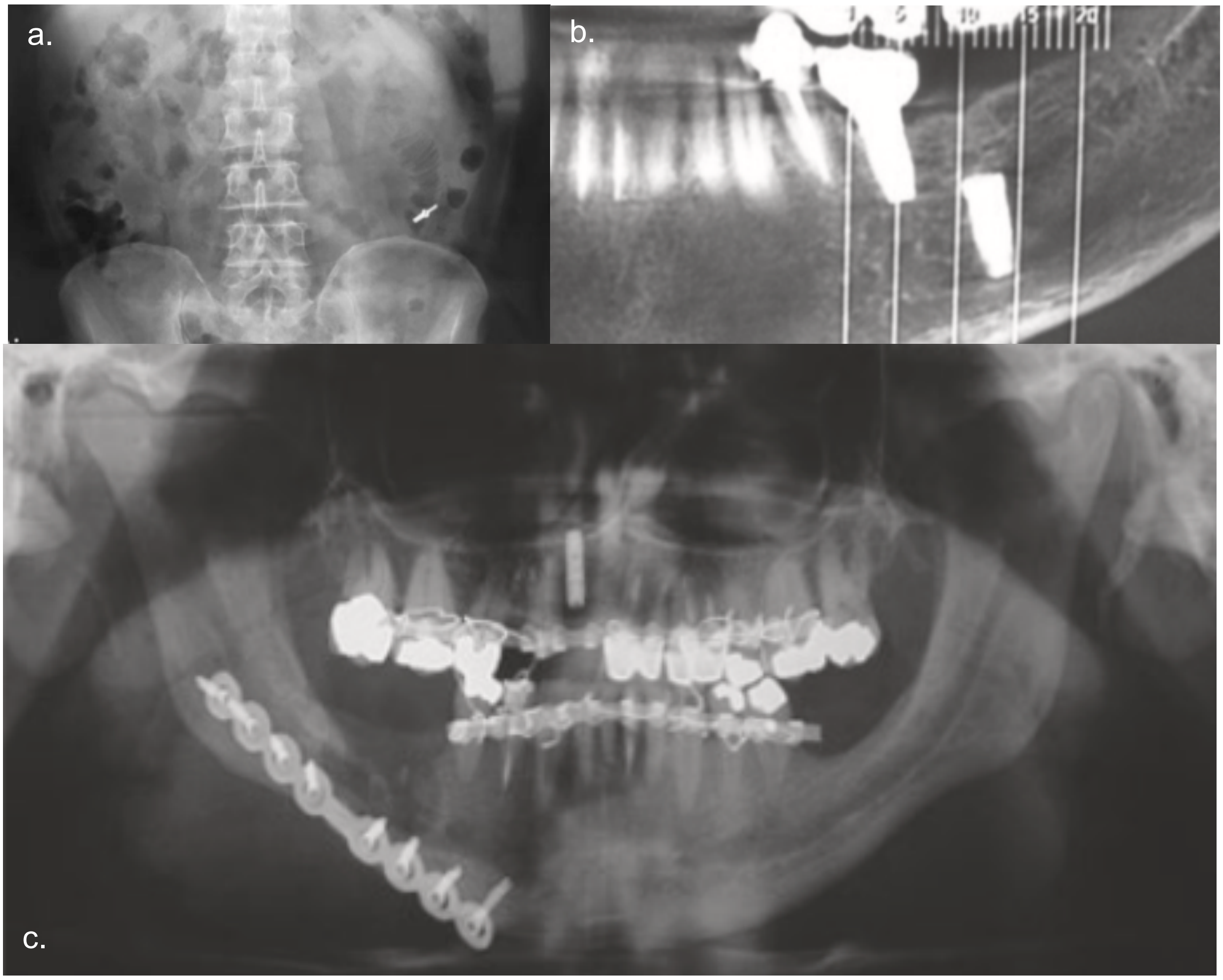
La colocación de un implante corto, como cualquier actuación médica, posee complicaciones predecibles o impredecibles. Estas complicaciones aumentan de par con la expansión de los implantes cortos en odontología. El estudio previo a la colocación de un implante resulta primordial para prevenirlos.(5)

Algunas complicaciones son inespecíficas y pueden ocurrir durante la colocación de un implante de cualquier longitud:

- Aspiración e ingestión del implante o de aditamentos (pilar de cicatrización…).
- Estabilidad primaria inadecuada o desplazamiento del implante a la zona submandibular(5).
- Daño de estructuras ajenas (diente, tejidos blandos)(5).
- Distancia inter-implantes incorrecta (engendrará una reabsorción ósea y una falta de desarrollo de los tejidos blandos al nivel interproximal)(5).
- Infecciones (colocación directa tras extracción de diente con proceso infeccioso activo, gap entre el implante y el alveolo artificial…)(5).
- Periimplantitis, cuya principal etiología es el biofilm bacteriano, provoca el fracaso del implante debido a una osteointegración deficiente(5)(27).
- Fracaso de la osteointegración(5).

No obstante, al colocar un implante en mandíbulas atróficas, el implantólogo puede encontrarse con mayor frecuencia:

- Dehiscencia o insuficiente cantidad de tejidos blandos que puede impedir el cierre por primera intención, cuya meta es prevenir las infecciones[5] (encía queratinizada insuficiente, tejido blando fino que se daña al manejarlo)[27].
- Hemorragias graves debido a la perforación de la cortical lingual que aloja subperiósticamente a ramificaciones de un plexo arterial (desde el hematoma lingual a la elevación del suelo de la boca y obstrucción de las vías aéreas).
- Fracturas mandibulares durante la preparación ósea debido al estrés mecánico que se produce en un hueso con densidad, vascularización y superficie reducida.
- Osteonecrosis por toma de bifosfonatos como tratamiento sistémico (una aplicación local podría favorecer la estabilidad primaria)[5].



<u>**Figura 10:**</u> Complicacions en implantología. (a) Ingestión de aditamento prótesico (b) Desplazamiento de un implante a la zona submandibular (c) Fractura mandibular durante la preparación ósea. Imagenes sacadas del libro *Complex Dental Implant Complications* de C. Bagheri S, R. Stevens M, Ali Khan H. Capitulo 3 : Intraoperative Dental Implant Complications. Paginas 30, 32 y 36.

2) Justificación y objetivos

La rehabilitación protésica en mandíbulas atróficas es un dilema al que el implantólogo se encuentra cada vez más enfrentado[8]. Este fenómeno se explica por el aumento de la prevalencia de caries y enfermedad periodontal en los países desarrollados. Estas patologías y la mayor esperanza de vida conllevan a un aumento de la tasa de edentulismo en esos países.

Al perder un diente pilar de la oclusión, como puede ser el primer molar inferior, la mandíbula está afectada rápidamente por un proceso de reabsorción ósea tanto en sentido vertical como horizontal[8]. Esta reabsorción ósea ya no está únicamente relacionada con la edad. La pérdida de dientes en edades tempranas puede dar lugar a huesos mandibulares atróficos en pacientes jóvenes[5].

La idea de que pueda existir un tratamiento menos invasivo, menos complejo y con menor morbilidad que las regeneraciones óseas[1][3][8][9][13][14][26][28] para rehabilitar la función masticatoria de estos pacientes, no siempre mayores, me suscitó mucha curiosidad y ganas de estudiar sobre el tema.

El objetivo de nuestro trabajo ha sido constatar en la literatura científica la viabilidad de los implantes cortos en el sector posterior de las mandíbulas atróficas para:

- Comparar su tasa de éxito con las alternativas terapéuticas existentes.
- Analizar la frecuencia de aparición de complicaciones en el tratamiento mediante implante corto y en el tratamiento mediante regeneración ósea e implante de longitud estándar.
- Determinar la influencia de la proporción corona-implante sobre la pérdida ósea peri-implante a corto y largo plazo.

3) Material y método

Para conseguir los objetivos del siguiente trabajo se recogió la información gracias a una búsqueda bibliográfica en los motores de búsqueda científicos Pubmed y Medline Complete, durante la cual se encontró 34 artículos científicos cuyas publicaciones eran de los últimos 9 años. Del hecho que los implantes cortos representan una opción terapéutica con numerosos avances recientes, es importante que los datos fuesen compilados a partir de un gran número de fuentes recientes para obtener resultados actualizados sobre los últimos avances técnicos.

Además, se encontraron 5 libros escritos en español a partir de la plataforma de la biblioteca CRAI cuya información era relevante para la realización de este trabajo.

Los datos fueron obtenidos a partir de artículos escritos en inglés y en español. Fueron encontrados con las palabras claves siguientes: *Bone, Regeneration, Technique, Short, Implants, Dental, Types, Atrophic, Mandible, Jaw, Indications, Long, Complication, Peri-implant, Surface, Classification, Connection,*

De los 46 artículos científicos encontrados, se guardaron los 34 artículos citados en el apartado de referencia según los siguientes criterios:

Entre los criterios de inclusión están:

- Artículos de revistas científicas de los últimos 10 años.
- Artículos incluyendo en su estudio la colocación de implantes cortos en el sector posterior de la mandíbula.

Entre los criterios de exclusión están:

- Artículos antiguos o de poca relevancia científica.
- Artículos que estudian la colocación de implantes cortos exclusivamente en el maxilar o en el sector anterior de la mandíbula.
- Artículos presentando estudios duplicados.

En cuanto a la metodología, se estudiaron las siguientes variables:

1. Sexo: varón (V) o mujer (M).
2. Edad: edad media de los pacientes incluidos en cada estudio.
3. Definición de un implante corto: debido a la falta de consenso sobre la longitud en milímetro de un implante corto entre los autores, esta variable permite estudiar la tendencia actual acerca de esta definición.
4. Número y tipo de implante colocado: número de implantes cortos colocados (extracortos y cortos) y número de implantes estándares colocados.
5. Años de seguimiento: número de años de seguimiento después de la colocación de los implantes en boca.
6. Diámetro del implante: diámetro medio en milímetro de los implantes colocados, en función de su longitud.
7. Tasa de éxito: porcentaje de éxito de los implantes cortos colocados en hueso residual mandibular, al nivel posterior, y de los implantes estándares colocados en hueso mandibular regenerado, al nivel posterior.
8. Estabilidad del implante post-cirugía: nivel de torque en Newton por centímetro (Ncm) con el cual se consiguió colocar el implante.

9. Complicaciones: acontecimientos no deseables que pueden ser divididos en quirúrgicos, biológicos o protésicos en función de su causa.
10. Pérdida ósea peri-implante (MLB): diferencia, en milímetro, entre el hueso y el cuello del implante a la colocación del implante y unos años después.

Las siguientes variables fueron estudiadas a partir de 10 artículos científicos cuyas informaciones vienen resumidas en la siguiente tabla.

Tabla 3: Artículos y estudios seleccionados

AUTOR	AÑO	AÑOS DE SEGUIMIENTO	DEFINICIÓN IMPLANTE CORTO	NÚMERO DE PACIENTES	NÚMERO DE IMPLANTES COLOCADOS
C. Guirado	2015	1	Extracorto : <5 mm	10	40
C. Slotte	2015	5	≤ 8 mm	32	77
E. Dursun	2016	1	≤ 8 mm	15	52
F. Pieri	2017	5	≤ 8 mm	45	97
A. Reza Rokn	2018	1	≤ 7 mm	11	47
R. Guarneri	2018	3	< 7 mm	28	28
P. Felice	2018	8	≤ 8 mm	60	121
K. Weerapong	2019	1	< 8 mm	46	50
E. Anitua	2019	15	≤ 8,5 mm	28	45
P. Felice	2019	5	≤ 8 mm	15	56

4) Resultados

Las siguientes variables han sido estudiadas sobre una muestra de 290 pacientes recopilados en 10 estudios aleatorios presentados en artículos de revistas científicas(7)(10)(15)(16)(25)(26)(29)(30)(31)(32).

4.1 Sexo

De los 290 pacientes estudiados, 197 eran mujeres (M) y 93 varones (V). El ratio V/M del estudio resulta ser 1 : 2,1.

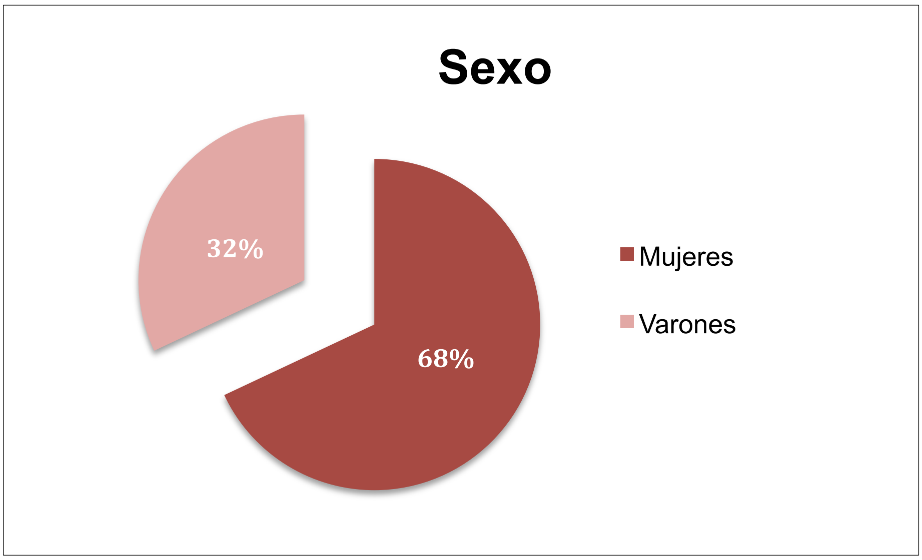


Figura 11: Porcentajes de distribución según el sexo.

4.2 Edad

La edad media de los pacientes integrados al estudio es de 56,2 años. El rango de edad es de 20 a 86 años.

4.3 Definición de un implante corto

Entre los 10 estudios utilizados en este análisis, 6 estudios consideraban un implante corto cuando tenía una longitud inferior o igual a 8 mm. 2 estudios definían un implante corto como un implante de longitud de 7 mm o menos; mientras que un único estudio los llamaban cortos en cuanto mesuraban 8,5 mm o menos.

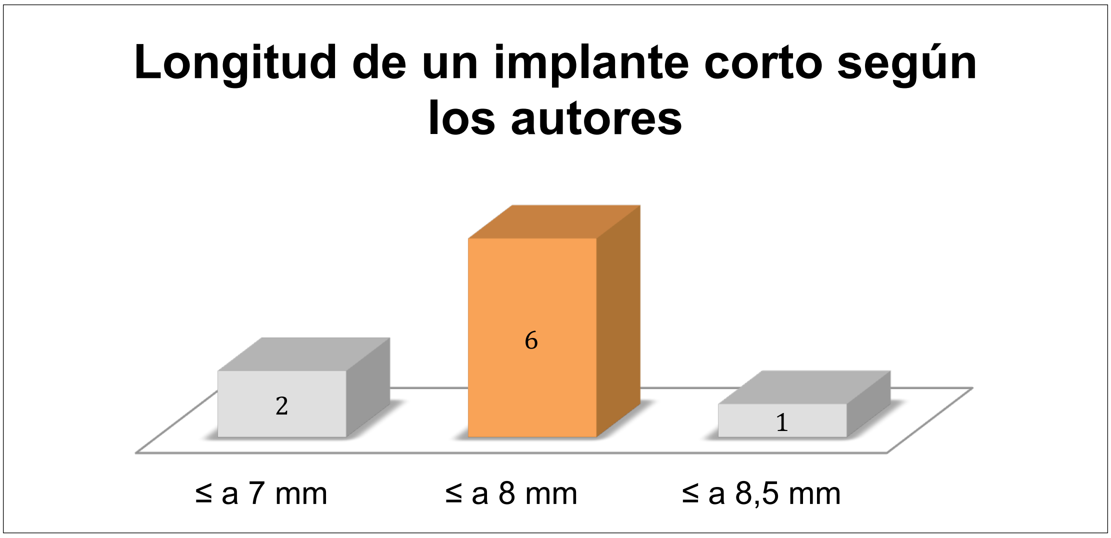


Figura 12 : Definición de un implante corto según los autores.

4.4 Número y tipo de implante colocado

Un total de 613 implantes fueron colocados en los pacientes. De los 613 implantes colocados, 383 fueron de longitud reducida y 230 de longitud estándar (≥ 9 mm). Dentro de los implantes de longitud reducida, 215 son considerados cortos (≤ 8 mm) y 168 extracortos (≤ 5 mm).

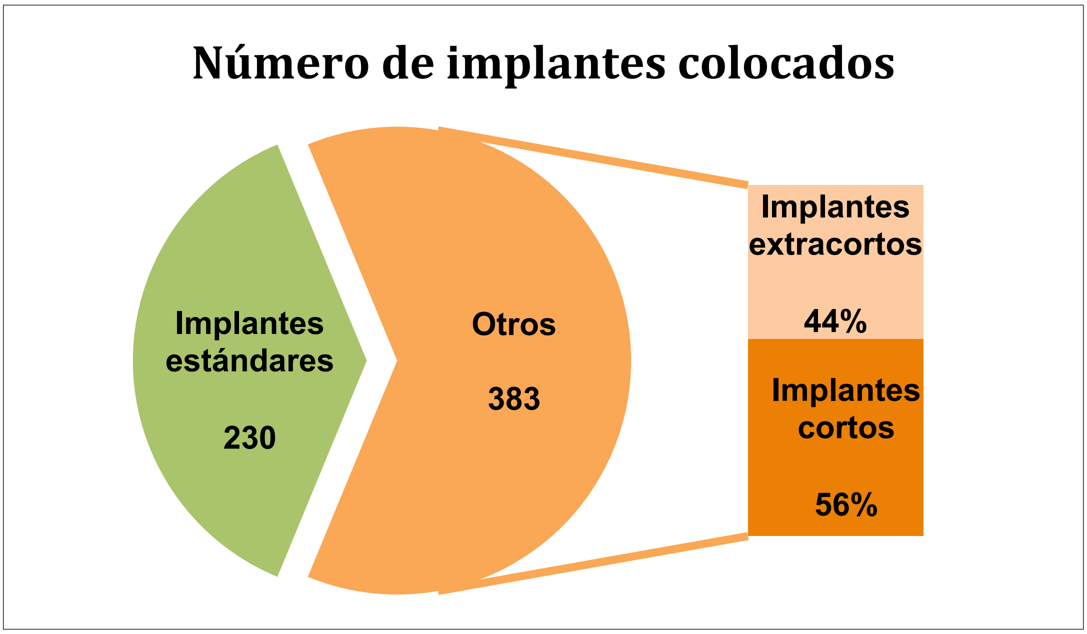


Figura 13 : Número de implantes colocados con respecto a su longitud.

4.5 Años de seguimiento

De los 10 estudios, 4 evaluaron los resultados al año, 1 a los 3 años, 3 a los 5 años, 1 a los 8 años y 1 a los 15 años. El seguimiento medio de este estudio es de 4,5 años.

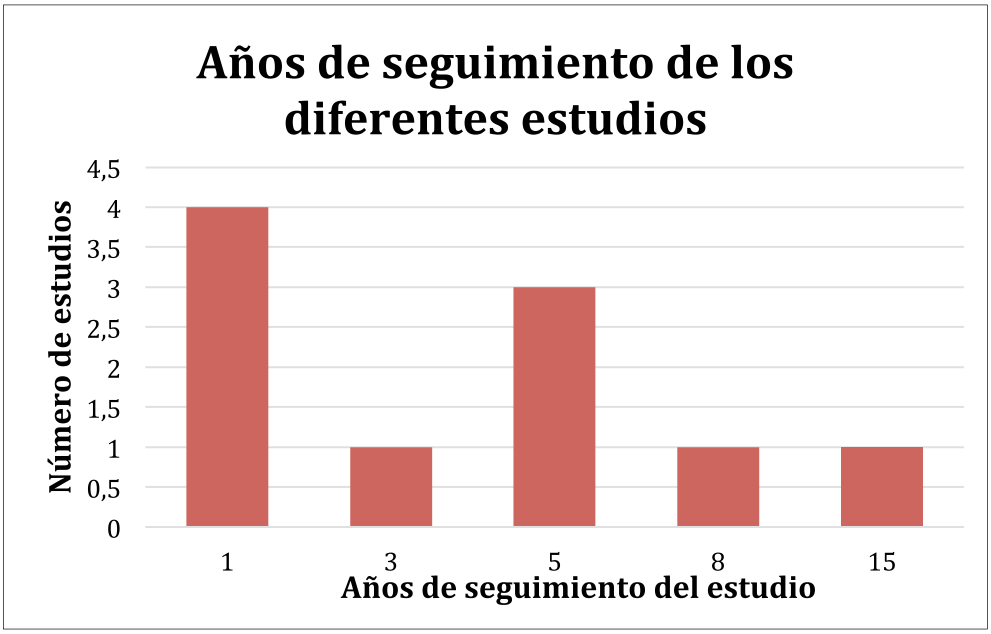


Figura 14 : Clasificación de los estudios según los años de seguimiento.

4.6 Diámetro del implante

Los implantes extracortos presentaron un diámetro medio de 4,4 mm mientras que los cortos tenían uno medio de 4 mm y los estándares de 4,2 mm.

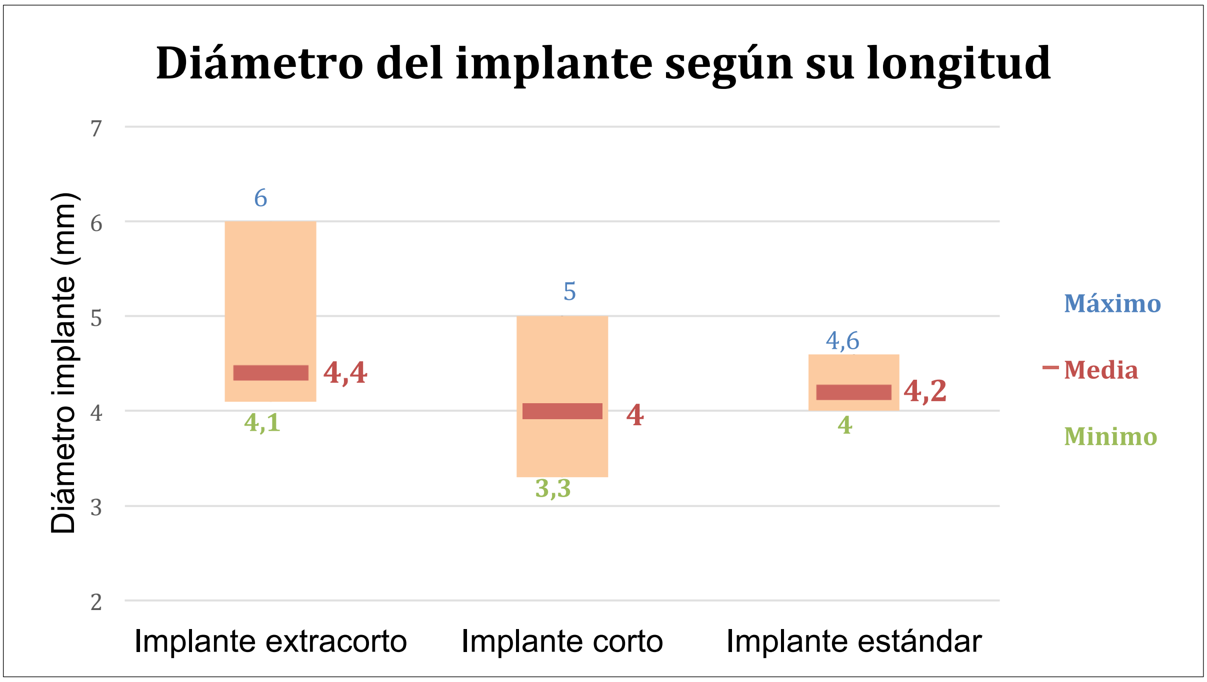


Figura 15: Diámetro de los implantes colocados.

4.7 Tasa de éxito

Las tasas de éxito encontradas para los implantes cortos colocados en el hueso residual y para los implantes estándares colocados en el hueso regenerado mediante hueso bovino anórganico y membrana reabsorbible de colágeno, no presentan una diferencia significativa.

No se encontró tampoco una diferencia significativa entre el número de fracaso de los diferentes grupos.

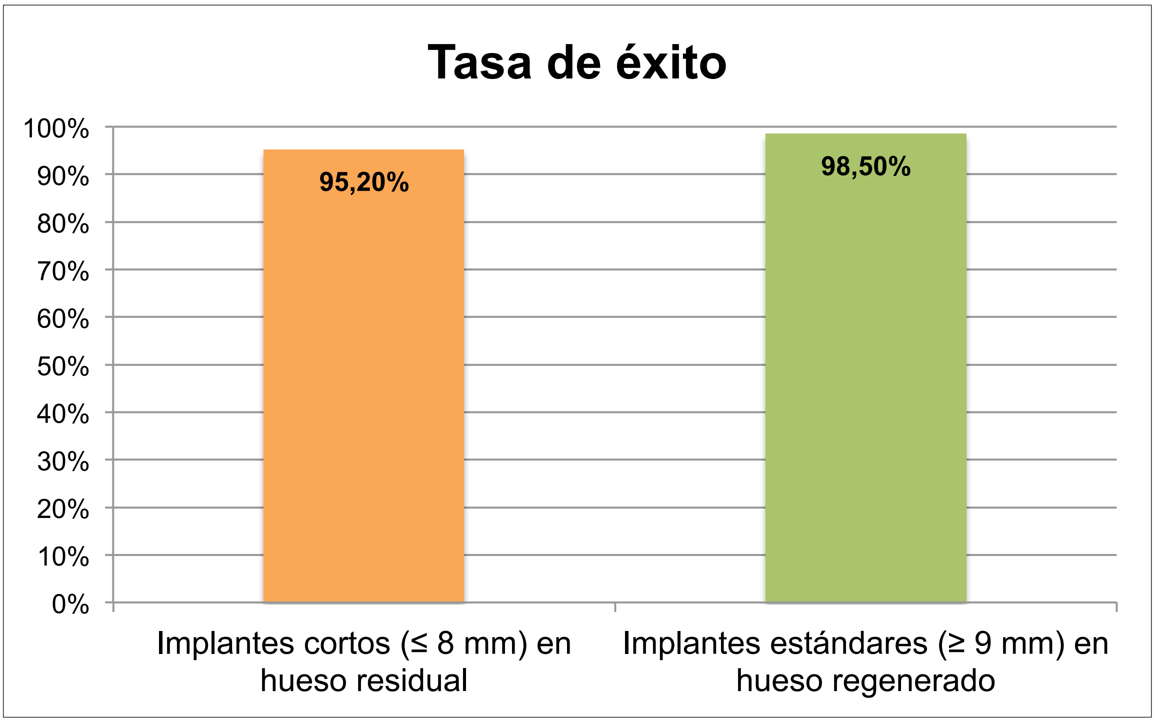


Figura 16: Tasa de éxito de los diferentes implantes a los 4,5 años.

4.8 Estabilidad del implante post-cirugía

No se encontró una diferencia significativa entre los diferentes niveles de torque conseguidos (en Ncm) durante la colocación de los implantes de los dos grupos.

4.9 Complicaciones

Las complicaciones quirúrgicas fueron significativamente más frecuentes en el grupo de hueso regenerado mediante técnicas invasivas.

No hubo diferencia significativa entre los dos grupos en cuanto al estudio de las complicaciones biológicas y protésicas.

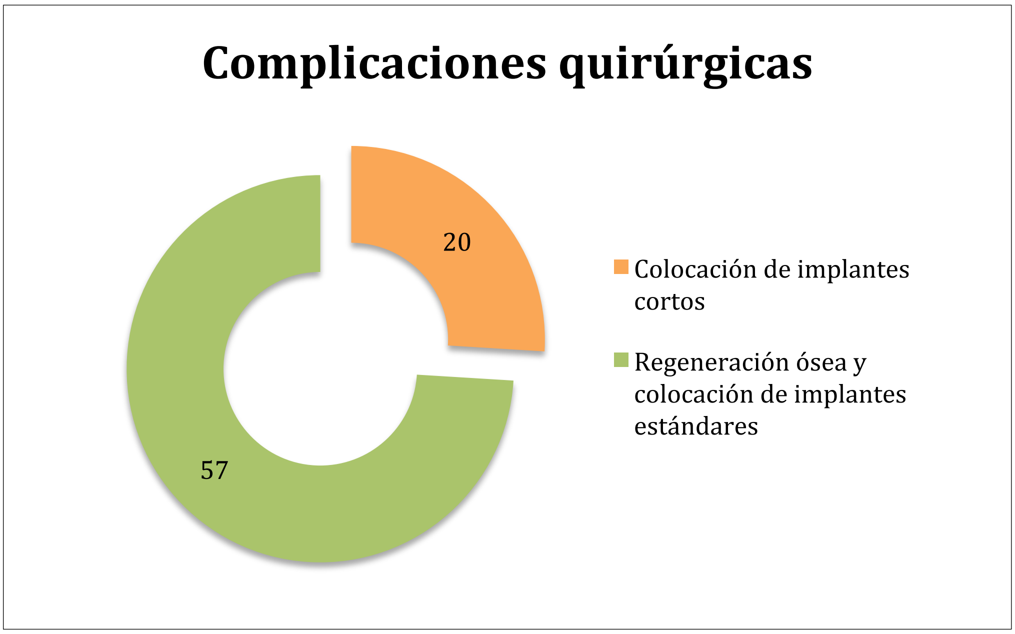


Figura 17: Número de complicaciones quirúrgicas en función de la técnica empleada.

4.10 Perdida ósea peri-implante

Al año, 6 estudios encontraron ausencia de diferencia significativa. Que sea entre el grupo de implante corto y el grupo de hueso regenerado(10)(25)(30), entre el grupo de implante corto y el grupo de lateralización del nervio dentario inferior(15), entre los implantes cortos y los estándares cargados inmediatamente(26) y entre los implantes extracortos en hueso atrófico y los implantes largos en hueso residual suficiente(29).

A partir de los 3 años, un estudio(30) concluyó de una diferencia no significativa entre los implantes cortos y los estándares en hueso regenerado; a diferencia de otro(10), que observó una perdida significativamente menor para el grupo de los implantes cortos colocados en el hueso residual.

Un estudio(31) no encontró una diferencia significativa entre las diferentes edades, sexos y proporciones corona-implante.

A los 5 años, 3 estudios(7)(10)(30) fueron de acuerdo en el descubrimiento de una diferencia significativa entre los dos grupos con una perdida ósea mayor en el grupo del hueso regenerado. F. Pieri y cols(7), observaron que un 54,5% del grupo de hueso regenerado habían perdido más de un 1 mm de hueso peri-implante con respecto a solo un 17,3% del grupo de los implantes cortos.

A los 8 años(10), el estudio sigue encontrando esta diferencia significativa.

5) Discusión

En relación con el sexo, la diferencia en porcentaje entre los dos grupos (varón y mujer) es significativa y se traduce, entonces, como una limitación de nuestro estudio. No obstante, estudios como los de Eduardo Anitua y cols(16) y Renzo Guarnieri y cols(31) no revelan diferencia significativa entre los resultados obtenidos en los varones y en las mujeres.

Sería, por consiguiente, aconsejable hacer más estudios en los varones para poder ampliar los resultados a este grupo poblacional.

Con respecto a la definición de un implante corto según su longitud, se aprecia una cierta variabilidad. Esta longitud está definida por la distancia, en mm, entre el cuello y la parte más apical del implante. Encontramos en este estudio que la tendencia actual de los autores es de hablar de implante corto en cuanto miden 8 mm o menos. Sin embargo, Giovanna Iezzi DDS y cols, en su metánalisis publicada en 2020(3), los consideran cortos únicamente si miden 7 mm o menos. Suya Chen y cols(14) y Luciano Malchiodi y cols(33) están de acuerdo con nuestro estudio y los definen cortos en cuanto miden 8 mm o menos.

Panos Papaspyridakos y cols(11) parecen ofrecer la definición más extrema de los implantes cortos en su estudio de 2018. Definieron los implantes cortos como implantes de longitud inferior o igual a 6 mm. Esta definición se acerca más a la definición de un implante extracorto de Calvo Guirado y cols(29) y de L. Malchiodi y cols(33) cuya longitud instraósea es inferior o igual a 5 mm.

Los siguientes estudios son suficientes para demostrar la falta de consenso y de nomenclatura acerca de la longitud de los implantes dentales. Hoy en día, la tendencia sigue siendo hablar de implantes cortos cuando estos miden 8 mm o menos. A pesar de ello, esta definición es muy variable con los años y seguirá evolucionando. Sería fundamental que los autores propongan una clasificación aceptada al nivel internacional para poder comparar los estudios correctamente, sin que esta variable influencie de ningún modo los resultados científicos.

Los implantes cortos empiezan a ser el sujeto de estudios retrospectivos científicos a largo plazo. El estudio a los 15 años de Eduardo Anitua y cols(16) o a los 5 años de S. Rameh y cols(4) son ejemplos de ellos. Apoyando a los autores anteriormente citados, Pietro Felice y cols(10)(30) publican varios estudios a los 5 o 8 años de seguimiento que pueden ayudar a los odontólogos, ya que proponen resultados a largo plazo. L. Malchiodi y cols(33) estudian la influencia de una proporción corona-implante alta en los implantes cortos a los 10 años y F. Amato y cols(18) la tasa de éxito de los diferentes implantes después de una carga inmediata a los 4 años.

Lo esperado, es que más estudios alentadores a largo plazo sobre los implantes cortos salgan, en vista de que los estudios a un año de seguimiento no pueden asegurar a los profesionales un buen pronóstico de esta nueva técnica; aún más si sabemos que será más frecuente, con el tiempo, colocarlos en gente joven y esperar de ellos que rehabiliten unas funciones masticatorias y estéticas durante muchos años.

En lo referente a las tasas de éxito de los implantes cortos colocados en el hueso mandibular residual (4-8 mm de hueso por encima del conducto alveolar inferior) o de los implantes dichos estándares en un hueso previamente regenerado con hueso bovino anórganico, coincidimos con los resultados de otros autores. En efecto, Giovanna Iezzi DDS y cols[3] y Suya Chen y cols[14] exponen unas tasas de éxito similares en los dos grupos. Panos Papaspyridakos y cols[11] describen respectivamente unas tasas de éxito a los 5 años de 96% y de 98% para el grupo de los implantes cortos y el grupo de hueso regenerado. Un estudio retrospectivo realizado por Luciano Malchiodi y cols[33] afirma una tasa de éxito de 92,9 % a los 9,5 años para implantes cortos colocados en mandibulas atróficas y rehabilitados con una proporción corona-implante de 3:1. Estos últimos estudios son de gran relevancia científica e incluyen un gran número de implantes colocados tanto en las mandíbulas como en los maxilares atróficos. En su estudio longitudinal aleatorio, Sara N. Shah y cols[8] reseña una tasa de éxito menor, a 1 año, para los implantes cortos. Otro estudio relevante de S. Rameh y cols[4] comenta una tasa de éxito de 94,39% de media a los 5 años para los implantes cortos colocados al nivel posterior de las mandíbulas atróficas. A los 10 años esta tasa de éxito baja a 90,87%. A pesar de ello, esta bajada se explica por el hecho de que incluye los implantes cortos colocados al nivel posterior del maxilar, caracterizado por ser un hueso más blando y entonces menos conveniente para este tipo de implante[4]. En su estudio de 2020, F. Amato y cols[18] presentan una tasa de éxito mayor, a los 4 años, que los autores anteriores aunque sean implantes cargados inmediatamente. En los implantes extracortos, la tasa de éxito llega a 98,4% mientras que en el caso de los implantes cortos, la tasa de éxito equivale a la de los implantes estándares con una tasa de éxito de 100%. Este último estudio demuestra la ausencia de diferencia significativa entre los implantes cargados inmediatamente o tardamente. Sin embargo, el número reducido de implantes colocados nos obliga a esperar los resultados de otros estudios con mayor número de implantes colocados[18].

Respecto a la tasa de fracaso, no se encuentra tampoco una diferencia significativa entre los implantes cortos y estándares colocados en hueso regenerado[3]. El fracaso de un implante ya no depende de su longitud, gracias a los avances técnicos que ocurrieron acerca del tratamiento de su superficie. A pesar de ello, Panos Papaspyridakos y cols[11] presentan un riesgo de fracaso más alto de 29% para los implantes cortos. Este resultado puede ser explicado por el hecho de que el estudio incluye la colocación de implantes cortos en el sector posterior del maxilar, cuyo hueso es mucho menos denso. Además, incluye estudios con carga inmediata de los implantes que pueden disminuir la tasa de éxito, puesto que dificultan la buena osteointegración. Por otra parte, Malchiodi y cols[33] encuentran un número de fracasos ligeramente más altos en la mandíbula que explican por su medida muy estricta del hueso antes de la colocación de los implantes.
Siendo las regeneraciones óseas más complejas y menos predecibles en la mandíbula, siguen siendo los implantes cortos la mejor alternativa de tratamiento[11].

Acerca de la estabilidad primaria de los implantes al momento de su colocación, nuestro estudio no encuentra una diferencia significativa entre los implantes de diferentes longitudes, pero sí que existe una estabilidad ligeramente aumentada para los implantes estándares. En el estudio de E. Dursun y cols[15], encuentran que los implantes estándares colocados en un hueso tratado mediante lateralización del nervio alveolar tienen una estabilidad mayor que si el hueso no fuese tratado y los implantes cortos colocados directamente. F.R. Alonso y cols[34], demuestran una correlación directa entre la estabilidad primaria del implante y la densidad del hueso. Cuanto más duro es el hueso, más estabilidad primaria conseguida. Parece además, que la técnica quirúrgica empleada pueda influir en los valores de torque obtenidos(34). Estos resultados son apoyados por el estudio de G. Oliveira y cols(35) que demuestra también esta relación entre la densidad ósea y el torque conseguido. Sin embargo, no encuentran una diferencia entre los valores de estabilidad primaria de los implantes cortos y estándares(35). R. Silva y cols(6) presentan un estudio in vitro en el cual podemos observar que al disminuir la longitud y el diámetro del implante, disminuyen los valores de torque obtenidos. Además, encuentran que los implantes cortos de paredes paralelas no llegan a valores de torque tan altos como los de paredes cónicas(6). La estabilidad primaria de los implantes cortos parece entonces depender de la densidad ósea, de la técnica quirúrgica y de la longitud de los implantes.

Para contrarrestar esta estabilidad primaria reducida en ciertas densidades de hueso, un nuevo estudio presenta los resultados obtenidos con un implante corto ampliable en anchura al nivel apical(36). Este aumento del diámetro al nivel apical, después de su colocación intraósea, permite aumentar la estabilidad primaria del implante comprimiendo el hueso atrófico horizontalmente. Los resultados parecen dar al tratamiento cierta viabilidad aunque más estudios son necesarios(36).

En cuanto a las complicaciones, se observa, en este estudio, un número significamente más alto en el grupo de los implantes estándares colocados en hueso regenerado mediante técnicas quirúrgicas. Lo más habitual de encontrar, es la aparición de parestesia temporal del nervio dentario inferior que puede extenderse de unos días a 1 o 2 meses[7][10]. En la técnica de lateralización del nervio, la parestesia más frecuente encontrada es la del nervio mentoniano durante 1 a 6 días[15]. El artículo de S.R. Schwartz y cols coincide con nuestros resultados acerca de esta técnica y las amplía a casos de hiperestesia e hipoestesia. Las causas identificadas, según este autor, son la alta frecuencia de traumatismos o deterioros de la red microvascular, presente en esta zona anatómica. Estos resultados no excluyen la posibilidad de que el paciente se quede con parestesia de por vida[12].

S.R. Schwartz y cols revelan un alto riesgo, en las técnicas de regeneración ósea guiadas, de exposición temprana o de pérdida de la membrana de colágeno que puede engendrar una infección del injerto óseo o una perdida significante de altura ósea[12]. Acerca de la técnica de injerto en bloque, además de ser obligado a realizar dos campos quirúrgicos en el paciente (zona donación y zona receptiva), demuestra la alta incidencia de parestesia temporal del nervio dentario inferior. La zona donante puede tener también frecuentemente defectos neurosensoriales[12]. Con respecto a la técnica de distracción ósea, presentan como complicación recurrente la dehiscencia o la perforación de los tejidos blandos, las infecciones, la obtención de distracción ósea insuficiente o incluso la fractura mandibular[12].

El estudio de S. Rameh y cols esta de acuerdo con nuestros resultados acerca de las complicaciones quirúrgicas, dado que demuestra más del doble de complicaciones para los implantes estándares colocados en hueso regenerado en la parte posterior del reborde alveolar de la mandíbula[4]. Además la técnica de distracción ósea implica al paciente una anestesia general en un quirófano[12].

El hecho de que los implantes cortos presenten menos incidencia de complicaciones quirúrgicas se puede explicar por la ausencia de necesidad de técnicas quirúrgicas tan invasivas como las descritas anteriormente[3].

No obstante, las complicaciones protésicas a los 5 años (decementado o fractura de la cerámica) son significativamente más frecuentes en los implantes cortos[4].

Hablando de la pérdida ósea peri-implante, S. Rameh y cols[4] demuestra una pérdida ósea en el sector posterior de la mandíbula entre 0,14 y 1,72 mm para los implantes cortos y entre 0,15 y 2,11 mm para los implantes estándares.

L. Malchiodi y cols[33] presenta un resultado coherente con el anterior y descubre una pérdida ósea peri-implante media de 1 mm entre la colocación del implante corto y la revisión a los 8-10 años, cuyo rango es entre 0,34 y 2,72 mm.

Sin embargo, G. Mendoza-Azpur y cols presentan a corto plazo (6-12 meses) una diferencia significativamente mayor en los implantes cortos. Esta pérdida ósea no exceda a los 0,53 mm, siendo entonces según los autores, mínima[37]. Su comparación con los implantes estándares muestra también una diferencia acerca del nivel de los tejidos blandos, ya que las recesiones llegan a ser más importantes en el grupo de los implantes estándares[37].

Los siguientes estudios apoyan los resultados encontrados en nuestro estudio, pues muestran que la diferencia entre los dos grupos de implantes se hace más llamativa con los años a favor de los implantes cortos. Los implantes cortos o extracortos pueden presentar mayor pérdida ósea peri-implante a corto plazo. Esta pérdida ósea se estabiliza con el tiempo y parece ser menos llamativa a largo plazo que la de los implantes estándares. Se puede explicar por el hecho de que los implantes cortos son cargados protésicamente después de unos meses y esta carga protésica permite que la zona alrededor del implante se vea estimulada por las fuerzas oclusales permitiendo de hecho la osteogénesis de la zona.

La proporción corona-implante es definida como el ratio entre la longitud de la corona supraósea y la parte intraósea del implante. Si se encontraba aumentada se consideró durante años como una palanca perjudicial para los implantes, basándose en la anatomía guía del diente natural. No obstante, estudios más recientes no encuentran asociación significativa entre esta variable y la pérdida ósea peri-implante o la tasa de fracaso(12).

Malchiodi y cols presentan resultados a los 10 años acerca de la influencia de la proporción corona-implante sobre el éxito de los implantes cortos. En su estudio, la media de proporción corona-implante es de 3,11; es decir una proporción superior a 3:1. Encuentran que esta alta proporción no altera la tasa de éxito ni la pérdida ósea peri-implante de los implantes cortos(33).

Henny J.A. y cols(38) presentan una metaánalisis sobre los implantes cortos unitarios que tampoco encuentra relación entre estas dos variables (proporción de 0,9 a 2,2)(38). Tang y cols(39) presentan el mismo resultado en su estudio a los 4 años.

Esta ausencia de relación significativa entre la alta proporción corona-implante y la pérdida ósea peri-implante se puede explicar debido al acúmulo de fuerzas oclusales al nivel de la cresta ósea que estimulan la creación de hueso en esta zona.

Los estudios más recientes están entonces de acuerdo sobre el hecho de que una proporción corona-implante aumentada, característica de los implantes cortos, no perjudica al pronóstico del tratamiento gracias a los avances técnicos y a las fuerzas biomecánicas.

La limitación principal de nuestro estudio ha sido la falta de consenso acerca de la definición de los implantes cortos. Nuestro estudio compara los implantes estándares con los implantes cortos cuyo rango de longitud es muy alto. Este rango puede ser causante de resultados alterados, debido a que un implante corto de 5 mm de longitud no actúa igual clínicamente que un implante corto de 8 mm. La tasa de éxito se verá también afectada por el diámetro del implante, puesto que el aumento de diámetro aumenta consideramente la superficie del implante.
Sería entonces conveniente para los odontólogos hacer estudios que comparan los diferentes implantes en función de su cantidad de superficie y no solamente en función de su longitud y/o de su diámetro, en razón de que un implante corto con diámetro aumentado resulta tener más interfase hueso-implante que un implante ligeramente más largo pero estrecho.

De cualquier forma los implantes cortos y extracortos representan una opción terapéutica en constante evolución y su uso puede extenderse a la rehabilitación de arcadas mandibulares atróficas completas, según L. Guida y cols[28]. Más estudios a largo plazo son necesarios para confirmar la viabilidad de estos avances.

6) Conclusión

1) Los implantes cortos, definidos hoy en día como implantes de longitud inferior o igual a 8 mm, representan una buena alternativa a las técnicas quirúrgicas invasivas de regeneración ósea por el menor tiempo de tratamiento y la menor morbilidad que tienen.
2) La tasa de éxito de los implantes cortos en el sector posterior de la mandíbula es ligeramente inferior a largo plazo con respecto a los implantes estándares. Sin embargo, cuando el hueso residual no es suficiente para colocar un implante estándar, los implantes cortos representan una opción terapéutica con buen pronóstico.
3) Las complicaciones quirúrgicas son menos frecuentes durante la colocación de los implantes cortos que en las cirugías regenerativas necesarias para colocar un implante estándar.
4) La proporción corona-implante aumentada (hasta 3:1) permite estimular la creación de hueso al nivel coronal del implante y permite obtener menos pérdida ósea peri-implante a largo plazo. A corto plazo (al año), no se encuentra diferencia significativa en esta variable entre los implantes cortos y los implantes estándares colocados en hueso regenerado.
5) Los estudios científicos a largo plazo empiezan a ser publicados y tienden a ser muy alentadores acerca de la viabilidad de los implantes cortos en el hueso mandibular atrófico.

7) Responsabilidad

Realizando este trabajo, se cumplieron las siguientes responsabilidades:

- Responsabilidad económica: el estudio de los implantes cortos permite demostrar que representan una opción de tratamiento válida en casos concretos. Esta técnica novedosa permite reducir en gran medida los costes de los tratamientos para los profesionales y por consecuente para los pacientes.

  El tiempo en el sillón reducido, la ausencia de necesidad de usar biomateriales o membranas de colágeno reabsorbibles y otros instrumentos estériles contribuyen a reducir el precio de los tratamientos de manera considerable.

- Responsabilidad medioambiental: dar fiabilidad a la colocación de los implantes cortos y demostrar su eficacia en las mandíbulas atróficas permite ofrecer a los profesionales opciones terapéuticas más ecológicas que las regeneraciones óseas, ya que permiten ahorrar tiempo de trabajo y materiales que contaminan el medioambiente.

- Responsabilidad social: este estudio ayuda a los profesionales saber si los implantes cortos representan una opción terapéutica válida, que pueden ofrecer a sus pacientes, siguiendo los principios éticos de beneficencia y no maleficencia al paciente.

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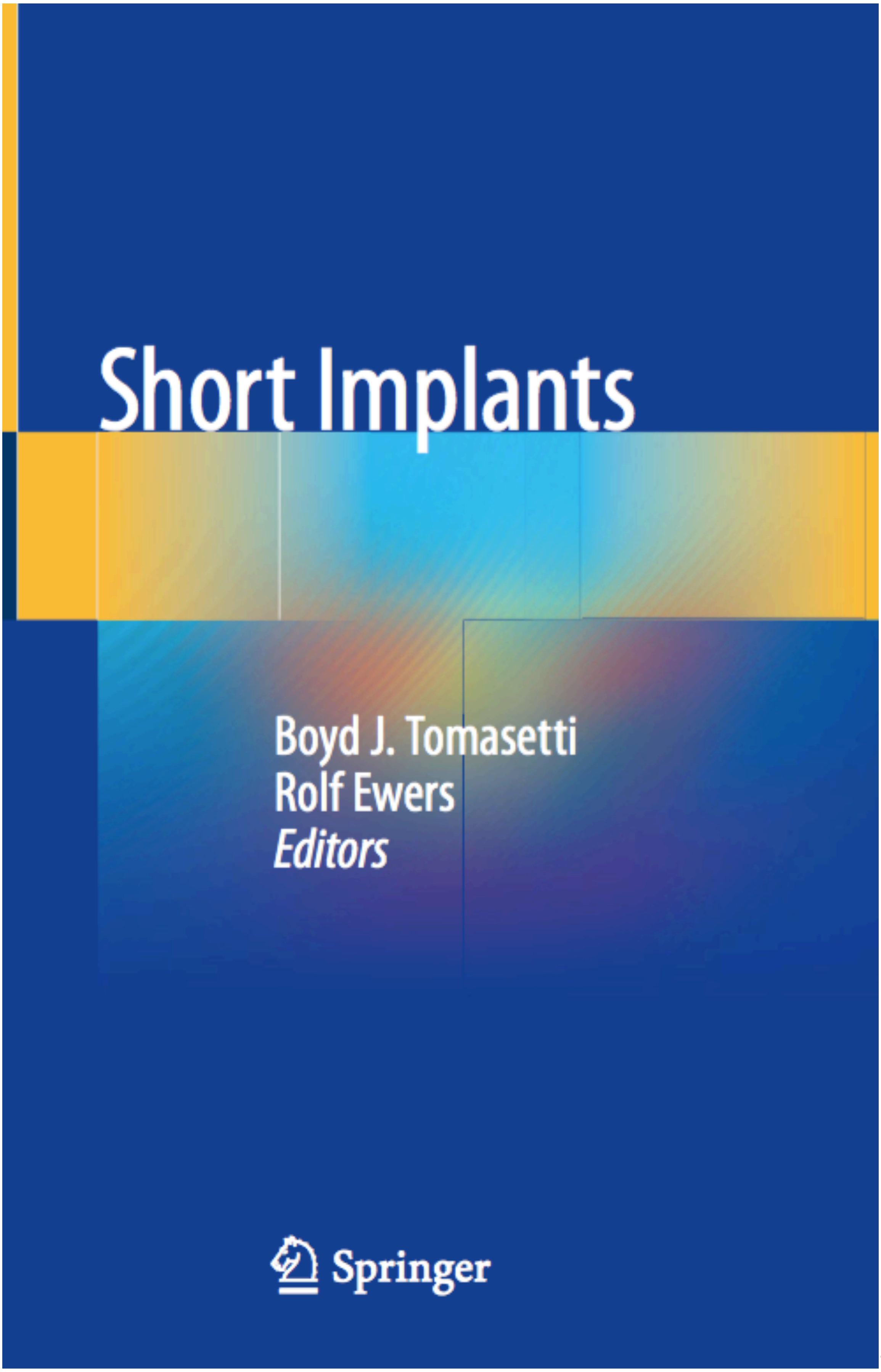
9) Anexos


Short Implants
Boyd J. Tomasetti
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[1]

CLINICAL REVIEW

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Short Dental Implants: A Systematic Review

ABSTRACT

Growing evidence has suggested the utility of short dental implants for oral reconstructive procedures in clinical situations of limited vertical bone height. The aim of this review was to systematically evaluate clinical studies of implants < 10 mm in length, to determine short implant-supported prosthesis success in the atrophic jaw. Implant survival, incidence of biological and biomechanical complications, and radiographic peri-implant marginal bone loss were evaluated. Screening of eligible studies, quality assessment, and data extraction were conducted by two reviewers independently. Meta-analyses were performed by the pooling of survival data by implant surface, surgical technique, implant location, type of edentulism, and prosthetic restoration. Two randomized controlled trials and 14 observational studies were selected and analyzed for data extraction. In total, 6193 short-implants were investigated from 3848 participants. The observational period was 3.2 ± 1.7 yrs (mean ± SD). The cumulative survival rate (CSR) was 99.1% (95%CI: 98.8-99.4). The biological success rate was 98.8% (95%CI: 97.8-99.8), and the biomechanical success rate was 99.9% (95%CI: 99.4-100.0). A higher CSR was reported for rough-surfaced implants. The provision of short implant–supported prostheses in patients with atrophic alveolar ridges appears to be a successful treatment option in the short term; however, more scientific evidence is needed for the long term.

KEY WORDS: dental implant, short implant, success rate, survival rate, literature review, dental prosthesis, implant-supported.

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INTRODUCTION

Over the years, various strategies have been proposed to overcome the dimensional limitations of the bone available for implant placement. Several surgical interventions for bone augmentation have been proposed, including bone grafts, guided bone regeneration, distraction osteogenesis, sinus floor elevation, mandibular nerve transposition, and the use of tilted or zygomatic implants. Although these techniques have gained a degree of success through the years, with the exception of sinus floor elevation, there are insufficient data on their predictability. Short implants (SHIs) have been proposed as an alternative choice for the prosthetic treatment of atrophic alveolar ridges, which may provide surgical advantages including reducing morbidity, treatment time, and costs.

However, longer implants have always been considered more reliable due to both an improved crown-to-implant ratio and a greater surface area available for osseointegration, which dissipates the imposed occlusal forces.

The introduction in the last decade of modified implant designs and micro-structured implant surfaces that augment the integratable surface area could help to compensate for the adverse effects of decreasing the implant length, so as to maintain the extent of the bone-implant interface (Goené *et al.*, 2005). The biomechanical rationale behind the use of SHIs is that the crestal portion of the implant body is the most involved in load-bearing, whereas very little stress is transferred to the apical portion (Lum, 1991) and the increase of implant length from 7 to 10 mm did not significantly improve its anchorage (Bernard *et al.*, 2003). Therefore, implant length may not be a primary factor in distributing prosthetic loads to the bone-implant interface. However, the poor bone density of the atrophic jawbone, the posterior location in the mouth, and the augmented crown height of the restorations represent important risk factors in the use of SHIs that might jeopardize their survival.

The present study was undertaken to gather and evaluate data from published articles to assess if the provision of short implants in patients with atrophic alveolar ridges may satisfy the desired outcomes of a successful implant therapy, as described by the Academy of Osseointegration Guidelines (2010) (for a detailed description, see Appendix Table 1).

In this review, implants with lengths of less than 10 mm were considered "short".

MATERIALS & METHODS

Study Selection Criteria

Study selection criteria were as follows:

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SYSTEMATIC REVIEWS AND META-ANALYSIS

WILEY

Are <7-mm long implants in native bone as effective as longer implants in augmented bone for the rehabilitation of posterior atrophic jaws? A systematic review and meta-analysis

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Abstract

Purpose: To compare clinical and radiographic outcomes of <7 mm short (SH) implants inserted in native bone vs longer (ST) implants placed in vertically augmented partially edentulous posterior jaws. A further aim was to evaluate if the residual bone dimension plays a role in the outcomes of SH and extra-SH implants.

Materials and Methods: This review was registered with PROSPERO. An electronic literature search was performed on PubMed, Scopus and Web of Science. Randomized controlled trials (RCTs) with at least 1-year follow-up, comparing fixed prostheses supported by SH vs ST implants in augmented sites were included. Marginal bone level (MBL) changes, implant survival rate, and complications were evaluated through a meta-analysis. Subgroup analysis was performed dividing the SH implants according to length at each follow-up (1-, 3-, 5-year of function).

Results: Twenty-five articles fulfilled the inclusion criteria, featuring a total of 650 SH implants placed in 415 patients and 685 ST implants placed in 403 patients. There was a trend for a significantly lower MBL associated with SH implants respect to ST implants at each follow-up, whilst there was no evidence of a difference in failure rates between SH and ST implants, for any SH length considered and at any follow-up. There was evidence for a lower incidence of complications in favor of SH implants at both 1-year ($P < .0001$) and 3-year follow-up ($P = .01$), while at 5-year follow-up there was no evidence of a difference between SH and ST groups ($P = .30$).

Conclusion: SH implants supporting partial fixed rehabilitations represent a valuable alternative to augmentation procedures in the medium term. While the performance of implants at least 5-mm long is well documented, more studies with at least 5-year follow-up are needed to confirm the promising outcomes observed with <5 mm-long fixtures.

KEYWORDS
complications, dental implants, extra-short implants, marginal bone loss, short implants, survival rate

† These authors share the first position.

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REVIEW ARTICLE

Key factors influencing short implant success

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Abstract

Aim This systematic article reviews the literature on the confounding parameters that affect short implant survival in order to establish specific surgical and prosthetic protocols that create an optimal biomechanical scenario and ensure implant longevity.

Materials and methods The available literature was screened for randomized clinical trials and prospective cohort and retrospective studies, published up to February 20, 2020, on the prognosis of short-length implants placed in posterior jaws. Studies evaluating the 5-year clinical performance of short dental implants (5 mm or 6 mm) in fixed rehabilitations of partially edentulous posterior jaws were included.

Results Eleven studies were selected after assessment of inclusion and exclusion criteria, of which 8 were RCTs, 2 were prospective studies, and 1 was a retrospective study. After 5 years in function, 22 short (12 in maxilla and 10 in mandible) and 10 standard (2 in maxilla and 8 in mandible) implants were lost, resulting in high survival rates independent of implant length or location. More biological complications were found in standard implants especially those placed in augmented posterior mandibles (135 complications compared to 48 in short mandibular implants). Splinted prostheses were associated with less technical complications (15 out of 53 complications affecting short implants).

Conclusion The findings of this review showed that, when used correctly, short implants achieve predictable and promising long-term outcomes, provided they are placed following a comprehensive surgical and prosthetic protocol, based on the different biomechanical parameters essential to optimize long-term prognosis.

Clinical significance The use of short implants in clinical practice has considerably increased in a wide variety of cases, given that they offer several advantages for both patient and practitioner. Recent literature shows that, when specific criteria are respected, new generations of short implants present high, long-term survival rates. This review is designed to provide a thorough understanding of the surgical and prosthetic protocols that create an optimal biomechanical scenario for short implants and improve their prognosis.

Keywords Short implant · Posterior maxilla · Posterior mandible · Survival rate · Surgical parameters · Prosthetic parameters

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Introduction

For decades now, implants are considered the golden solution for the rehabilitation of partially or completely edentulous jaws. In many clinical situations, the use of standard-length implants is contraindicated due to the presence of vital anatomical obstacles such as the maxillary sinus and the alveolar nerve. In order to rehabilitate such reduced volume sites, treatment options are either non-invasive therapy that adapts to the clinical situation (short/angulated/zygomatic implants) or additional surgical therapy that relies on augmentation procedures in order to increase bone volume (GBR, sinus floor elevation…). In the past, the use of reduced-length implants was avoided because of their high failure rates. Consequently, researchers focused on placing the longest implant possible to increase chances of implant survival. Recently, and with the


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Original Article

Effect of macro-design in the primary stability of short and extra-short implants using resonance frequency analysis. An ex vivo study

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ABSTRACT

Objective: This study aimed to determine the effect of macro design in the primary stability of short and extra-short implants using resonance frequency analysis (RFA).
Material and methods: On an ex-vivo model using pig's ribs, we inserted 80 short and extra-short dental implants (20 implants per brand): Biohorizons®(B) 4.6 × 6mm; Intralock®(I) 4.75 × 6.5 mm; Straumann®(S) 4.1 × 4mm; and Tixos®(T) 5 × 5mm. Primary implant stability was measured using an RFA device. We compared mean ISQ values through ANOVA test.
Results: Mean ISQ values: B = 73.36 (± 3.39); I = 75.13 (± 3.88); S = 65.38 (± 8.38); T = 72.13 (± 11). B and I showed higher ISQ than S (p-value < 0.001). Short (I) showed higher ISQ than extra-short (B,S,T) implants (p-value = 0.001). Tapered (B,I) had higher ISQ than parallel (S,T) implants (p-value < 0.001). There was a moderate positive correlation between ISQ and length (r = 0.52), and a weak correlation with diameter (r = 0.33).
Discussion: The final result is a combination of implant design, length, and diameter. Tapered design (B and I) and larger implants (I) showed better primary stability in terms of ISQ values. This information could be beneficial at implant selection in a severely reabsorbed low-quality bone, privileging length (as long as it is safe), and conical walls design.

1. Introduction

Sufficient bone volume (height and width) is necessary for predictable functional and esthetic results of dental implants. Tooth loss is always associate with bone volume resorption.[1] The amount of bone loss could be up to 22% of the original volume during the first six months after extraction, being in the horizontal and vertical plane, compromising the implant placement surgery.[1] Also, the vertical bone loss could expose anatomic structures (e.g., inferior alveolar nerve and vessels, maxillary sinus) to surgical damage during dental implant placement. Several bone augmentation surgical techniques have been proposed in the literature, adding monetary cost, longer treatment times, and morbidity to the patient.[2]

Short dental implants have proven to be a reliable and safe technique that can avoid these drawbacks with excellent survival rates comparable to standard size implants (risk difference of −0.02; 95%CI: -0.04-0.00, in favor of short implants).[3] Among short implant literature, there are multiple designs proposed by different manufacturers making complicated their comparisons. Some classifications are available to classify them, particularly in terms of their length.[4–6] For this article, we will use the classification proposed by Al-Johany et al.[7] for diameter: extra narrow (< 3 mm), narrow (≥3.0 mm to < 3.75 mm), standard (≥3.75 mm to < 5 mm) and wide (≥5.0 mm); for length: extra-short (≤6 mm), short (> 6 mm to < 10 mm), standard (≥10 mm to < 13 mm), and long (≥13 mm).

There is consensus that implant stability plays a vital role in achieving osseointegration and is a prerequisite for immediate loading protocols.[8] Primary stability definition is the absence of movement at the surgery time that is obtained by the friction between the implant and the bone walls.[9] It depends on surgical factors (surgical technique and implant design), and patient factors (bone quality and quantity).[10] Dental implant macro-design could affect primary stability, especially considering that short and extra-short implants could have less contact area during insertion in the bone. Design characteristics such as diameter, length, wall design (parallel, tapered), thread (v-shaped, square, buttress, reverse buttress, etc.), facial angle, and apex design can influence implant stability.[11]

Due to the variety of short implant designs, and their possible influence on primary stability, we aimed to determine the effect of macro-design in the primary stability of short and extra short implants using

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Clinical Paper
Dental Implants

Short implants (6 mm) vs. vertical bone augmentation and standard-length implants (≥9 mm) in atrophic posterior mandibles: a 5-year retrospective study

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F. Pieri, C. Forlivesi, E. Caselli, G. Corinaldesi: Short implants (6 mm) vs. vertical bone augmentation and standard-length implants (≥9 mm) in atrophic posterior mandibles: a 5-year retrospective study. Int. J. Oral Maxillofac. Surg. 2017; xxx: xxx–xxx.

Abstract. This retrospective study compared the 5-year clinical and radiographic outcomes of short implants (6 mm) (short group), and standard-length implants (≥9 mm) placed after a vertical augmentation with autologous bone blocks (augmentation group), supporting partial fixed prostheses in the posterior mandible. Forty-five partially edentulous patients were enrolled in the study and evaluated after 5 years: 22 (51 implants) in the augmentation group and 23 (46 implants) in the short group. Eight surgical complications occurred in the augmentation group versus none in the short group ($P = 0.003$). One short implant failed before loading and one standard-length implant failed after 4 years because of peri-implantitis ($P = 1.0$). Eight biological and two prosthetic complications occurred in the augmentation group vs. three biological and three prosthetic complications in the short group ($P = 0.09$ and $P = 1.0$, respectively). A mean marginal bone loss of 1.61 ± 1.12 mm in the augmentation group and 0.68 ± 0.68 mm in the short group was found ($P = 0.002$). Within the limitations of this study, both techniques resulted in successful clinical results after 5 years, but short implants exhibited less surgical complications and marginal bone loss than standard-length implants placed in augmented bone.

Key words: atrophic mandible; vertical augmentation; bone graft; short dental implants.

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QUINTESSENCE INTERNATIONAL
IMPLANTOLOGY


Sara N. Shah

Can extra-short dental implants serve as alternatives to bone augmentation? A preliminary longitudinal randomized controlled clinical trial

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Objective: A randomized trial to assess clinical and radiographic outcomes of short versus standard dental implants placed with concomitant vertical bone augmentation. **Method and Materials:** Patients requiring dental implants were randomized to receive either 6-mm implants (experimental) or 10-mm implants with vertical augmentation (control). Custom load-bearing healing abutments were connected to allow for indirect resonance frequency analysis measurements. Standardized radiographs were taken at implant placement (baseline), and at 3 and 12 months. Implants were restored at 3 to 6 months, and final measurements were taken at 12 months. **Results:** Fifty patients with 25 implants per group were included. Five implants failed, four experimental and one control (84% and 96% cumulative survival rate, respectively). Short implants required significantly less surgical time (51.6 ± 23 versus 68.5 ± 35 minutes, $P = .05$). Implant stability quotients at baseline (67.9 ± 8.3 experimental and 70.8 ± 7.6 control, $P = .215$) and 12 weeks (70.17 ± 7.4 and 72.03 ± 5.9, respectively, $P = .513$) were similar and unchanged. Positive correlation was found between the two measurement methods ($r^2 = .6$, $P = .025$). One-year average marginal bone loss was slightly lower for the experimental group (0.6 ± 0.16 mm) compared to the control group (0.86 ± 0.19 mm); however, this was not statistically significant ($P = .287$). **Conclusion:** Short dental implants may offer an alternative for implant placement in an atrophic jaw; however, they are associated with reduced first-year survival rate. Short dental implants should be used judiciously in light of this potential predicament, and alternatives assessed.
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Key words: bone loss, immediate restoration, regeneration, short implants, success, survival

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Atrophic or suboptimal alveolar bone in sites requiring dental implant placement presents one of the greatest challenges in implant dentistry. Both maxillary and mandibular ridges begin to resorb postextraction, and will continue to atrophy over time.[1] The current standard of care for these atrophied areas involves bone augmentation prior to or during placement of an implant. There are numerous treatment modalities to negotiate these deficient ridges including the use of various barriers, bone grafts from different sources and forms, distraction osteogenesis, sinus augmentation procedures, and even placement of tilted implants.

Vertical Ridge Augmentation in the Atrophic Mandible: A Systematic Review and Meta-Analysis

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Purpose: *To systematically appraise the effectiveness/reliability of vertical ridge augmentation (VRA) in the atrophic mandible. Articles that addressed any one of the following four areas were included in this study: amount of VRA, implant survival (ISR) and success rates (SSR) in the area of newly regenerated bone, complication rate during the bone augmentation procedure, and bone resorption.* ***Materials and Methods:*** *An electronic literature search was conducted by two independent reviewers in several databases, including MEDLINE, EMBASE, Cochrane Central Register of Controlled Trials, and Cochrane Oral Health Group Trials Register databases for articles reporting VRA in the atrophic mandible via distraction osteogenesis (DO), inlay block grafting (IBG), onlay block grafting (OBG), and guided bone regeneration (GBR). For meta-analysis, two primary (VRA and ISR [%]) and two secondary outcomes were studied (SSR [%] and vertical bone resorption [VBR] [%]). Additionally, for qualitative assessment, complications (ie, causes of failure) were further extracted and comprehensively described.* ***Results:*** *Overall, 73 full-text papers were evaluated. Of these, 52 articles fulfilled the inclusion criteria. The weight mean (WM) of VRA (± SD) was 4.49 ± 0.33 mm (95% CI: 3.85 to 5.14 mm). It was most notable that DO involved greater VRA than IBG, and thus, significantly higher than GBR and OBG. The technique significantly influenced the mean VRA obtained (P < .001). Nonetheless, no technique showed superiority in terms of ISR or SSR. VBR and complications were shown to be minimized for GBR.* ***Conclusion:*** *If ~ 4 mm of VRA is needed, any technique in optimum local and systemic conditions should be equally reliable in the atrophic mandible. However, when greater VRA is needed, DO and IBG have demonstrated accuracy. By means of complication and VBR rates, GBR was shown to have the lowest. For ISR and SSR, no statistical differences existed among all techniques. Controlled studies are needed to examine the long-term peri-implant bone fate and the frequency of biologic complications in each technique applied for the vertical augmentation of the atrophied mandible.* INT J ORAL MAXILLOFAC IMPLANTS 2017;32:291–312. doi: 10.11607/jomi.4861

Keywords: *alveolar bone, bone, dental implant, endosseous implant, evidence-based dentistry, trabecular*

In the era of modern implantology, the advancement of techniques and biomaterials as well as implant micro-/macrodesigns allows clinicians to confront challenging scenarios with high predictability. For instance, short[1] and narrow[2] implants in the edentulous ridges permit oral rehabilitation in the areas of limited bone height and width. For example, short dental implants have shown not only to be effective in restoring function,[1,3] but also for having acceptable long-term outcomes in the presence of an incommensurable crown-to-implant ratio.[4] However, in cases of severe ridge atrophy, the aforementioned alternatives might not be feasible. As such, bone regenerative procedures are needed. It has been shown that in areas of slight vertical atrophy (≤ 3 mm), more conservative approaches are often recommended (ie, orthodontic extrusion); however, for medium (4 to 6 mm) or large (> 7 mm) defects, guided bone regeneration (GBR) or onlay bone graft (OBG) might be preferred.[5] Furthermore, not only the size of the defect but also the defect location might play a role in deciding what procedure to choose. In the posterior atrophic maxilla, sinus floor augmentation has shown high reliability in achieving mechanical and biologic stability.[6]

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Short implants versus longer implants in vertically augmented posterior mandibles: result at 8 years after loading from a randomised controlled trial

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Key words *bovine anorganic bone, inlay graft, short dental implants, vertical augmentation*

Purpose: To evaluate whether 6.6-mm long implants could be a suitable alternative to longer implants placed in vertically augmented atrophic posterior mandibles.

Materials and methods: Sixty partially edentulous patients having 7 to 8 mm of residual crestal height and at least 5.5-mm thickness measured on computed tomography scans above the mandibular canal were randomly allocated according to a parallel-group design either to receive one to three submerged 6.6-mm long implants or 9.6-mm or longer implants (30 patients per group) placed in vertically augmented bone. Bone was augmented with interpositional anorganic bovine bone blocks fixed with titanium plates and covered with resorbable barriers. Grafts were left to heal for 5 months before implant placement. Four months after implant placement, provisional acrylic prostheses were delivered, replaced, after 4 months, by definitive metal-ceramic prostheses. Outcome measures were: prosthesis and implant failures, complications, and radiographic peri-implant marginal bone level changes. Patients were followed up to 8 years after loading.

Results: Eight years after loading 12 patients dropped out, five from the short implant group and seven from the augmented group. The augmentation procedure failed in two patients and only 6.6-mm long implants could be inserted. There were no statistically significant differences for prosthesis and implant failures. Four prostheses failed in three patients of the short implant group versus three prostheses in three patients of the augmented group (Fisher exact test $P = 1.000$; difference in proportions = 0.01; 95% CI: –0.19 to 0.22). Five short implants failed in three patients versus three long implants in three patients (Fisher exact test $P = 1.000$; difference in proportions = 0.01; 95% CI: –0.19 to 0.22). There were statistically more complications in augmented patients (27 complications in 22 augmented patients versus 9 complications in 8 patients of the short implant group) (Fisher exact test $P < 0.001$; difference in proportions = 0.64; 95% CI: 0.38 to 0.79). Both groups gradually lost peri-implant bone in a statistically significant way. Eight years after loading, short implant group patients lost an average of 1.58 mm of peri-implant bone compared with 2.46 mm in the augmented group. Short implants experienced statistically significantly less bone loss (0.88 mm, 95% CI: 0.50 to 1.26 mm) than long implants.

Conclusions: When residual bone height over the mandibular canal is between 7 and 8 mm, 6.6-mm short implants are an interesting alternative to vertical augmentation in posterior atrophic mandibles since the treatment is faster, cheaper and associated with less morbidity.

Conflict of interest statement: *Biomet 3i manufactured the implants used in this investigation and partially supported this trial up to the 5-year follow-up; however, data belonged to the authors and Biomet 3i was not involved in the conduct of the trial or the publication of the results. After that date Biomet 3i was acquired by Zimmer Dental, and sponsorship of the study was discontinued.*

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WILEY CLINICAL ORAL IMPLANTS RESEARCH

REVIEW ARTICLE

Survival rates of short dental implants (≤6 mm) compared with implants longer than 6 mm in posterior jaw areas: A meta-analysis

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Abstract

Purpose: To systematically review randomized controlled clinical trials (RCTs) reporting on the long-term survival and failure rates, as well as the complications of short implants (≤6 mm) versus longer implants (>6 mm) in posterior jaw areas.

Materials and Methods: Electronic and manual searches were conducted to identify studies, specifically RCTs, reporting on short dental implants (≤6 mm) and their survival and complication rates compared with implants longer than 6 mm. Secondary outcomes analyzed were marginal bone loss and prosthesis survival rates.

Results: Ten RCTs fulfilled the inclusion criteria and featured a total of 637 short (≤6 mm) implants placed in 392 patients, while 653 standard implants (>6 mm) were inserted in 383 patients. The short implant survival rate ranged from 86.7% to 100%, whereas standard implant survival rate ranged from 95% to 100% with a follow-up from 1 to 5 years. The risk ratio (RR) for short implant failure compared to standard implants was 1.29 (95% CI: 0.67, 2.50, $p = 0.45$), demonstrating that overall, short implants presented higher risk of failure compared to longer implants. The heterogeneity test did not reach statistical significance ($p = 0.67$), suggesting low between-study heterogeneity. The prosthesis survival rates from the short implant groups ranged from 90% to 100% and from 95% to 100% for longer implant groups, respectively.

Conclusion: Short implants (≤6 mm) were found to have *higher variability* and *lower predictability* in survival rates compared to longer implants (>6 mm) after periods of 1–5 years in function. The mean survival rate was 96% (range: 86.7%–100%) for short implants, and 98% (range 95%–100%) for longer implants. Based on the quantity and quality of the evidence provided by 10 RCTs, short implants with ≤6 mm length should be carefully selected because they may present a greater risk for failure compared to implants longer than 6 mm.

KEYWORDS
dental implants, short dental implants

Short Implants

An Answer to a Challenging Dilemma?

Steven R. Schwartz, DDS[a,b,*]

KEYWORDS

• Dental implants • Short dental implants • Bone grafting • Bone augmentation
• Sinus grafts • Vertical bone graft • Complications

KEY POINTS

- Short implants (<8 mm) have been promoted as a treatment option in many clinical scenarios with limited bone volume where long/standard length implants were otherwise contraindicated if not for complex, sophisticated and costly bone augmentation procedures that would have been required.
- This article reviews the efficacy of using the currently available short implants with enhanced macrosurface and microsurface technology and abutment interfaces allowing their placement in cases previously thought ill-advised.
- This allows implant treatment in a potentially faster, less expensive, less complicated manner, with decreased morbidity and comparable success rates with long/standard length implants with concomitant bone augmentation procedures.

INTRODUCTION

Mankind's desire for teeth to be able to chew and smile precedes all recorded dissertations on dentistry. Human mandibles with seashells carved into tooth shapes and placed into extraction sockets date back as far 600 AD.[1] But, at what cost, physically, financially, and emotionally to our patients? Decreasing bone quantity and quality has traditionally necessitated increasing surgical complexity, cost, and potential complications. Is there anything we can do to mitigate these potential road blocks to successful implant treatment? Maybe short implants can be part of the solution.

WHAT ARE SHORT IMPLANTS?

There is still no generally accepted length to classify implants as standard or long, short, and ultrashort. Various authors have defined implant lengths less than 11 mm,[2] 10 mm,[3] 8 mm,[4] and 7 mm[5] as short implants. When this author first wrote about this topic in

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Review Article

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Dentistry Section

Short Implants: New Horizon in Implant Dentistry

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ABSTRACT

The choice of implant length is an essential factor in deciding the survival rates of these implants and the overall success of the prosthesis. Placing an implant in the posterior part of the maxilla and mandible has always been very critical due to poor bone quality and quantity. Long implants can be placed in association with complex surgical procedures such as sinus lift and bone augmentation. These techniques are associated with higher cost, increased treatment time and greater morbidity. Hence, there is need for a less invasive treatment option in areas of poor bone quantity and quality. Data related to survival rates of short implants, their design and prosthetic considerations has been compiled and structured in this manuscript with emphasis on the indications, advantages of short implants and critical biomechanical factors to be taken into consideration when choosing to place them. Studies have shown that comparable success rates can be achieved with short implants as those with long implants by decreasing the lateral forces to the prosthesis, eliminating cantilevers, increasing implant surface area and improving implant to abutment connection. Short implants can be considered as an effective treatment alternative in resorbed ridges. Short implants can be considered as a viable treatment option in atrophic ridge cases in order to avoid complex surgical procedures required to place long implants. With improvement in the implant surface geometry and surface texture, there is an increase in the bone implant contact area which provides a good primary stability during osseo-integration.

Keywords: Dental implants, Functional surface area, Implant length, Poor bone quality

INTRODUCTION

The choice of implant length in relation to the available bone quality and quantity and biting force is a critical factor in the success of implants and longevity of the prosthesis. Long implants have always been considered more desirable in this respect but in patients with advanced alveolar bone resorption their placement is problematic due to the anatomic boundaries. Anatomical limitation in resorbed maxilla includes the maxillary sinus posteriorly and nasal floor and nasopalatine canal anteriorly whereas in resorbed mandible it is inferior alveolar canal. Advanced surgical procedures such as guided bone regeneration, block grafting, maxillary sinus floor grafting, distraction osteogenesis and nerve repositioning can be carried out to gain alveolar height in these areas and permit placement of long length implants but these techniques are sensitive, challenging, costly, time consuming and increase surgical morbidity. Short implants offer a less invasive treatment alternative in resorbed ridge cases [1-3]. There is no general consensus on the definition of short implant. Most of the authors have considered implants less than 10mm as short implants [4-6]. [Table/Fig-1] summarizes the studies conducted on short implants depicting their survival rates and comparison with long implants.

Author	Year	Study
Wyatt et al., [7]	1998	Studied 77 patients with 230 machined implants with a follow-up of 12 years and found that cumulative survival rate of short implants was 75% whereas that of long implants was 95%
Bahat et al., [8]	2000	Found a high failure rate of 17% for 7mm and 8.5mm implants
Weng et al., [9]	2003	Conducted a study on 493 patients with 1179 implants with a follow-up of 72 months and found a cumulative survival rate of 74% with 7mm implants, 81% with 8.5mm implants and 93.1% with >10mm implants
Herrmann et al., [10]	2005	Conducted a multicenter analysis of 487 implants and found a 10.1% failure rate for 10mm implants and 21.8% failure rate for 7mm implants
Esposito et al., [1]	2011	Conducted a study on 60 patients comparing 6.3mm with 9.3mm implants associated with vertical augmentation procedure and found more complications with augmented patients and less bone loss, less time, less cost and less morbidity with short implants
Annibali et al., [11]	2012	Conducted a systematic review and meta-analysis and concluded that more long term follow-up results are required to support the use of short implants
Hassani et al., [12]	2013	Found initial post-operative sensory impairment to be the most common complication after inferior alveolar nerve transposition with 16% of patients left with a permanent and irreversible condition
Vasquez et al., [13]	2014	Documented complication rate in 200 sinus lift procedures and found that Schneiderian membrane perforation occurred in 25.7% of the cases
Al-Hashadi et al., [14]	2014	Concluded that there is sufficient evidence showing high success rates with short implants as compared to surgical augmentation procedures in the treatment of atrophic ridges
Nisandand Renouard [15]	2014	Reviewed studies on short implants and found similar survival rates and reduced treatment cost and time when compared to long implants assisted by advanced surgical procedures

[Table/Fig-1]: Studies comparing survival rates of long and short implants.

Advantages of Short Implants

1. Bone grafting to compensate for less height is unnecessary.
2. Less money, pain and time associated with various surgical procedures before placement of implant.
3. Complex surgical techniques are often associated with complications during surgery such as bleeding, perforation of the Schneiderian membrane or nerve injury and post-operatively such as transient or permanent alteration of mandibular sensation, graft and/or membrane exposure, infections and increased peri-implant bone loss. This can be avoided.
4. Osteotomy preparation is simplified since shorter bone preparation is required at the implant site which provides direct

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REVIEW

Short implants (5-8 mm) vs long implants (≥10 mm) with augmentation in atrophic posterior jaws: A meta-analysis of randomised controlled trials

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Abstract
The aim of this systematic review was to compare the survival rate, marginal bone loss changes and complications between short implants (5-8 mm) and long implants (≥10 mm) with a bone-augmented procedure in the posterior jaw. An electronic search of the MEDLINE (PubMed), Embase and Cochrane Library databases through September 2018 was done to identify randomised controlled trials (RCT) assessing short implants and long implants with at least a 1-year follow-up period after loading. A quantitative meta-analysis was conducted on the survival rate, marginal bone loss changes and complications. Ten RCTs met the inclusion criteria. There were no significant differences in the survival rate (RR: 1.01; 95% CI: [0.99, 1.03]; P = .32) and complications (RR: 0.48; 95% CI: [0.20, 1.17]; P = .11) between the two groups. Compared with the long implant group, the short implant group had a lower marginal bone loss change, and the effect measure was significant (mean difference: −0.13; 95% CI: [−0.20, −0.06]; P < .05). This systematic review showed no difference between the survival rates and complications of short implants (5-8 mm) and long implants (≥10 mm). The marginal bone loss changes in short implants are lower than those in long implants.

KEYWORDS
atrophic jaw, dental implant, meta-analysis, short implant

1 | INTRODUCTION

An edentulous posterior jaw is a common dentition defect in clinical practice. The loss of posterior teeth can lead to the elongation of jaw teeth, cause occlusal interference and affect the masticatory function of patients, which eventually reduce the quality of life of edentulous patients (Appendix 1).[1] Therefore, it is necessary to repair the defect of the posterior teeth.

In the defect of posterior teeth, it is greatly difficult to finish primary implant placement following with the expansion of the maxillary sinus and the resorption of the alveolar bone. Generally, previous methods to increase the ridge height in the posterior jaws, including maxillary sinus lifting, bone block graft.[2-5] However, there are some problems of the two methods, such as the complication of operation, the cost and duration of the treatment and the success rates. A systematic review showed that the complications of sinus floor elevation by a lateral window approach reached 38% in 3 years of follow-up,[6] and the failure rate of the implant was 17% over 3 years.[5] In addition, bone graft often leads to an unavoidable amount of resorption or even a high failure rate. Recently, the placement of short implants is considered an alternative treatment to avoid the complicated surgical procedures.

Generally, 5- to 8-mm-long implants have been defined as short implants. Short implants have high success rate and good stability with the development of material surface treatment technology and structural modifications of the titanium surface now.

ORIGINAL ARTICLE

Management of Limited Vertical Bone Height in the Posterior Mandible: Short Dental Implants Versus Nerve Lateralization With Standard Length Implants

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Abstract: Inferior alveolar nerve lateralization (IANL) and short dental implants (SDI) are 2 viable implant-based treatment approaches in the presence of atrophied posterior mandible. Despite the risks of dysfunction, infection, and pathologic fractures in IANL, it becomes possible to place standard implants. The purpose of this study was to compare SDI and IANL approaches from clinical and radiographic aspects. Fifteen subjects having unilateral atrophic mandibles were allocated to SDI and IANL treatment groups. Following surgical procedures, early postoperative complications, implant survival, and periimplant clinical and radiographic parameters including probing pocket depth, attachment level, keratinized tissue amount, vertical tissue recession, and marginal bone loss were recorded at baseline and 1-year after prosthetic rehabilitation. In both groups, no implant was lost. Except usual postoperative complications, 2 patients had transient paraesthesia after IANL. According to time-dependent evaluation, both groups showed significant increase in probing pocket depth and attachment level at 1-year follow-up compared with baseline ($P < 0.05$). Except a slight but significant increase in mesial surface of SDI group ($P < 0.05$), no remarkable time-dependent change was identified in vertical tissue recession. Keratinized tissue amount did not exhibit any inter- or intragroup difference during whole study period. Marginal bone loss did not show any difference between IANL and SDI groups at follow-up. SDI placement or standard length implant placement with IANL can be considered promising alternatives in the treatment of atrophic mandibular posterior regions. However, SDI may be preferred in terms of lower complication risk.

Key Words: Alveolar bone atrophy, dental implants, mandibular canal, nerve injury, paraesthesia

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Lack of sufficient bone height in the edentulous posterior regions of mandibula often restricts placing endosseous dental implants and presents a challenge for clinicians due to the presence of inferior alveolar nerve (IAN). To overcome this limitation in patients with severe mandibular atrophy, there are 3 treatment options such as short dental implant (SDI) placement, onlay vertical bone grafting, IAN lateralization (IANL) or repositioning that have been suggested.[1] There are several advantages and disadvantages for all proposed treatment options at their own.

Advanced surgical augmentation techniques such as vertical bone augmentation are often performed for placing long implants in vertically deficient alveolar ridges.[2,3] Vertical bone augmentation procedures on deficient alveolar ridges are technically sensitive and may cause significant morbidity and complications such as severe pain, swelling, and graft resorption.[4] Within these techniques, nerve lateralization is one of the treatment options to place dental implants in mandibular posterior area in the presence of limited bone height and/or highly located inferior alveolar nerve. The advantages of nerve lateralization can be summarized as follows: longer implants can be placed in the same surgical step, greater primary stability may be obtained due to bicortical mandibular fixation, and no bone grafting is needed.[5–7] However, the technique is complex, difficult, and may cause significant morbidity involving mandibular fracture and the neurosensory disturbances of anesthesia, paresthesia, and neuralgia.[8]

Short implant placement is a relatively novel approach in case of reduced bone height in edentulous sites and is proposed as an alternative to avoid from the disadvantages of vertical augmentation procedures such as increased cost, morbidity, and treatment time.[9] Although many studies have demonstrated that placement of short implants is a predictable treatment option,[10] there is still lack of strong evidence on the comparison of clinical short and long implants.[9] Some studies have shown higher marginal bone loss and higher failure rates after short implants when compared with long implants and the difference was attributed to crown–implant ratio.[11,12] On the other hand, several clinical studies have demonstrated high success rates with short dental implants.[13–16] Esposito et al[10] compared the results of vertical bone augmentation and short implants, and they suggested short implants as a superior treatment option to vertical bone grafting which have higher implant failure and complication rate. The inconsistency between studies regarding short implants may be due to several variables such as machined or rough surface characteristic, different surgical sites, the controversial definition of short implants.[9,17]

The null hypothesis tested in the study is no difference is present between inferior alveolar nerve lateralization and short dental implant procedures in terms of primary outcome measure against the alternative hypothesis of a difference. The aim of this study was

Fifteen-Year Follow-up of Short Dental Implants in the Completely Edentulous Jaw: Submerged Versus Nonsubmerged Healing

Eduardo Anitua, MD, DDS, PhD* and Mohammad Hamdan Alkhraisat, DDS, MSc, PhD†

Purpose: *Short implants are a minimally invasive alternative in the management of alveolar bone atrophy. This study aimed to assess the influence of the surgical approach (1-stage vs 2-stage) on the 15-year survival and marginal bone loss of short implants in a fixed complete denture.*

Materials and Methods: *A retrospective clinical study was conducted in a single private dental clinic that included short implants placed between January 2001 and December 2002.*

Results: *Forty-one short implants supported 18 screw-retained complete dentures. The mean follow-up time was 15 ± 3 years. The surgical approach (1-stage vs 2-stage) did not significantly affect implant survival and marginal bone loss. The implant survival rate was 90.2%.*

Conclusions: *Short dental implants could be predictably indicated to support fixed complete dentures. The implants could be placed through a 1- or 2-stage surgery. (Implant Dent 2019;28:551–555)*

Key Words: short implant, implant survival, marginal bone loss, submerged healing, long-term

Minimally invasive implantology has gained popularity in recent years.[1] This popularity could be related to improvements in the surface and design of the implants and to the development of minimally invasive surgical techniques that preserve, at most, the residual alveolar bone.[2,3]

The use of short implants could be an alternative to bone augmentation surgery. Short (length ≤8 mm) implants have been shown to have high survival rates and have resulted in 3 times fewer intraoperative complications compared with long implants.[4] Different meta-analysis studies have found similar implant and prosthesis survival rates for short dental implants and standard implants placed in vertically augmented bone.[5,6] Short dental implants may be the preferred treatment in atrophic alveolar bone, as they have been associated with lower biological complications and decreased morbidity, costs, and surgical times.[4,7]

There are 2 types of implant surgery: a 1-stage surgery in which the implant and a transmucosal abutment are placed in the same surgery (nonsubmerged healing) and a 2-stage surgery in which the implant and the abutment are placed in 2 different surgical interventions (submerged healing).[8–11] Submerged healing enables implant osseointegration, and it protects the implant from excessive micromovements.[8,9] Nonsubmerged healing is less invasive and shortens the time of implant loading and prosthesis delivery.[10,11] However, it is important to avoid implant micromovements that exceed 150 μm due to the detrimental effect on implant osseointegration and the increase in the risk of early implant failure.[12–15]

The high life expectancy at birth and the longevity of our patients indicate that dental implants work for an increased time. However, there is a paucity of clinical studies that have assessed the long-term prognosis of short dental implants. There have been few studies with a follow-up time longer than 10 years.[16–18]

The purpose of the study was to assess the long-term outcomes of short dental implants supporting fixed complete prostheses and the effect of the

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Potential Bone to Implant Contact Area of Short Versus Standard Implants: An In Vitro Micro–Computed Tomography Analysis

Alessandro Quaranta, DDS, PhD,* Orlando D'Isidoro, DDS,† Fabrizio Bambini, DDS,‡ and Angelo Putignano, MD, DDS§

Aim: *To compare the available potential bone-implant contact (PBIC) area of standard and short dental implants by micro–computed tomography (μCT) assessment.*

Methods: *Three short implants with different diameters (4.5 × 6 mm, 4.1 × 7 mm, and 4.1 × 6 mm) and 2 standard implants (3.5 × 10 mm and 3.3 × 9 mm) with diverse design and surface features were scanned with μCT. Cross-sectional images were obtained. Image data were manually processed to find the plane that corresponds to the most coronal contact point between the crestal bone and implant. The available PBIC was calculated for each sample. Later on, the cross-sectional slices were processed by a 3-dimensional (3D) software, and 3D images of each sample were used for descriptive analysis and display the microtopography and macrotopography.*

Results: *The wide-diameter short implant (4.5 × 6 mm) showed the higher PBIC (210.89 mm²) value followed by the standard (178.07 mm² and 185.37 mm²) and short implants (130.70 mm² and 110.70 mm²).*

Conclusions: *Wide-diameter short implants show a surface area comparable with standard implants. Micro-CT analysis is a promising technique to evaluate surface area in dental implants with different macrodesign, microdesign, and surface features. (Implant Dent 2016;25:97–102)*

Key Words: dental implant, short implant, x-ray microtomography

Micro–computed tomography (Micro-CT) analysis is a fast, noninvasive, and accurate x-ray microtomography for in vitro evaluation of specimens[1] that has been recently introduced in dentistry.[2] In this technique, bidimensional (2D), tridimensional (3D) reconstructions, and volumetric measurements can be obtained. In fact, it is possible to acquire 3D images of specimen with dimensions of 15 mm in extent and a resolution of 5 to 8 μ.[3] The availability of this technology has allowed to investigate the trabecular and cortical components of autologous bone specimen and alloplastic grafts without any irreversible sample preparation and consequent destruction.[4–7] Micro-CT has been also used to have 3D sample reconstructions, assess material volumes, and study the characteristic of different scaffolds.[8–10] Moreover, μCT analysis has been adopted to evaluate the bone-implant interface and assess the osseointegration process.[11,12]

The atrophy of jaws could jeopardize the use of dental implants with the necessity of bone grafting techniques to allow the placement of standard implants.[13,14] Bone augmentative procedures generally require an extensive autogenous donor site from intraoral or extraoral sites.[15] These procedures highly depend on soft and hard tissue management and are potentially at risk for a series of early and late complications that could hinder the final result.[16,17] In case of reduced crestal bone height, an alternative therapeutic procedure could be the placement of short implants with no need to perform additive surgical techniques provided that strict surgical procedures are adopted.[18–20] When placing a short dental implant, bone grafting or sinus floor elevation before implant placement is usually not necessary, the site preparation could be simplified, the potential for overheating is reduced,

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Immediate Loading of Fixed Partial Dental Prostheses on Extra-Short and Short Implants in Patients with Severe Atrophy of the Posterior Maxilla or Mandible: An Up-to-4-year Clinical Study

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Purpose: The goal of this study was to evaluate the cumulative survival rate and marginal bone loss (MBL) of extra-short (5- and 6-mm-long) and short (6.5-mm-long) implants inserted into severely atrophic, partially edentulous posterior maxillae and mandibles that were immediately restored with provisional fixed dental prostheses. ***Materials and Methods:*** Between October 2013 and December 2017, partially edentulous patients with severe vertical bone atrophy in the posterior area in need of replacement of premolars and/or molars with fixed prostheses were enrolled in the study. Analysis of cumulative survival rate and MBL was determined with respect to implant length at the longest, biannual follow-up period (38 ± 10 months; range: 25 to 48 months). ***Results:*** Fifty-five patients were included in the study. A total of 62 extra-short (5 and 6 mm), 15 short (6.5 mm), and 69 standard-length (≥ 10 mm) implants were immediately placed and loaded. Cumulative survival rates were similar for all implants (99.3%). One mandibular extra-short implant failed and was removed but was replaced 2 months later with another implant of the same length and diameter and successfully reloaded. Implant length did not impart any significant differences in MBL, though the presence or absence of platform switching was influential. ***Conclusion:*** The cumulative survival rate and MBL reported in this study encourage the use of short and extra-short implants to immediately restore with fixed prostheses partially edentulous patients with severe vertical bone atrophy in posterior areas. Thus, it could be an alternative treatment to vertical bone augmentation. *Int J Oral Maxillofac Implants 2020;35:607–615. doi: 10.11607/jomi.7943*

Keywords: immediate restoration, implant-supported prosthesis, occlusal loading, posterior edentulism, short implants

Dental implants have long been used to replace missing or "hopeless" teeth.[1] However, anatomical limitations such as inadequate posterior bone height may limit their use.[2,3] In the past, 10 to 12 mm of residual alveolar bone height has been considered to be the minimum amount of bone necessary to enable predictable implant treatment.[4] When dental implants were first introduced, an assumption was made that longer implants would not only prove more advantageous than shorter implants due to an improved crown-to-implant ratio,[5] but also offer greater implant surface area available for osseointegration.[1] A viable standard implant was considered to be 4 mm in diameter and 10 mm in length because these dimensions could ensure sufficient bone-to-implant contact and adequate crown-to-implant ratios for implant restorations.[6–9]

Frequently, posterior bone height is insufficient to allow for the use of such standard implants[2,10,11] unless invasive surgical procedures such as sinus elevations, vertical bone augmentation,[12–14] or alveolar nerve transposition have been undertaken. Risks of intraoperative and postoperative complications, infection, or graft resorption have been reported for these procedures, along with increased duration and cost of treatment.[15–18] Advancement in textured surfaces enabled increases of implant surface areas that presumably compensated for the shorter length of bone contact when using short implants. As a consequence, the use of short dental implants was suggested as an alternative to regenerative procedures in atrophic posterior ridges, where the presence of the maxillary sinus or the mandibular inferior alveolar canal often reduces available bone height.[19–21] In 1991, implants shorter than 10 mm (8 and 9 mm) were defined as "short." Since then, the definition of short implants has been controversial, with studies and reviews lacking consensus about the meaning of that term.[22] The present study adheres to a

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Short implant in limited bone volume

DAVID NISAND & FRANCK RENOUARD

Introduction

Rehabilitation of severely resorbed jaws with dental implants remains a surgical and prosthetic challenge for clinicians (25, 53). Several advanced surgical techniques have been developed over the years to restore bone volume, allowing the placement of dental implants and improving esthetic outcomes. The same surgical techniques have also been applied to improve crown-to-implant ratios, to allow the placement of longer implants and to optimize the positioning of implants for adequate load distribution. However, the latter indications remain controversial, and the increased treatment time, cost and risk of complications should be analyzed in line with the expected benefits.

Sinus lift elevation, guided bone regeneration, onlay bone grafting, distraction osteogenesis and displacement of the inferior alveolar nerve were developed and applied for the management of reduced alveolar bone height. Some of these techniques, such as sinus lift elevation, are supported by a large number of publications and display excellent survival rates for dental implants (18). On the other hand, less data are available for surgical displacement of the inferior alveolar nerve, vertical augmentation or distraction osteogenesis (26, 94, 107). Moreover, long-term follow-up studies of dental implants placed in augmented bone are not available for each technique. Even for the well-documented technique of sinus lift elevation, it should be remembered that the best results, obtained with rough surface implants and biomaterial, are based only on short-term follow-up studies (87).

Complex surgical techniques are often associated with complications (42). Complications may occur during surgery (such as bleeding (Fig. 1), perforation of the Schneiderian membrane (Fig. 2A–D) or nerve injury) or postoperatively (including transiently or permanently altered mandibular sensation (25), graft and/or membrane exposure (Fig. 3), infections (122) and increased peri-implant bone loss (88)). Even when the risk for complications is limited, advanced surgical techniques may be contraindicated in some patients for medical or anatomic reasons. As an alternative to complex surgeries (those performed to allow the placement of longer implants or for biomechanical reasons), the use of dental implants with reduced length should be considered. Along with their simplicity, short-length implants allow for less expensive and faster treatment with reduced morbidity (43, 44). However, both survival rate and indications are still controversial. In the past, short-length implants were often associated with increased failure rates (125), which were explained by reduced implant primary stability and bone-to-implant contact, as well as by unfavorable crown-to-implant ratios. As a consequence, the use of short-length implants was mainly restricted to rescue situations.

The purpose of this review was to evaluate the data available on the survival rate of short and extra-short implants and to discuss the impact of an increased crown to implant length ratio on biological and technical complications. Indications and clinical procedures for short-length implants in clinical practice are also reviewed, along with a discussion on the selection of the implant length. The paper also introduces a new concept in implant dentistry: stress-minimizing surgery.

Definition

There is still some controversy over the exact definition of a short-length implant. According to Striezel & Reichart (112), an implant of ≤11 mm is considered as short, whereas Tawil & Younan (114) stated that an implant must be ≤10 mm to be regarded as

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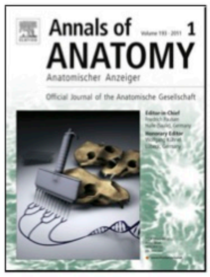

Title: 15-year follow-up of short dental implants placed in the partially edentulous patient: Mandible Vs maxilla

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Dental Implant Length and Diameter: A Proposed Classification Scheme

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Dental implant; size; diameter; length; classification.

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Abstract

Purpose: To propose a length-and-diameter-based classification scheme for dental implants to standardize terminology in the dental literature and communication between interested parties.
Materials and Methods: This study was mainly based on searching two major resources: published scientific research papers and 14 of the most popular dental implant manufacturers. Indexed databases were searched from January 2004 up to and including February 2016 using the keywords "dental implant length" and "dental implant diameter." Retrieved titles and abstracts were screened, and related full-text articles were reviewed. Full-text articles that clearly stated the terms and measurements of implants used were included and considered for proposing this classification scheme.
Results: The initial search for implant diameter and length yielded 1007 and 936 articles, respectively. A total of 85 studies (41 about diameter, 44 about length) were selected and reviewed. The remaining studies (966 about diameter, 892 about length) that did not abide by the eligibility criteria were excluded. The terms "long," "short," "standard," "wide," and "narrow" were the most commonly used terms in the literature. A classification scheme for implants by diameter and length was proposed.
Conclusions: Indexed publications contain a variety of terms used by authors to describe diameter and length of dental implants without conformity and standardization. The classification scheme proposed in this article could serve as a reference for interested parties.

With the increasing use of dental implants for the replacement of missing teeth, implants of varying dimensions have been fabricated in an attempt to manage different clinical scenarios. This growing demand on dental implants led to many manufacturers entering the dental implant industry, with more than 220 dental implant brands worldwide.[1] Each implant system has its own diameters and lengths not necessarily coinciding with other systems. Furthermore, there is no agreement between manufacturers in terms of definition and categorization. This confusion in diameter and length description has transferred to the scientific literature. For example, Renouard and Nisand[2] defined wide implants as those with a diameter of 4.5 mm or greater, whereas Mijiritsky et al[3] defined them as implants greater than 5 mm in diameter; however, Jackson[4] considered implants with a diameter of 4.7 mm to be "large implants." Moreover, Balaji et al[5] used the term "mini" for implants with a width of 2.4 mm, whereas Christensen[6] described implants with the same diameter as "small in diameter." Al-Nawas et al[7] also used the term "small" for implants with a diameter of 3.3 mm, which was considered "standard" in another study.[6]

Moreover, in a recent study by Romanos et al[8] the term "narrow implant" was used to describe a 3.7 mm diameter implant; however, Ioannidis et al[9] used the same term to define implants with a diameter of 3.3 mm. More interestingly, Christensen[6] termed 3.3 mm diameter implants as "standard diameter implants." Furthermore, Ertugrul and Pipko[10] categorized dental implants with diameters of 2.2 mm as mini-implants, whereas in Sivamurthy and Sundari's study,[11] dental implants with diameters ranging between 1 and 1.3 mm were considered "mini-implants." As a result of this confusion, it is not unexpected to find in the literature an implant with known diameter (1.8 mm) that has four different classifications in four different studies (mini,[12] small,[4] narrow,[13] and very small[14]). Another example of unconformity would be when two different terms were used to describe the same implant size by the same author.[11,15-17] These results suggest a lack of consensus over the definition of implant size (diameter).

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RESEARCH Open Access

Three-dimensional finite element analysis of extra short implants focusing on implant designs and materials

Haruka Araki, Tamaki Nakano*, Shinji Ono and Hirofumi Yatani

Abstract

Aim: When using short implants, fracture of the implant body and bone resorption are a concern because stress concentrates on and around a short implant. The purpose of this research is to investigate the differences in stress distribution between tissue level (TL) and bone level (BL) implant body designs, and between commercially pure titanium (cpTi) and the newer titanium–zirconium (TiZr) alloy in using short implants.

Materials and methods: Models of TL and BL implants were prepared for three-dimensional finite element analysis. The implants were produced in 10 mm, 8 mm, and 6 mm lengths, and the TL was also produced in a 4-mm length. A static load of 100 N inclined at 30° to the long axis was applied to the buccal side of the model. The largest maximum principal stress value in the cortical bone and the largest von Mises stress value in the implant body were evaluated.

Results: Stress concentration was observed at the connection part of the implant, especially above the bone in TL and within the bone in BL. In the TL design, tensile stress occurred on the buccal side and compressive stress on the lingual side of the cortical bone. Conversely, in the BL design, tensile stress occurred on the lingual side of the cortical bone. CpTi and TiZr showed a similar stress distribution pattern. The maximum stress values were lower in the TL design than the BL design, and they were lower with TiZr than cpTi for both the cortical bone and implant body. The maximum value tended to increase as the length of the implant body decreased. In addition, the implant body design was more influential than its length, with the TL design showing a stress value similar to the longer BL design.

Conclusion: Using TiZr and a TL design may be more useful mechanically than cpTi and a BL design when the length of the implant body must be shorter because of insufficient vertical bone mass in the mandible.

Keywords: Short dental implant, Titanium–zirconium alloy, Tissue level implant, Finite element analysis, Biomechanics

Summary

Dental implants are widely used as a treatment option to replace a defective prosthesis. In recent years, treatment using short implants, which are ≤ 8 mm in length, has been increasing in cases with vertical bone resorption [1]. It is thought that this will become more popular as the number of patients who require minimally invasive treatment, such as older patients and those with chronic disease, is increasing [2–5].

There are two major implant designs; tissue level (TL) implants, where the platform is located under the soft tissue level, and bone level (BL) implants, where the platform is placed at the crestal bone level. TL implants are often avoided in the esthetic area, but there are no clear criteria for the selection of either implant design. Conversely, TL implants are more structurally favorable for a shorter implant body than BL implants because of the submerged design and shorter abutment screw. Clinically, the 4-mm-long TL implant is the shortest used [6, 7]. However, no report has been previously undertaken on the difference between the mechanical behavior of TL and BL implants, so it is not clear which design is more advantageous.

Recently, a titanium–zirconium alloy (TiZr) has been developed, which contains approximately 15% zirconium in titanium and has high biocompatibility, similar to commercially pure titanium (cpTi). Furthermore, TiZr

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Implant Surfaces and their Biological and Clinical Impact
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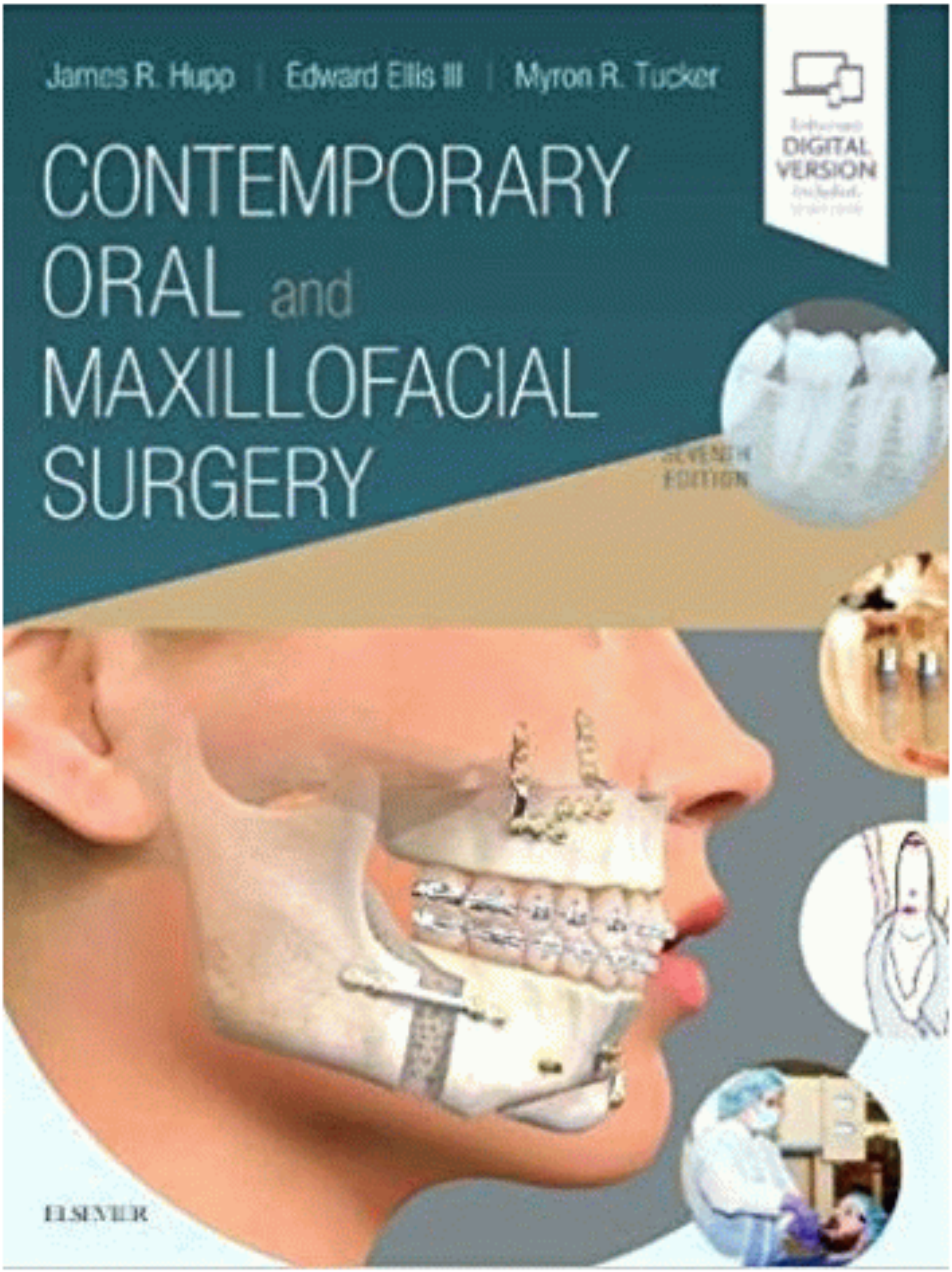
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ORIGINAL ARTICLE

Comparing 4-mm dental implants to longer implants placed in augmented bones in the atrophic posterior mandibles: One-year results of a randomized controlled trial

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Abstract

Background: Short implants have been proposed as an alternative for the rehabilitation of atrophic edentulous areas.

Purpose: To evaluate the efficacy of 4-mm implants vs longer implants in the atrophic posterior mandibles.

Materials and Methods: Eleven patients with bilateral atrophic mandibles were rehabilitated with two to four 4-mm implants and 10 or 8-mm long implants in augmented bone using Guided Bone Regeneration procedure. One side of the mandibles was randomly allocated to vertical augmentation with mixed autogenous bone and allograft. Implants were placed in both sides of the mandible after 6 months, and loaded after another 2 months. Subsequently, implant and prosthesis failures, marginal bone levels changes, and any complication were evaluated after 1-year follow-up.

Results: In this study, one patient dropped out and no failures occurred. However, 4-mm implants loss of 0.30 ± 0.34 mm peri-implant marginal bone and long implants loss of 0.47 ± 0.54 mm marginal bone were observed after 1-year of follow-up. The difference between the two groups was not statistically significant (difference = -0.16 ± 0.68 mm; $P = 0.46$). Eight complications occurred in five augmented sites of the patients, and no complication was found to occur in the short implants sites.

Conclusions: One-year after loading, 4-mm implants had similar outcomes as long implants in augmented bone. Therefore, short implants might be a feasible treatment in atrophic mandibles.

KEYWORDS

Alveolar Ridge Augmentation, Dental Implants, Dental Restoration Failure, Postoperative Complications/etiolog

Comparative Study of Immediate Loading on Short Dental Implants and Conventional Dental Implants in the Posterior Mandible: A Randomized Clinical Trial

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Pathawee Khongkhunthian, DDS, Dr Med Dent[1]

Purpose: *Immediate dental implant loading has been investigated with favorable results. However, short implants have not been investigated in this treatment option. This study compared the clinical outcomes and survival rates of immediately loaded short and conventional-length dental implants in replacing mandibular molar teeth.* ***Materials and Methods:*** *Forty-six implants (23 short dental implants and 23 conventional dental implants) in 46 patients were included in the study. Provisional computer-aided design/computer-aided manufacturing (CAD/CAM) ceramic crowns were cemented to the abutments and immediately loaded. Several clinical parameters were recorded and statistically analyzed at 4-month and 1-year follow-up.* ***Results:*** *Two short implants lost integration, and one conventional implant failed. No statistically significant difference between the two implant types was found (P = 1.00). Minor complications were recorded; three provisional crown fractures were found in the short implant group and two provisional crown fractures in the conventional implant group. There was no significant difference in implant stability quotient values for short or conventional implants between baseline (short: 73.86 ± 2.38, conventional: 75.05 ± 3.26, P = .088), 4 months after loading (short: 72.37 ± 1.35, conventional: 72.89 ± 1.87, P = .165), and 1 year after loading (short: 74.60 ± 2.03, conventional: 75.35 ± 2.66, P = .296). The mean marginal bone level loss 4 months postloading was 0.28 ± 0.29 mm for short implants and 0.25 ± 0.25 mm for conventional implants (P = .73), and at 1 year postloading was 0.33 ± 0.47 mm for short implants and 0.26 ± 0.27 mm for conventional implants (P = .554); there was no statistical difference between the two implant types.* ***Conclusion:*** *The immediate loading of short implants is comparable to conventional-length implants in terms of implant survival, marginal bone level change, and implant stability quotient value.* Int J Oral Maxillofac Implants 2019;34:141–149. doi: 10.11607/jomi.6732

Keywords: *CAD/CAM, immediate loading, short implant, standard implant*

The term osseointegration was defined by Brånemark et al to describe a direct connection between titanium implants and living bone without fibrous tissue encapsulation.[1] Previously, titanium dental implants could be loaded after 3 to 4 months for the mandible and 6 to 8 months for the maxilla. That period of stress-free healing after implant placement was an essential requirement for osseointegration.[2,3]

Recently developed designs and improved implant surface characteristics enhance primary implant stability and biologic healing; immediate loading has become a better option.[4] Immediate loading has elicited several advantages, for example, increased chewing function, better prosthetic stability,[5] minimizing uncontrolled transmucosal loading, acceleration of bone remodeling, improvement of gingival contours, and better esthetics.[6–8]

Some posterior edentulous areas may present insufficient bone volume to place standard-length implants. Sinus elevation or vertical ridge augmentation procedures are selected to enable the placement of standard-length implants in such areas. However, these procedures are associated with additional surgical intervention, costs, surgical time, and patient morbidity. In particular, vertical augmentation bone graft

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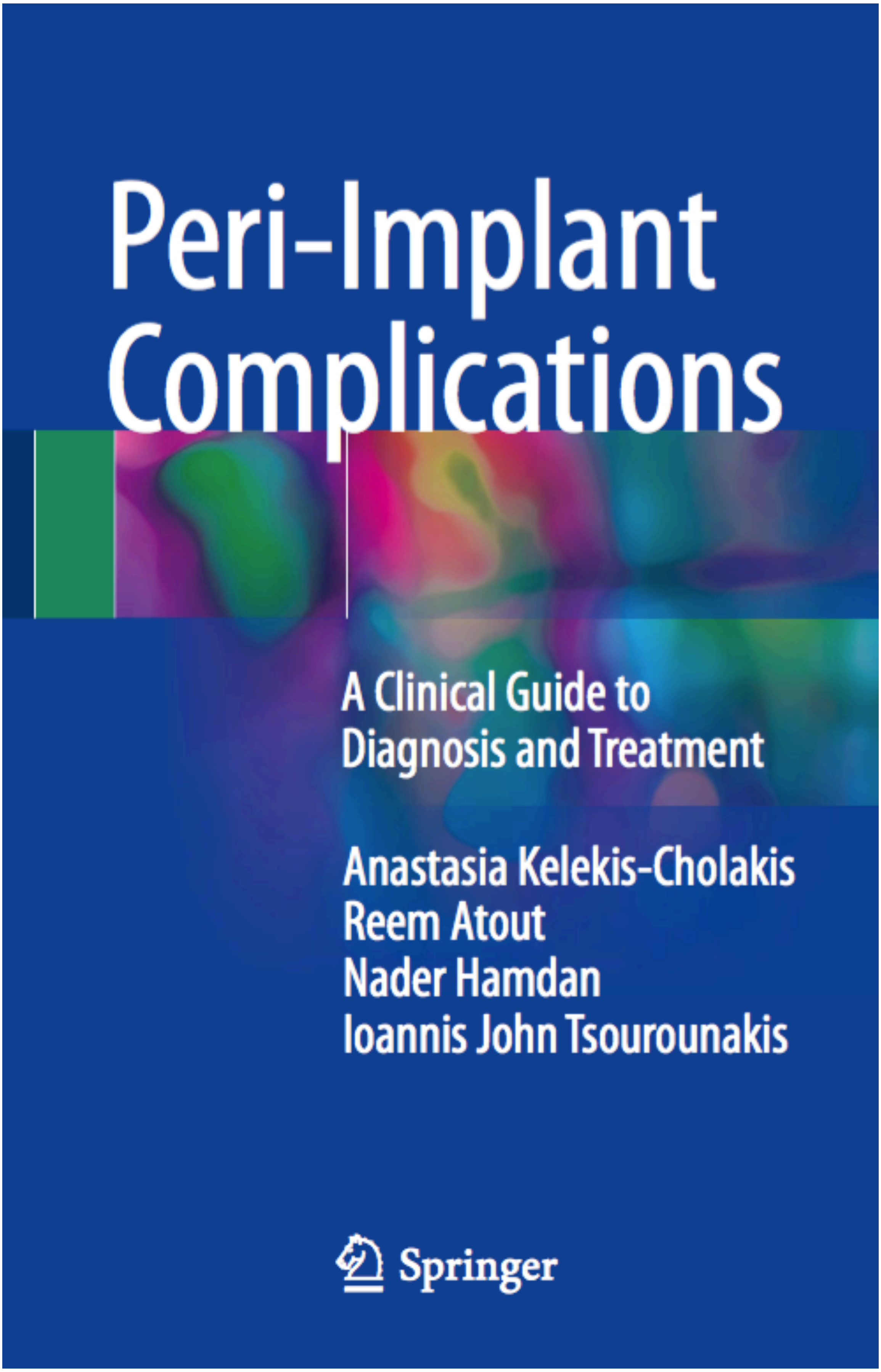
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ORIGINAL RESEARCH

CLINICAL ORAL IMPLANTS RESEARCH WILEY

6-mm-short and 11-mm-long implants compared in the full-arch rehabilitation of the edentulous mandible: A 3-year multicenter randomized controlled trial

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Abstract

Objective: The aim of this multicenter parallel-group randomized controlled trial is to compare 6-mm-short with 11-mm-long implants in the rehabilitation of totally edentulous mandible in a completely comparable clinical situation, from anatomical, surgical, and prosthetic point of view.

Material and methods: Thirty patients were selected in three study centers to receive a fixed full-arch mandibular rehabilitation supported by five inter-foraminal implants. Patients were randomly allocated, at the time of surgery, half to the test group (6-mm-long implants) and half to the control group (11-mm-long implants). No bone augmentation procedure was performed. After 3 months, a screw-retained full-arch prosthesis with distal cantilevers was positioned (baseline). Peri-implant marginal bone level change (MBLc), implant and prosthesis survival rate, and biological/technical complications were evaluated after 1 and 3 years.

Results: Thirty subjects (150 implants) were evaluated after 1 year and 28 (140 implants) after 3 years. No implant or prosthesis loss occurred. No significant inter-group difference for biological/technical complications was registered. No statistically significant ($p > .025$) intra-group or inter-group difference in the mean MBLc values was registered. The mean MBLc was 0.01 ± 0.19 mm and −0.04 ± 0.21 mm at 1 year, and −0.10 ± 0.24 mm and 0.02 ± 0.25 mm at 3 years (test and control groups, respectively).

Conclusions: 6-mm-short implants may be a reliable option when used in the rehabilitation of total edentulous mandibles. These results need to be confirmed by longer follow-up data from well-designed randomized controlled clinical trials.

KEYWORDS
edentulous jaw, randomized controlled clinical trial, short dental implant

1 | INTRODUCTION

The clinical use of dental implants in the rehabilitation of totally and partially edentulous patients represents a well-documented long-term and highly predictable procedure (Adell, Lekholm, Rockler, & Brånemark, 1981; Ekelund, Lindquist, Carlsson, & Jemt, 2003). One of the main limitations for a correct implant placement, however, still remains the availability of a sufficient amount of bone at implant site. In case of reduced bone height, indeed, standard length fixtures can be inserted only after advanced reconstructive

CLINICAL ORAL IMPLANTS RESEARCH

Case Report

Evaluation of extrashort 4-mm implants in mandibular edentulous patients with reduced bone height in comparison with standard implants: a 12-month results

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José Alberto López Torres
Michel Dard
Fawad Javed
Carlos Pérez-Albacete Martínez
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Key words: edentulous patients, extrashort implants, short dental implants, short implants

Abstract

Objective: The aim of this research was to evaluate the primary stability, the marginal bone loss, the survival, and the success criteria, of 4-mm-length implants compared with implants of conventional length supporting fixed prostheses.

Materials and Methods: Ten patients were selected for treatment of their atrophic edentulous jaws. Each patient received the following treatment: six dental implants were inserted, two anterior implants of conventional length (10-mm) in the interforaminal area and four posterior short implants of 4-mm length (Standard Plus, Roxolid, SLActive, Institut Straumann AG). The implants supported screw-retained fixed complete dentures. Examinations were conducted at day 0, three, six, and twelve months after surgery for the evaluation of the implant primary stability, secondary stability, crestal bone loss and survival by clinical evaluations, insertion torque values, resonance frequency analysis (RFA), and periapical radiography, respectively.

Results: Sixty implants were inserted in ten patients. Mean insertion torque was slightly lower for 4-mm implants than 10-mm implants (38.1 Ncm vs. 42.2 Ncm) but without statistically significant difference. Implant stability was similar for extrashort and conventional implants. Marginal bone loss was similar for both groups for all the time periods. One short implant was lost before loading. The survival rates twelve months after implant placement were of 97.5% and 100% for short and conventional implants, respectively. Similarly, implant stability as measured by RFA was nonsignificantly lower for the 4-mm implants compared to the 10-mm implants. The marginal bone loss was lower for short implants three, six, and twelve months after the surgery without statistical significant difference.

Conclusions: Within the limitations of this study, we conclude that short dental implants (8 mm or less in length) supporting single crowns or fixed bridges are a feasible treatment option with radiographic and clinical success rates similar to longer implants for patients with compromised ridges. Long-term data with larger number of implants and subjects are needed to confirm these preliminary results.

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Dental implant treatment can be short, simple, beneficial, and highly predictable. However, the placement of dental implants can be limited due to physical situations, such as the size of the residual bone crest (Annibali et al. 2012).

The insertion of the implant after preparing the undersized osteotomy requires a considerable force, which is referred to as the insertion torque. Considering that primary implant stability is influenced by the mechanical interlocking between the implant and the receiving host bone bed, it has been suggested that the implant success can be accelerated and/or enhanced by a surgical protocol applying high insertion torques (Trisi et al. 2009).

The alveolar bone resorption (horizontal, vertical or, combined defects) is frequently observed in patients with edentulous arches of long evolution (Reich et al. 2011). The insertion of dental implants in patients with reduced alveolar bone is difficult and might require invasive procedures (Esposito et al. 2009) such as sinus lift, grafts, transposition of the dental nerve, bone regeneration, or even the use of nonconventional implants:

RANDOMISED CONTROLLED CLINICAL TRIAL

Pietro Felice, Carlo Barausse, Roberto Pistilli, Daniela Rita Ippolito, Marco Esposito

Five-year results from a randomised controlled trial comparing prostheses supported by 5-mm long implants or by longer implants in augmented bone in posterior atrophic edentulous jaws

KEY WORDS

bovine anorganic bone, inlay graft, short dental implants, sinus elevation, vertical augmentation

ABSTRACT

Purpose: To evaluate whether 5-mm short dental implants could be an alternative to augmentation with anorganic bovine bone and placement of at least 10-mm long implants in posterior atrophic jaws.

Materials and methods: Fifteen patients with bilateral atrophic mandibles (5 to 7 mm bone height above the mandibular canal) and 15 patients with bilateral atrophic maxillae (4 to 6 mm bone height below the maxillary sinus), and bone thickness of at least 8 mm, were randomised according to a split-mouth design to receive one to three 5-mm short implants or at least 10-mm long implants in augmented bone. Mandibles were vertically augmented with interpositional bone blocks and maxillary sinuses with particulated bone via a lateral window. Implants were placed after 4 months, submerged and loaded, after another 4 months, with provisional prostheses. Four months later, definitive provisionally cemented prostheses were delivered. Outcome measures were: prosthesis and implant failures, any complication and peri-implant marginal bone level changes.

Results: In five augmented mandibles the planned 10-mm long implants could not be placed and shorter implants (7.0 and 8.5 mm) had to be used instead. Five years after loading, six patients, five treated in the mandible and one in the maxilla, dropped out. Three prostheses (one mandibular and two maxillary) failed in the short-implant group versus none in the long-implant group. In mandibles one long implant failed versus two short implants in one patient. In maxillae one long implant failed versus three short implants in two patients. There were no statistically significant differences in implant (n = 26; $P = 1.00$, difference = 3.85%, 95% CI: –12.95% to 20.64%) and prosthetic (n = 26; $P = 0.250$, difference = 11.54%, 95% CI: –0.74% to 23.82%) failures. Eleven patients had 16 complications at short implants (one patient accounted for six complications) and 12 patients had 14 complications at long implants. There were no statistically significant differences in complications (n = 28; $P = 1.00$, difference = –3.57%, 95% CI: –30.65% to 23.51%). Five years after loading, patients with mandibular implants lost on average 1.72 mm at short implants and 2.10 mm at long implants of peri-implant marginal bone. This difference was statistically significant (difference = 0.37 ± 0.43 mm; 95% CI: 0.07 to 0.68 mm; $P = 0.022$). In maxillae, patients lost on average 1.31 mm at short implants and 1.79 mm at long implants. This difference was statistically significant (difference = 0.48 ± 0.43 mm; 95% CI: 0.22 to 0.74 mm; $P = 0.002$).

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Short vs. Standard Laser-Microgrooved Implants Supporting Single and Splinted Crowns: A Prospective Study with 3 Years Follow-Up

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Keywords
Laser-microgrooved collar; marginal bone loss; short implants; survival rate.

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Abstract

Purpose: The aim of this study was to compare survival rates, marginal bone loss (MBL), and peri-implant soft tissue parameters between short and standard laser-microgrooved implants supporting single or splinted crowns 3 years after loading.
Materials and Methods: 30 subjects received 1 short (≤ 7 mm) and 1 standard length (≥ 9 mm) laser-microgrooved implant in adjacent sites of the premolar and molar regions of the mandible or maxilla. Peri-implant soft tissue parameters and intraoral radiographs were recorded at the delivery of definitive crowns (baseline) and 3 years later. Cumulative survival rate (CSR) and marginal bone loss (MBL) in relation to crown/implant (C/I) ratio, implant length, location, type of antagonist, and type of prosthetic design (single or splinted), were evaluated.
Results: CSR of short implants was 98%, compared to 100% for standard implants, without significant statistical difference. MBL was not significantly different over the observation period, with an average of 0.23 ± 0.6 mm and 0.27 ± 0.3 mm for short and standard implants, respectively. No statistical differences were found between short and standard implants regarding plaque (14.7% vs. 15.7%), number of sites BOP (8.3% vs. 5.9%), probing depth (1.13 ± 0.6 mm vs. 1.04 ± 0.8 mm), and mean mucosal recession (0.18 ± 0.3 mm vs. 0.22 ± 0.3 mm). Analyzing MBL in relation to the C/I ratio, implant length, location, type of antagonist, and type of prosthetic design, no statistically significant differences were found.
Conclusion: Regardless of C/I ratio, implant length, location, type of antagonist, and type of prosthetic design, short and standard laser-microgrooved implants had similar survival rates, MBL, and peri-implant soft tissue conditions over the observation period of 3 years.

Several surgical techniques have been proposed to overcome the limitations for standard length implants in atrophic jaws with insufficient vertical bone height.[1,2] However, these surgical techniques are still associated with several disadvantages, such as increased postoperative morbidity, longer treatment time and cost, and higher risk of complications.[3,4] In clinical situations with limited vertical bone height, placement of short implants could be an alternative to advanced surgical bone augmentation techniques.[5-8] Some studies have reported high success rates for short implants,[2,9,10] while others have reported low success rates.[11,12] Low success rates have been associated with low-density atrophic jawbones where primary stability was more difficult to achieve with short implants due to decreased bone-to-implant contact.[13,14] Additionally, a crown-to-implant (C/I) ratio >1 could act as a lever arm creating a bending moment and transferring stress to peri-implant crestal bone.[15,16] Few studies have compared outcomes of short and standard implants placed in adjacent sites of the premolar and molar regions of the mandible or maxilla. The aim of this prospective study was to evaluate cumulative success rates, (CSR), marginal bone loss (MBL), plaque score (P), number of sites bleeding on probing (BOP), probing depth (PD), and mean mucosal recession (REC), of short (≤ 7 mm) and standard (≥ 9 mm) laser-microgrooved implants supporting single or splinted crowns.

Materials and methods

Thirty patients (14 females, 6 males) were screened to participate in this prospective study and received at least one short and one standard laser-microtextured implant in adjacent sites of the mandibular or maxillary premolar/molar regions. The

Four-Millimeter-Long Posterior-Mandible Implants: 5-Year Outcomes of a Prospective Multicenter Study

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ABSTRACT

Background: There is lack of evidence on long-term success of short dental implants in reduced alveolar bone.

Purpose: In this prospective 5-year study, survival and marginal bone loss of 4-mm implants, which supported fixed dental prostheses (FDPs) in severely resorbed posterior mandibles, were evaluated.

Material and Methods: In 28 patients, evaluation of 86 osseointegrated 4-mm-long implants, which supported a 3- or a 4-unit FDP by crown splinting without the use of pontics or cantilevers, was performed over a 5-year period.

Results: Three subjects dropped out for non-study reasons: one subject had her three implants removed after 1 year and two subjects died (six implants). Five implants in three subjects were lost between 3 and 5 years. Twenty-four subjects and 71 implants were active at the 5-year follow-up (92.2% survival). After 1 year, significant ($p < .001$) mean (standard error of the mean [SEM]) 0.44-mm (0.05) marginal bone loss occurred. At 2, 3, and 5 years, mean (SEM) bone loss of 0.57 mm (0.06), 0.55 mm (0.07), and 0.53 mm (0.08) occurred, respectively (no significant change after 1 year). At 5 years, average plaque levels were 13.3%; 69% of the implants were plaque free. On average, mucosal bleeding occurred at 8.1% of the implants. During 5 years, two subjects experienced uncomplicated bridge loosening. No other complications occurred during the study.

Conclusion: Four-millimeter implants can support FDPs in severely resorbed posterior mandibles for 5 years with healthy peri-implant conditions.

KEY WORDS: bone atrophy, bone loss, bone resorption, clinical trial, crown-implant ratio, short implants

INTRODUCTION

Often, dental implant rehabilitation is a safe, well-documented treatment. In situations regarding limited bone, new techniques emerged to enable implant placement – but not always without risk for failure or biological complications.[1–3] In addition, such procedures are technically demanding, require longer treatment times, and incur higher morbidity and costs for patients. Implant device designs, which facilitate fitting that is aligned with anatomical and morphologic circumstances in the jaws, have enabled avoidance of augmentation procedures and long treatment times.[4,5]

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ORIGINAL ARTICLE

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Influence of crown–implant ratio on implant success rate of ultra-short dental implants: results of a 8- to 10-year retrospective study

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Abstract

Objectives The use of short implants has been suggested in recent years as an option for facilitating prosthetic restoration in resorbed jawbones. The aim of the present study was to determine how implant success rate is affected in the long term when ultra-short implants are rehabilitated with fixed restorations, resulting in a crown to implant (C/I) ratio of more than 3:1.

Materials and methods The study was conducted as an analysis on all patients operated from December 2005 to November 2007 with ultra-short dental implants. All implants were sintered porous-surfaced (SPS) with a length of 5 mm and a diameter of 5 mm (5 × 5 mm) and were restored with a single crown or a fixed dental prosthesis (FDP). Data collected included implant positioning site, crestal bone levels (CBL), and clinical and anatomical C/I ratios, and pre-established success criteria were used to evaluate the success rate of the implants. Statistical analysis was used to determine any significant differences or correlations ($p = 0.05$).

Results Forty-one patients completed the follow-up and were eligible for this retrospective study on a total of 50 ultra-short SPS implants. The mean follow-up was 9.5 years (range 8.3 to 10.2 years). Three of the 50 implants failed because they were lost due to peri-implantitis, while all the other 47 met the pre-established success criteria giving an overall implant success rate of 94%. During the follow-up period, the mean peri-implant bone loss (PBL) was 0.41 + 0.36 mm.

Conclusions This study shows that ultra-short SPS implants can prove a reliable solution for prosthetic restoration in patients with severe alveolar bone atrophy. In selected patients with a sufficient bone width, ultra-short implants with a resulting C/I ratio of more than 3:1 presented no contraindications.

Clinical relevance In selected cases, ultra-short implants may represent an alternative to bone augmentation procedures and a long-term predictable solution.

Keywords Ultra-short dental implants · Sintered porous-surfaced (SPS) · Long-term follow-up · Success rate · Peri-implant bone loss

Introduction

Partial posterior jaw edentulism is not unusual and often treated with removable partial dentures to replace the missing teeth. This solution poses problems of instability and discomfort; however, that can be avoided by using implant-supported fixed prostheses instead. The posterior jaw may lack the bone height needed to insert dental implants of "adequate" length, presenting anatomical issues such as a risk of inferior alveolar nerve damage or a pneumatized maxillary sinus [1]. Several strategies have been suggested over the years to overcome the dimensional limitations of the bone available for implant placement. These include bone augmentation surgery, possibly involving bone grafts, guided bone regeneration, distraction osteogenesis, sinus floor elevation, and mandibular nerve transposition [2]. Such techniques reportedly have generally high success rates in implantology, but the outcomes have varied and proved rather unpredictable. Many patients are also unable or unwilling to submit to this type of surgical approach because it is costly and demands multiple surgical procedures, or due to poor general health

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Primary and Secondary Stability of Single Short Implants

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Purpose: This prospective cohort study assessed the effect of bone quality on the primary and secondary stability of single short implants placed in the posterior region.

Materials and Methods: A total of 39 short implants (4.1 × 6-mm long) were placed in the posterior region of the maxilla or mandible in 18 patients. Bone quality was classified into type I, II, III, or IV as assessed intrasurgically. Primary implant stability was measured with insertion torque, damping capacity (PTV values), and resonance frequency analysis (ISQ values). Secondary stability was measured by ISQ and PTV at abutment installation. Data were analyzed by using repeated-measures ANOVA and Tukey's test, Kruskall–Wallis test, and Spearman correlation tests.

Results: Implants placed in bone type IV had significant lower insertion torque and ISQ values as well as higher PTV values than in bone types I to II ($P < 0.05$). The mean ISQ values were higher at abutment installation than at implant placement ($P < 0.05$), regardless the bone type. The assessment methods of implant stability showed a moderate correlation.

Conclusions: Bone quality influences both the primary and secondary stability of single short implants in the posterior region.

Key Words: Bone quality, primary stability, secondary stability, single short implants

The oral rehabilitation of a severely resorbed alveolar ridge may include large surgical procedures, such as guided bone regeneration,[1] distraction osteogenesis,[2] sinus floor elevation,[3] inferior alveolar nerve lateralization,[4] and autogenous bone grafts.[5] In patients with limited height of the alveolar ridge, short dental implants may be a clinical alternative with a simplified approach and easier surgical handling in cases of reduced interocclusal space, resulting in less treatment time, morbidity, and costs.[6,7] Some systematic reviews on short implants have reported cumulative survival rates from 84% to 100% up to 10 years,[8] but increased failure and marginal bone loss in the mandible.[9]

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Clinical success with short implants has been attributed to the technical enhancement of the surface topography and to modifications of the implant–abutment connection.[10,11] The surface treatment provides faster new bone formation and an increase of the bone-to-implant contact and mechanical retention.[11,12] Some factors that may influence the primary stability of dental implants are bone quality,[13] surgical technique,[14] and implant characteristics (length, diameter, design, and surface).[15]

The primary stability has been assessed by insertion torque,[12,16] damping capacity,[17,18] and resonance frequency analysis (RFA).[19,20] In a recent meta-analysis on short dental implants,[9] few studies evaluated the relationship between primary stability and bone quality, and their actual role on the prognosis of short implants remains unclear. Insertion torque was more frequently used as a method for stability assessment. Both damping capacity and RFA assessments of short implants were also limited, although the results suggest a similar performance to that of longer implants.[21] To date, the secondary stability (at abutment installation) of short implants has not been objectively related to bone quality or primary stability.

This study assessed the effect of bone quality on the primary and secondary stability of single short implants placed in the posterior region of mandible and maxilla.

MATERIALS AND METHODS

This prospective cohort study was approved by the Institutional Review Board according to the national ethics requirements and the Declaration of Helsinki for research in humans. All eligible subjects that voluntarily agreed to participate in the clinical study signed a written consent form.

The inclusion criteria for patient selection were as follows: need for single-tooth replacement in the posterior region of the maxilla or mandible, with limited bone height for the placement of an implant of conventional length; and indication of a 6-mm-long implant, considering a 2-mm safety margin in relation to the mandibular canal or to the sinus floor. The exclusion criteria were as follows: previous failure of osseointegration at the site of interest, bone grafts and/or biomaterials, noncompensated type II diabetes, heavy smoking (>10 cigarettes/d), immunosuppression, head and neck radiotherapy, active periodontal disease, poor oral hygiene, and removable dentures on the opposing arch.

Sample

Thirty-nine implants (SLActive RN, ø4.1 × 6-mm long) (Straumann AG, Basel, Switzerland) were placed either in the mandible (23 implants; 18 molars and 5 premolars) or in the maxilla (16 implants; 12 molars and 4 premolars) of 18 patients (12 female, 6 male). The implants were placed after the one-stage protocol recommended by the manufacturer. The profile drill and the screw promoter were not used. Bone quality was assessed according to the surgeon's tactile sensitivity and classified into types I, II, III, and IV after the Lekholm & Zarb classification.

Implant stability data were collected at different times:

- T1 (implant placement): primary stability assessment through insertion torque, damping capacity (PTV values) (Periotest, Medizintechnik Gulden, Germany), and RFA (Osstell, Integration Diagnostics AB, Göteborg, Sweden).
- T2 (abutment installation—3 months after T1): secondary stability assessment by means PTV and RFA.

Primary Stability Measurement

Insertion torque was measured using a manual wrench (Straumann AG) and classified into 3 categories: <15 Ncm, between

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In vitro evaluation of the primary stability of short and conventional implants.

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Abstract:	The objective of this study was to evaluate the primary stability of short and conventional dental implants with different platform types at different site densities in vitro. One hundred and twenty implants were placed in polyurethane blocks that simulate different bone densities (bone type I and IV). The implants were divided into 10 groups with 12 implants each according to the type of prosthetic connections (external hexagon-EH, and morse taper-MT) and size of the implants (conventional 4x10 mm and short 5x5 mm; 5.5x5 mm; 5x6 mm; 5.5x6 mm). Insertion torque and resonance frequency analyses were performed to evaluate the primary stability. The Kruskal-Wallis test complemented by Dunn's test and the Mann-Whitney test were used for statistical analysis. These tests were applied at the confidence level of 95% ($p < 0.05$). The implants installed in blocks with density type IV exhibited reduced insertion torque compared with implants placed in blocks with density type I. Short implants with EH exhibited increased insertion torque compared with short implants with MT in blocks with bone density type I. In general, implants installed in blocks with density type I exhibited greater primary stability. The short implants with EH with a 5.5 mm diameter and the short implants with MT with a 5 mm diameter exhibited reduced primary stability. No differences between short and conventional implants were noted. Short implants have primary stability and insertion torque at least equivalent to conventional implants irrespective of the platform type and density of the site.
Response to Reviewers:	Dear Dr. Jonathan Brown Please find below our response to the comments of the reviewers of our manuscript (aaid-joi-D-16-00094) entitled: " In vitro evaluation of the primary stability of short and conventional implants." We have carefully addressed all the points raised by the reviewer and we hope that the paper can be considered for publication. All changes mentioned below are highlighted in the manuscript. We're looking forward to hearing from you soon.

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TECHNICAL ADVANCE Open Access

Novel expandable short dental implants in situations with reduced vertical bone height—technical note and first results

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Abstract

Purpose: Short implants often have the disadvantage of reduced primary stability. The present study was conducted to evaluate the feasibility and safety of a new expandable short dental implant system intended to increase primary stability.

Methods: As a "proof of concept", a prospective clinical cohort study was designed to investigate intraoperative handling, primary and secondary implant stability (resonance frequency analysis), crestal bone changes, implant survival and implant success, of an innovative short expandable screw implant. From 2014 until 2015, 9 patients (7–9-mm vertical bone height) with 30 implants (length 5–7 mm, diameter 3.75–4.1 mm) were recruited consecutively.

Results: All 30 implants in the 9 patients (age 44 to 80 years) could be inserted and expanded without intraoperative problems. Over the 3-year follow-up period, the implant success rate was 28/30 (93.3%). The mean implant stability quotients (ISQ) were as follows: primary stability, 69.7 ± 10.3 ISQ units, and secondary stability, 69.8 ± 10.2 ISQ units ($p = 0.780$), both without significant differences between the maxilla and mandible ($p \geq 0.780$). The mean crestal bone changes after loading were (each measured from the baseline) as follows: in the first year, 1.0 ± 0.9 mm in the maxilla and 0.7 ± 0.4 mm in the mandible, and in the second year, 1.3 ± 0.8 mm and 1.0 ± 0.7 mm, respectively.

Conclusions: Compared to other prospective studies, in this indication, the success rate is acceptable. Implant stability shows high initial and secondary stability values. The system might present an extension of functional rehabilitation to the group of elderly patients with limited vertical bone height. Further long-term investigations should directly compare this compressive implant with standard short implants.

Keywords: Bone atrophy, Expandable, Macrodesign, Short implant, Implant stability

Introduction

Endosseous implants have been established over several decades. The evaluation of treatment results under biomechanical, physiological, psychological, social and economic aspects has been well documented [1]. Furthermore, patient-based outcomes reveal a predictable gain in oral health-related quality of life [2].

Especially in patients with limited vertical bone height, process of treatment is extensive. Prior to implantation, augmentation procedures are required [3]. Depending on gender, vascularisation and bone mineralisation up to 25% of the primary volume are resorbed due to remodeling of augmented alveolar ridges [4]. Recently, short dental implants have evolved into a promising and reliable treatment option in the orofacial rehabilitation of atrophic mandibles and maxillae, namely as an alternative to vertical ridge augmentation [5–8]. The prognosis of short implants and patient satisfaction is high [9–12].

The definition of short implants in the literature is not uniform. In this present study, we considered short implants with 5–8-mm length [5, 7, 13]. Other authors set the cut-off at 6 mm [8, 9, 11, 14, 15]. According to the recent consensus paper of the 11th European Consensus Conference (EuCC), dental implants are referred to as

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Assessment of Marginal Peri-implant Bone-Level Short-Length Implants Compared with Standard Implants Supporting Single Crowns in a Controlled Clinical Trial: 12-Month Follow-up

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Jorge Rojas, DDS[4]
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In oral rehabilitation, crown-to-root ratio is accepted as an indicator of bone loss, and this concept was transferred to implants. Recent studies have indicated that there is no significant difference between short and standard implants. The aim of this study was to compare marginal bone level alteration through radiographic evaluation and clinical parameters between short and standard implants supporting single crowns. This prospective clinical trial study included 82 systemically healthy, nonsmoking subjects. Patients were divided into two groups: one group for short dental implants measuring 5.5 or 7 mm, and one group for standard dental implants measuring 10 or 12 mm, in accordance with the individual needs of the patient. A clinical dental history was taken for each subject, including model casts, dental radiography, and cone beam computed tomography. A periapical analysis was also performed using ImageJ computer software to establish the initial bone measurement and periapical bone loss. A statistically significant difference was found in favor of the standard-length implants after 12 months, with greater gingival recession around the implant; however, bone loss in the short implants did not exceed 0.53 mm. The treatment with 5.5- to 7-mm-length implants is as reliable as treatment with 10- or 12-mm implants. Peri-implant bone loss is minimal, and therefore use of short implants can be recommended as treatment for the restoration of partially edentulous patients without the need for splinted crowns.
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Dental implants have been employed as a functional alternative for total and partial edentulism, improving patients' chewing ability, avoiding prosthesis mismatch, and improving self-esteem.[1] Follow-up studies have demonstrated a high success rate for implant use associated with different types of prosthetic rehabilitation.[2]

In oral rehabilitation, crown-to-root ratio is accepted as an indicator of bone loss. This concept was transferred to implants. In the early stages of implant technology, placement of long implants was assumed to be better because the crown-to-implant ratio and bond-to-implant contact were improved.[3] In some clinical situations there is not enough bone to enable placement of a standard-length implant. In cases of severe atrophy of the maxilla, an augmentation of the maxillary sinus floor is generally considered to augment the bone volume sufficiently to place a normal-length implant. However, this bone is not always a good substitute in terms of quality and stability. In the case of the maxilla, a vertical bone growth procedure would involve a complex surgical procedure, increased cost, and an increased risk of possible complications.[3]

Recently, some reviews have maintained that short implants should be considered as an alternative treatment for posterior partial

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SUPPLEMENT ARTICLE

WILEY CLINICAL ORAL IMPLANTS RESEARCH

Is there an effect of crown-to-implant ratio on implant treatment outcomes? A systematic review

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Abstract

Objectives: High crown-to-implant ratios may lead to complications due to unfavorable occlusal forces, including nonaxial forces, on the bone surrounding the neck of the implant and within the connection of the crown and implant itself. The aim of this study was to perform a systematic review on the influence of crown-to-implant ratio of single-tooth, nonsplinted, implants on biological and technical complications.

Materials and Methods: MEDLINE (1950–January 2018), EMBASE (1966–January 2018), and Cochrane Central Register of Controlled Trials database (1800–January 2018) were searched to identify eligible studies. Inclusion criteria were as follows: crown-to-implant ratio of single-tooth, nonsplinted, implant-supported restorations in the posterior maxilla or mandible and follow-up of at least 1 year. Main outcome measures were as follows: implant survival rate, marginal bone level changes, biological complications, and technical complications. Two reviewers independently assessed the articles. A meta-analysis was carried out for implant survival rate and peri-implant bone changes.

Results: Of 154 primarily selected articles, eight studies fulfilled the inclusion criteria. Study groups presented a mean crown-to-implant ratio varying from 0.86 (with 10-mm implants) to 2.14 (with 6-mm implants). The meta-analysis showed an implant survival of more than 99% per year and mean peri-implant bone changes of <0.1 mm per year. Limited biological and technical complications were reported.

Conclusion: Data reviewed in the current manuscript on crown-to-implant ratio, ranging from 0.86 to 2.14, of single-tooth, nonsplinted, implants did not demonstrate a high occurrence of biological or technical complications.

KEYWORDS
biological complications, crown-to-implant ratio, dental implants, technical complications

1 | INTRODUCTION

High crown-to-implant ratios may lead to biological and technical complications due to unfavorable occlusal forces, including nonaxial forces, on the bone surrounding the neck of the implant and within the connection of the crown and implant itself (Lai et al., 2013; Malchiodi, Cucchi, Ghensi, Consonni, & Nocini, 2014). Systematic reviews of Blanes (2009), Quaranta, Piemontese, Rappelli, Sammartino, and Procaccini (2014), and Esfahrood, Ahmadi, Karami, and Asghari (2017) revealed that high crown-to-implant ratios did not have an impact on peri-implant bone loss; however, Garaicoa-Pazmiño et al. (2014) reported as a result of

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WILEY

ORIGINAL ARTICLE

Influence of crown-to-implant ratio and different prosthetic designs on the clinical conditions of short implants in posterior regions: A 4-year retrospective clinical and radiographic study

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Abstract

Background: Short implants (intra-bony length ≤ 8 mm) are generally considered as an alternative to bone augmentation in challenging situations; however, clinical evidence from large-scale studies with long follow-up regarding the application of short implants remains deficient.

Purpose: The present study aimed to assess the mid-term clinical outcomes of short implants supporting fixed prostheses in the posterior region, and to investigate the effects of the crown-to-implant ratio (C/I), and other patient-, implant-, prosthesis-relevant factors on the clinical conditions around short implants.

Materials and methods: 180 Thommen short implants in 130 partially edentulous patients were enrolled in the study after 3 to 7 (mean 4.2) years of follow-up. Potential risk factors (patient sex and age, implant diameter and location, splinted vs single-tooth restorations, retention mode, anatomical and clinical C/I ratios) were evaluated according to the following outcomes: Implant survival, marginal bone loss (MBL), and mechanical and biological complications.

Results: In total, four implants in four patients failed as a result of peri-implantitis. The cumulative survival rate was 97.8% for implant-based analysis. The peri-implant MBL around 180 short implants was 0.90 ± 0.78 mm. The mean clinical C/I ratio was 1.16 ± 0.36. Correlation analysis revealed that the influence of the clinical C/I ratio and patient age were significant for MBL ($P < .05$), whereas other potential risk factors showed no significant association with the outcome. Among 180 short implants, 24 cases (13.3%) had biological complications and 32 cases (17.8%) had mechanical complications, respectively. Peri-implant MBL and complication rates around splinted and non-splinted implants were not statistically different.

Conclusion: Within the limitations of this study, short implants supporting fixed prostheses in the posterior region achieved predictable clinical outcomes over a 3 to 7 year period. Within the range of 0.47 to 3.01, the higher the C/I ratio, the less the peri-implant MBL.

KEYWORDS
crown-to-implant ratio, marginal bone loss, short implant, splint

