GRADUATION PROJECT

Degree in Dentistry

INTRAOPERATORY SURGICAL COMPLICATIONS IN IMPLANTOLOGY

Madrid, academic year 2025/2026

Identification number: TFG_77

RESUMEN

Introducción: La implantología hoy en día es una de las principales opciones de tratamiento para reemplazar dientes ausentes, con el objetivo de recuperar la función y la estética, y por lo tanto se considera un tratamiento quirúrgico rutinario en el ámbito de la odontología. Sin embargo, este tratamiento, presenta ciertos riesgos de complicaciones durante su realización, especialmente las complicaciones intraoperatorias. Estas complicaciones pueden afectar a distintos tejidos, implicar diversos factores mecánicos y presentarse en todas las etapas quirúrgicas, desde la anestesia hasta la colocación del implante y las suturas. **Objetivos**: El objetivo principal de este trabajo fue investigar las diferentes complicaciones que pueden ocurrir durante una cirugía de implantes y analizar su relación con la edad, el sexo, los tejidos afectados, la etapa quirúrgica y el estado de salud de los pacientes, con el fin de evaluar la prevalencia y la aparición de estas complicaciones en función de dichos parámetros. **Material y métodos:** Se realizó una revisión bibliográfica en la literatura científica utilizando MEDLINE Complete y Dentistry & Oral Sciences Source, centrándose en artículos relacionados con nuestro tema mediante el uso de filtros y seleccionando únicamente artículos desde 2020 en adelante. Se emplearon términos MeSH y palabras clave libres no específicas con operadores booleanos. Las palabras clave utilizadas fueron “intraoperatorio”, “complicaciones”, “implantología dental”, “colocación de implantes” y “cirugía de implantes”. El objetivo de esta metodología fue maximizar la sensibilidad y la especificidad de la búsqueda. **Resultados:** Aplicando los criterios descritos en la sección de métodos, se obtuvieron un total de 36 pacientes que presentaron complicaciones, a partir de 17 artículos incluidos en la tabla de resultados. Estos artículos se utilizaron posteriormente para comparar diferentes características de los pacientes que sufrieron complicaciones en el siguiente orden: edad, sexo, etapa quirúrgica en la que ocurrió la complicación, tejido anatómico afectado, tipo de complicación y, finalmente, la condición médica del paciente. **Conclusión:** El estudio realizado mostró que las complicaciones intraoperatorias que pueden ocurrir durante una cirugía de implantes son múltiples y pueden afectar tanto a los tejidos de la cavidad oral como a otras partes del cuerpo. La edad y el sexo no se correlacionaron con la aparición de complicaciones; la etapa quirúrgica más afectada fue la colocación del implante; el tejido más afectado fue el seno maxilar; la complicación principal fue la colocación incorrecta del implante; y la condición médica no se asoció con un mayor riesgo de complicaciones intraoperatorias. Se necesitan futuras investigaciones enfocadas en la prevención de estas complicaciones y en el desarrollo de protocolos para evitarlas en la práctica clínica habitual.

PALABRAS CLAVE

Implantología dental, complicaciones, intraoperatorio, cirugía dental, colocación de implantes

ABSTRACT

Introduction: Implantology is nowadays one of the main treatment options to replace missing teeth aiming to recover function and aesthetics and is therefore considered a routine surgical treatment in the dentistry field. However, this treatment even being frequent represents some risks of complications during the treatment being the intraoperative complications. These complications will range across different tissues, different mechanical factors and will affect all the surgical steps from the anesthesia to the implant placement and sutures. **Objectives:** The principal objective of this work was to investigate the different complications that could occur during an implant surgery and to examine the relationships with age, sex, tissues, surgical step and health status of patients to examine relation in prevalence and occurrence of the complications with these parameters. **Material and methods:** Bibliographic research in the scientific literature was conducted using MEDLINE Complete and Dentistry & Oral Sciences Sources database, focusing on article related to our subject using filters and electing only articles from 2020 and above. MeSH terms and non-specific free-text words with Boolean operators were used. The keywords used were “Intraoperative”, “complications” “implant dentistry”, “implant placement”, “implant surgery”. The objective of this methodology was to maximize sensitivity and specificity of the research. **Results:** Applying the criteria of the methods section we obtained a total of 36 patients that suffers complications out of 17 articles referred in the results table. These articles were then used to compare different characteristics of the patient suffering the complications in the following order, age, sex, surgical step of the complication, anatomical tissue affected by the complications, complication itself and finally the medical condition of the patient suffering the complications. **Conclusion:** The study conducted showed that the intraoperative complications that can happen in a surgery of an implant were multiple and capable of affecting tissues in the mouth but also in other part of the body. The age and sex were not correlated to complications, the main affected surgical step was the implant placement itself, the most affected tissue was the maxillary sinus, the main complication was incorrect implant positioning and finally that medical condition was not correlated to an increased risk of intraoperative complications. Further research should intend to focus on preventing the complication and find protocols to avoid them in the routine clinical work.

KEYWORDS

Implant dentistry, complications, intraoperatory, dental surgery, implant placement

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1. INTRODUCTION

Implant dentistry is the odontology field that has the principal goal of rehabilitating lost teeth with the use of implant materials that are screwed in to gain optimal osteointegration in the maxillary or mandibular bone (1,2). We know that tooth loss is mainly due to caries and periodontal diseases nowadays (3), which are some very prevalent diseases and a socio-economic problem increasing the number of partially edentulous patients and fully edentulous patients. Therefore, implant dentistry is nowadays a frequent treatment option to consider for the replacement of lost teeth. These implants will later be the support for prosthesis such as fixed implant supported single crowns, implant supported FPD (fixed partial dentures), implant supported complete dentures or implant retained dentures. The goal of implant placement is to recover patient teeth function and aesthetic with the prosthesis placed over it (2). Implant dentistry is a specialty that includes surgery during the procedures of placing implant and seeking osteointegration of the device and these procedures are subjected to complications. A lot of complications can happen during the surgery of implant placement being intraoperative complications because they happen directly during the surgery. Knowing and understanding the complications is an important factor for our treatment prognosis and patient care (4). All the different steps of the implant placement can be subject to different complications, theses complications can depend on the different anatomical structures that we have in oral environment (5-19), they may vary depending on the step of the implant placement and there are also some mechanical complications that can occur due to the material used, wrong medical history knowledge and operator technique and experience.

1.1 Complications depending on anatomical structures

1.1.1 Complications on soft tissues

Implant placement procedures need the dentist to act on the soft tissues in most cases. During the surgery a management and a manipulation of the soft tissues are necessary to access to the bone and to start the drilling even though now flapless surgery (5) can be performed and it does not need a flap. During the implant surgery the soft tissue will need to be incised to reach the periosteum barrier, retracted and protected to avoid mechanical arm. Implant placement can be harmful for soft tissues, in some cases the Schneiderian membrane could be perforated or mucoperiosteal flap tears can happen leading to an intraoperative complication (6).

1.1.2 Complications on nervous tissues

During implant placement the nervous tissues can be exposed to complications, these complications can happen at 3 steps, during anesthesia, during osteotomy and drilling and finally during implant screwing (7). Regarding anesthesia the main problem that has been associated with complications during the administration is the neurotoxicity of the local anesthetics used nowadays such as articaine or lidocaine being articaine the most neurotoxic and the most used in implant dentistry for his potency and good anesthetic properties (8,9). Also, in implant surgery the inferior alveolar nerve for example can be subject to direct trauma by being drilled with the bone or being injured during the implant screwing. We also know that complications related to the neurovascular complex will be mostly prevalent in the mandibular region and the most exposed nerves are the inferior alveolar nerve (IAN), followed by the lingual nerve (10). Another complication regarding nervous tissues was the misevaluation of the case regarding the distance from the implant apex to the nerve that could be less than the 2 mm recommended and by placing the implant too close to the nerve during the surgery it can produce a chronic stimulation on the nerve (11,12).

1.1.3 Bone tissue complications

Bone can also be subject to complications during implant surgery in two phases during the drilling phase to create the space for the implant and during the implant placement step itself (11,12). Regarding the drilling phase the complication that can occur is the thermal injury that will happen if the bone undergoes a thermal stimulation of more than 47 °C for 1 minute which will produce permanent blood flow stoppage and further bone necrosis (12). Another complication that can compromise the treatment is a fracture of a bone plate such as the buccal bone plate during the implant placement being a rare complication but a severe one (11).

1.1.4 Blood tissue complications

Blood complications in implant surgical procedures will happen at any phase of the implant placement from the anesthesia to the suturing (13). A daily exercise in implant dentistry is the performance of an inferior alveolar block to obtain the anesthesia of a unilateral mandible area. When performing this type of anesthesia, a complication that can occur is the injection of the local anesthetic in the facial artery located close to the inferior alveolar nerve (both in the

internal part of the mandibular ramus). If an injection inside the facial artery of the patient happens, the patient will have an immediate reaction with acute pain and regional paleness (14). Regarding systemic effects it can produce hypertension, nausea and tachycardia. As well during implant surgery the bleeding complications that can happen will be due to rupture of a blood vessel when doing the flap, when drilling, when inserting the implant and when suturing. The vessels mostly affected are the submandibular, sublingual and submental arteries producing mouth floor elevation, tongue elevation, swallowing difficulties, speech difficulties, airway obstruction due to floor of the mouth elevation and obviously acute bleeding inside the tissues or in the mouth (13,15). Another parameter to consider when placing implants is the health status of the patient because in some cases even when doing classical surgical interventions, we can have an increased risk of bleeding during the intervention with difficulty achieving hemostasis. This is the case in patients treated with anticoagulant drugs such as warfarin, which can compromise the coagulation cascade and induce significant bleeding during and right after the surgery and that could be life threatening for the patient (16). For special patients treated with anticoagulant drugs for example, interconsultation is key to avoid further complications and to protect ourselves as health care professionals from surgical complications and therefore to protect our patients.

1.1.5 Bone cavity and anatomical space complications

Another complication that will concern the dentist during the surgery is the introduction or the perforation of the implant in a bone cavity or inside an anatomical space different than the one we want (17–19). One of the most common implant complication in a bony cavity is the implantation inside the maxillary sinus when placing the implant (17). Another less known complication is the insertion of the implant in the nasal cavity and usually in the inferior meatus and surprisingly this condition can occur for implant placement of posterior teeth such as premolars even though these teeth appear way distal to the nasal floor and cavity (18). A very poorly known complication that can happen in the aesthetic region is the interaction of the implant with the canalis sinuosus which is a branch of the infraorbital canal that contains anterior superior alveolar nerve, artery and vein. This overlooked canal can be affected by implant placement and can lead to complications if implants are placed in this bony cavity affecting the integrity of the structure included in this canalis (20). Finally the last complication that can occur is regarding an anatomical region with the insertion of implant in posterior mandibular region and with insertion inside the mandibular body (19).

1.2 Mechanical complications

1.2.1 Ingestion of implant and material

A common complication that concerns general dentistry is the ingestion of dental material (21), unfortunately this is also concerning implant dentistry because this discipline cannot use a rubber dam and complete isolation being the most effective way to avoid this kind of complications. Implant material can be ingested into the gastrointestinal tract which usually does not present further complications except if it blocks itself during the course. The most severe complication related to ingestion is when the material goes into the respiratory tract, which can become a life threatening condition because of airway blockage (22). Instruments usually ingested are screwdrivers or implants, with the ingestion of the screwdriver being more severe because of its sharp end (23,24).

1.2.2 Thermal injuries during implant procedures

As we said previously the problem with bone drilling step is that it can generate a lot of heat on the bone and this can produce lesions even though abundant irrigation is used. So drilling is a critical phase in case of complications with the risk of thermal injuries that can compromise the health of bone tissues. Heat injuries will range from blockage of microcirculation and bone marrow macrophage initiation in the heated area to the alteration of alkaline phosphatase at 56° C producing bone necrosis and implant failure as a final outcome (25,26).

1.2.3 Wrong position implant insertion

Implant mispositioning during the surgery is a common complication that occurs during the drilling and implant placement and that can compromise patient function and aesthetics when the prosthesis will be inserted (27). This is included in the intraoperative complications because it concerns the insertion and the drilling phase that are surgical steps and that will further on influence the position of the implant. These wrong positions can occurs in three dimensions, mesiodistal, corono-apical and orofacial angulation (27), that can be incorrect and compromise implant prognosis later and complicate further prosthetic work.

1.2.4 Torque problems

At the end of the surgery the implant that has been inserted needs to be covered by either a cover screw in two-step surgery, or healing abutment in case of a one-stage surgery (28). The torque value is something that needs to be managed precisely and that nowadays can be handled with a torque control device. However, the optimal and manufacturer values are not always obtained. Indeed, some cases of over torquing or under torquing have been reported, over torquing resulting in immediate deformation or fracture of the different implant components (implant, healing abutment, cover screw ...). On the contrary, under torquing exposes the patient to post surgical complication such as screw loosening more than intraoperative complications (28).

1.2.5 Allergies to implants material (titanium)

Nowadays, dental implants are mainly made of titanium which is a highly biocompatible material. However even though it is very biocompatible titanium has history of allergic reaction in oral cavity producing mainly type I and type IV allergic reactions in implant placement (29–32). Type IV delayed hypersensitivity, induced with T lymphocytes will not be included in intraoperative complications contrary to hypersensitivity type I that is immediate and induced by IgE (32). The intraoral allergic reaction type I to titanium will be manifested by facial erythema, intraoral edema and hyperplasia of tissues, sometimes not affecting the tissues near the implant (30).

1.3 Complications depending on the surgical steps

The following table outlines the complications associated with the surgical steps of the implant surgery, categorizing the affected tissues and providing a description of each related complication.

Table (1): Complications regarding steps, tissues affectations and complications description:

Steps	**Tissues affected**	**Complications**
Anesthesia	- Nerve tissues	Neurotoxicity (10,11)
	- Blood tissues	Injection into facial artery (16)
	- Adjacent structures and soft tissues	Needle breakage during inferior alveolar nerve block injection (33).
	- Systemic alterations, skin and mucosal tissues.	Type I mediated IgE mediated allergies to local anesthetics such as lidocaine that produce urticaria, edema, bronchospasm or anaphylactic shock (34).
Flap and Reflection	- Soft tissues	Flap tearing and hemorrhage (8)
Drilling	- Bone tissues	Heat generation with risk of bone necrosis due to blood flow interruption from overheating (23,24).
	- Nerve tissues	Drilling near or into a nerve producing complications such as paresthesia. (12)
Placement	- Nerve tissues	Implant placement too close to nerve tissue, at less than 2mm from the nerve and producing permanent stimulation on the nerve (12).
	- Bone tissues	Risk of implant fracture or screw loosening in case of mishandling of the torque values (26).

2. OBJECTIVE

After exhaustive documentary systematic review, the objectives of this work will be to analyze the different intraoperative complications that could happen during an implant placement surgery and to investigate the prevalence of the different possible complications.

Specific objectives:

- Examine the correlation between sex, age, and the prevalence of complications
- Observe the tissues affected by the complications
- Analyze the surgical steps where complications occur
- Compare the different types of complications
- Assess the patients' systemic factors related to complications

3. MATERIAL AND METHODS

The bibliographic research was conducted with MEDLINE Complete and Dentistry & Oral Sciences Sources data base helping us to find accurate articles. To maximize the sensitivity and specificity, we used MeSH terms and non-specific free-text words with Boolean operators ("AND", "OR", "NOT"), the keywords used were "Intraoperative", "complications" "implant dentistry", "implant placement", "implant surgery" … The limits of the research were the following, using only articles written in English and published within the last 5 years were included (until 2020), only antemortem studies and findings that only concern dental implants and that are related to intraoperative surgical complications only, were considered eligible. Also, as the study subject was related to complications that are usually scarce and very specific situation the result section and table are made with a lot of case reports, these being the one type of articles that gives us the most information about age, sex, surgical step of the complication, oral tissues affected by the complication and health state of the patient. And regarding the fact that the study was conducted to have precise results on these data, case report studies were the most appropriate type of articles that can be used.

For the sake of simplicity and clarity for the readers we decided to put the inclusion and exclusion criteria used for the selection of the articles in the following table that summarizes them in two columns, one for the inclusion and the other one for the exclusion criteria.

Table (2): Inclusion and exclusion criteria:

Inclusion criteria:	**Exclusion criteria:**
English articles	Other languages than English
Antemortem studies	Postmortem studies
Article from 2020 and above	Articles published before 2020
Intraoperative complications	Preoperative and postoperative complications
Scientific articles from MEDLINE and Dentistry & Oral Sciences Source data base	Other kind of documents from a different database of MEDLINE and Dentistry & Oral Sciences Source and from common website
Articles that include at least one case of surgical intraoperative complication in the surgery of an implant or a step that is going	Articles that does not include an intraoperative complication or that does not give sufficient information about the

to be made during an implant surgery.	complication and the data of the patient.

Regarding the methodology the variables that are going to be analyzed are:

1) Age of patient
2) Sex of patient: Male (M) or Female (F)
3) Surgical step where the complication occurred
4) Oral tissues affected by the complication
5) Complication itself
6) Medical history of the patient suffering the complication

In case one of the types of information was not available we put “N/A” meaning not applicable and therefore it was not included in the results section, giving us different numbers of patients depending on whether the data was available for the different subsections of the results section.

We finally obtained a total of 17 articles that reports intraoperative implant complications, and these included studies contain an overall 36 patients that suffered complications ranging from simple aspiration to more severe complication such as bone fractures with the buccal plate or implant displacement to maxillary sinus or nasal cavity. Also, during the study, we sometimes found similar complications but with different consequences within the same organ. For the sake of simplicity to have more reliable results we decided to unify all the gastro-intestinal tract (from esophagus to rectum) as a single complex regarding implant swallowing. We also unified the pulmonary regions as lungs tissues not distinguishing between bronchus, lung base or segmentary bronchus to consolidate data for aspiration complications. Regarding the bone cavity such as nasal cavity or maxillary sinus, they have been unified as bone cavity complications to make the data to be more statistically relevant.

Also, in the results section we will only focus and give results for the patients that suffered complications which are 36 of them. We specify that because the entire study includes a total of 11 849 patient founded in the 17 articles included in the study. We only take the result of those 36 patients because they are the one that experienced complications and that are relevant for the study based on complications. The results are divided into the same subsections

as the columns of our results table, providing more detailed, understandable, and precise information for each table category.

Diagram (1): PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only:

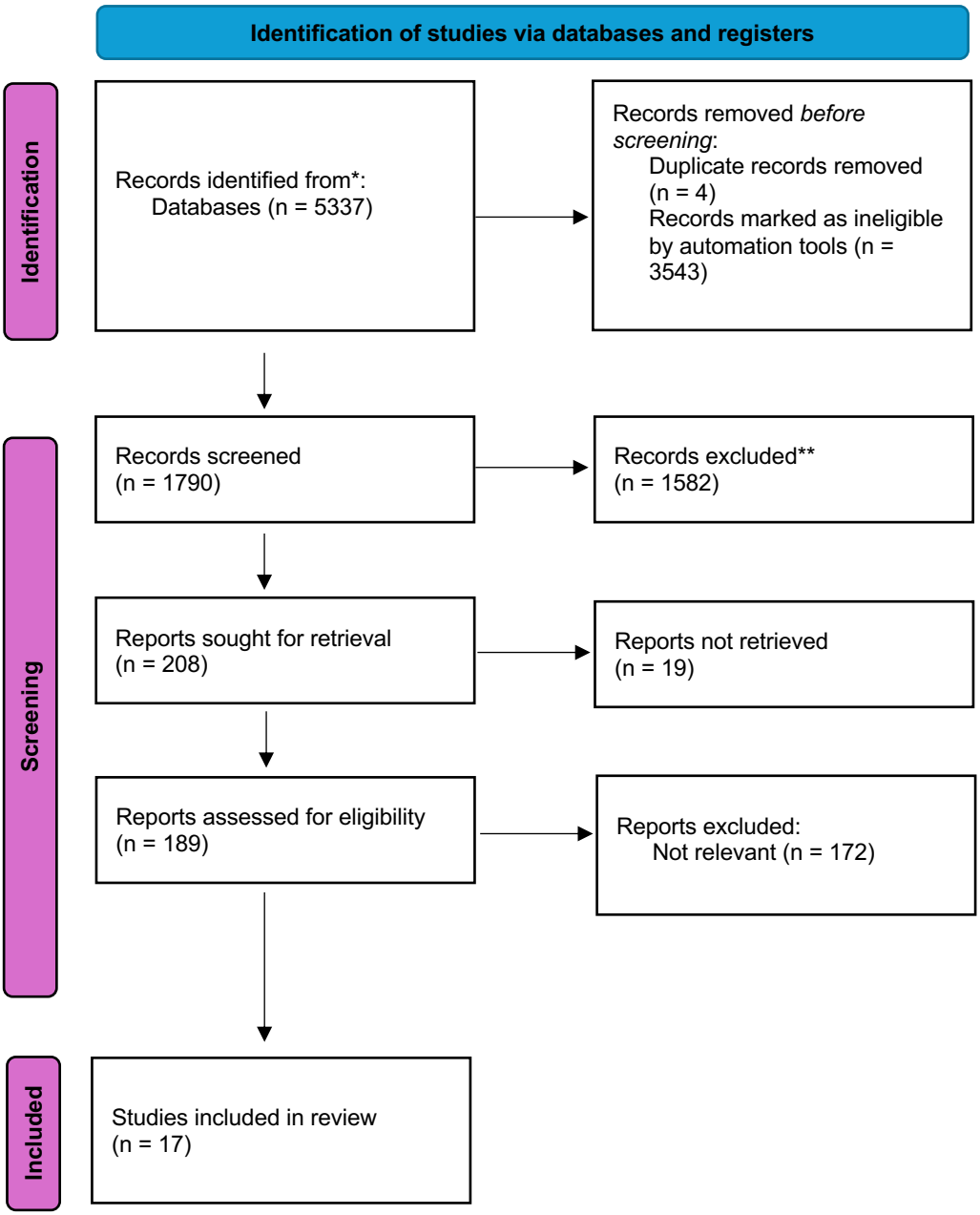


Table (3): Selection of articles and cases for the results section following the material and methods mentioned above.

Author	Year	Number patients	Patient that suffer complication	Age	Sex	Surgical step	Tissue affected	Complication	Systemic disease of the patient
Gary M. Blyleven (6)	2023	38	2	N/A	N/A	Flap procedure	Soft tissue	Flap perforation or tear	N/A
Shivakumar Baskaran (7)	2024	1	1	65	M	N/A	Inferior alveolar nerve (nerve)	Nerve injury	History of Myocardial infaction
Theodoros Lillis (8)	2023	1	1	56	M	Anesthesia	Mental and lingual nerve (nerve)	Neurotoxicity	Gastroenteritis-induced Guillain Barré Syndrome
Ahmad Albassal (11)	2025	1	1	48	F	Implant placement	Mandibular buccal plate (bone)	Bone fracture	Healthy
Garcia-Blanco M (14)	2021	1	1	58	M	Anesthesia	Facial artery (blood vessel)	Vessel injection	Controled Hypertension
Sfondrini D (15)	2024	2	2	52	M	Implant placement	Sublingual branch of the lingual artery (blood vessel)	Hemmorage	N/A
				69	F	Implant placement	Sublingual branch of the lingual artery (blood vessel)	Hemmorage	N/A
Muchnik D (17)	2025	32	7	70	F	Implant placement	Maxillary sinus (bone cavity)	Insertion in sinus	N/A
				33	F	Implant placement	Maxillary sinus (bone cavity)	Insertion in sinus	N/A
				54	F	Implant placement	Maxillary sinus (bone cavity)	Insertion in sinus	N/A
				68	M	Implant placement	Maxillary sinus (bone cavity)	Insertion in sinus	N/A
				56	F	Implant placement	Maxillary sinus (bone cavity)	Insertion in sinus	N/A
				19	F	Implant placement	Maxillary sinus (bone cavity)	Insertion in sinus	N/A
				36	F	Implant placement	Maxillary sinus (bone cavity)	Insertion in sinus	N/A
Yeom HG (18)	2023	3	3	51	F	Implant placement	Nasal cavity (bone cavity)	Insertion in nasal cavity	N/A
				64	M	Implant placement	Nasal cavity (bone cavity)	Insertion in nasal cavity	N/A
				76	F	Implant placement	Nasal cavity (bone cavity)	Insertion in nasal cavity	N/A
Rosas-Díaz J (19)	2024	3	3	67	F	Implant placement	Mandibular body (bone cavity)	Displacement in mandibular body	Healthy
				37	F	Implant placement	Mandibular body (bone cavity)	Displacement in mandibular body	Healthy
				74	F	Implant placement	Mandibular body (bone cavity)	Displacement in mandibular body	Diabete type II controlled
Huh J (23)	2022	586	1	N/A	N/A	Implant removal	Gastrointestinal tract	Swallowing	N/A
		11 170	4	N/A	N/A	Implant placement	Gastrointestinal tract	Swallowing	N/A
Srivastava N (24)	2024	1	1	62	M	Implant placement	Gastrointestinal tract	Swallowing	Healthy
Terada K (33)	2022	1	1	36	W	Anesthesia	Pterygomandibular space	Needle breakage	N/A
Gandagule RR (21)	2025	1	1	67	M	Implant placement	Lungs tissues	Aspiration	Healthy
Pilar Barragán-Reyes (22)	2023	3	3	80	M	Implant placement	Lungs tissues	Aspiration	Healthy
				91	M	Implant placement	Lungs tissues	Aspiration	Arterial hypertension, ischemic heart disease, benign prostate hypertrophy, acute pancreatitis and choledocholithiasis
				80	M	Implant placement	Lungs tissues	Aspiration	Hypertension, dyslipidaemia, obesity, permanent atrial fibrillation and hypertensive heart disease
Mariana Pinto (16)	2025	1	1	80	W	Implant placement	Maxillary region	Maxillary bleeding and bone exposure	Anticoagulated patient
Azim SA (35)	2024	1	1	57	M	Implant torquing	Implant itself	Broken srew inside implant while torquing	N/A
Bär and Al-Nawas (36)	2024	3	2	70	M	Flap (for second surgery)	Nasal cavity (bone cavity)	Insertion in nasal cavity	Heavy smoker
				53	M	Flap (for second surgery)	Maxillary sinus (bone cavity)	Insertion in sinus	Heavy smoke/ Anxiety disroders

4. RESULTS

4.1 Age:

The average age of the 29 patients included in the study, for whom the age date was available (7 patients without the data of the age available) was 59,62 years old, with a median of the patient that is 62, the mode was 80 years old with 3 patients having this age, the range of the study was of 72 years, varying from 19 years old to 91 years old patients. These are logical result for the age because implant procedures are destined to people that have lost teeth to restore them in terms of function and aesthetics. Considering that, from an age of 40 years old the risk of tooth loss is significantly increased mainly due to periodontal disease and caries (37).

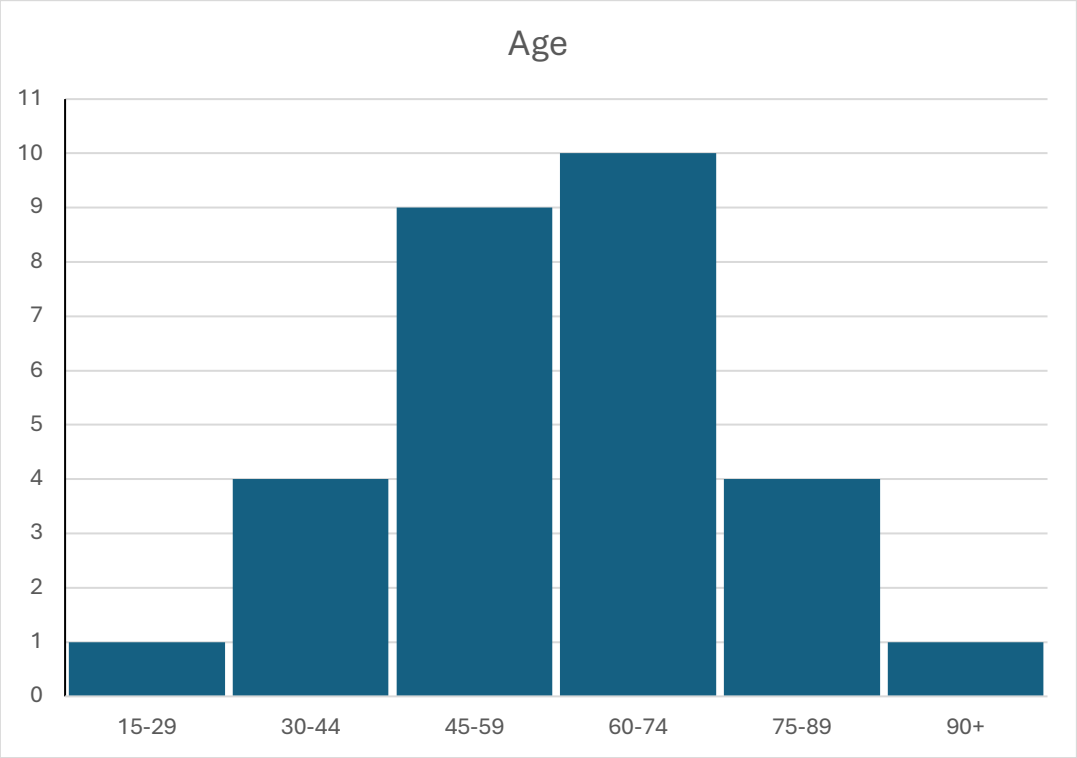


Figure (1): Diagram of the age distribution of patients that suffered complications, divided in intervals of 15 years.

4.2 Sex:

Regarding the sex of the patients that suffered complications out of the 29 patients for whom we obtained the data of the sex (7 excluded due to lack of information) we observed almost a 50/50% ratio, with 15 females and 14 males that suffered complications in the scientific study giving us a total of 52% of females and 48% of males in the study.

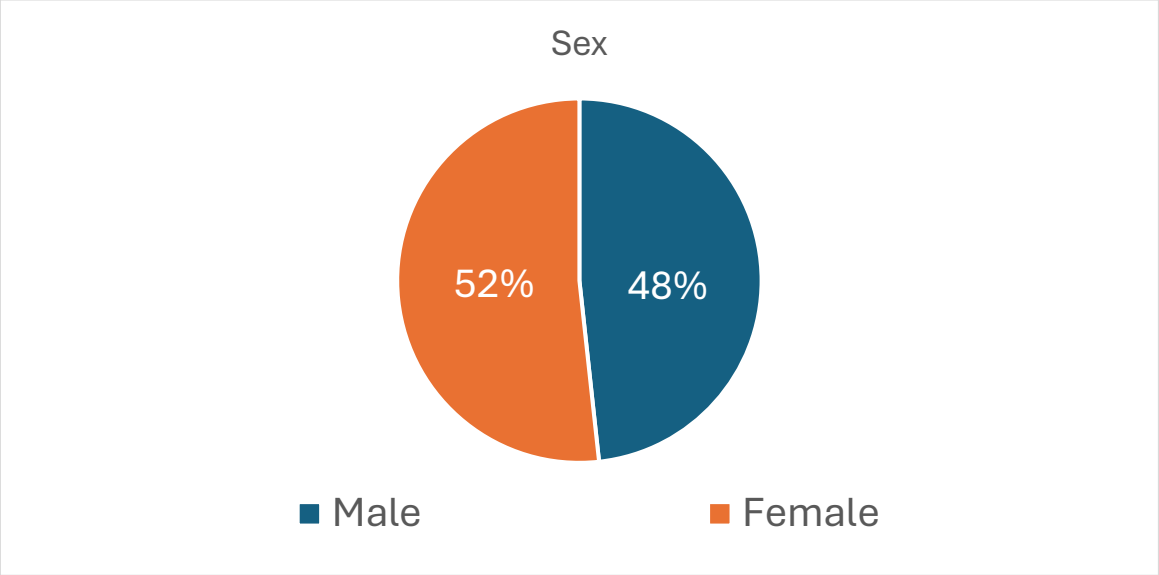


Figure (2): Diagram of the proportion between males and females that suffered complications.

4.3 Surgical step when the complication occurred:

We obtained results showing that 74% of complications occurred during the implant placement step, giving us 26 patients in that surgical step, 9% for the anesthesia step with 3 patients, a total of 11% of complications for the flap step with 4 patients and including 2 flap complications for the flap of the second-stage surgery. Then we have 3% for the torquing step with 1 patient and 3% for the implant removal step, also with 1 patient. These results were obtained from 35 patients as we are missing data for one patient regarding the surgical step of the complication.

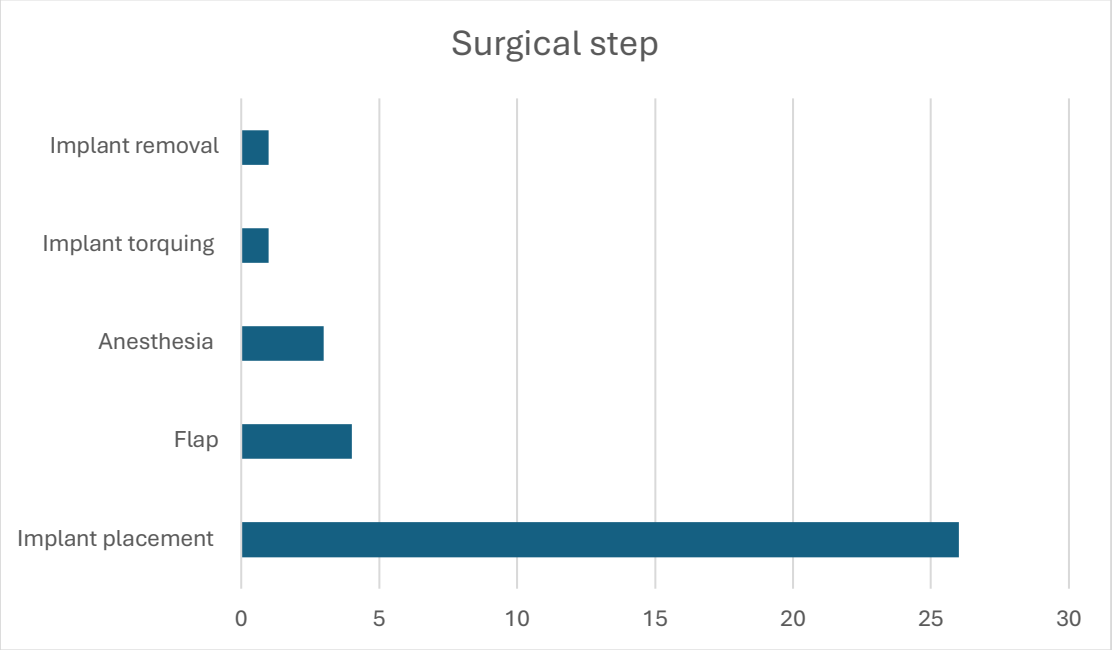


Figure (3): Number of patients that suffered complications regarding the surgical step in which the complication occurred.

4.4 Anatomical tissue affected by the complications:

In the following diagrams you will find the occurrence of complications per anatomical tissues concerned by a complication in the 36 patients included in the scientific research. The obtained results show a clear increased involvement of sinus cavities with 8 patients having their maxillary sinus affected and 4 in the nasal cavity. We also have high involvement of the airways and gastrointestinal tracts, with 6 patients suffering from gastrointestinal complications and 4 lung complications. Then we have vascular tissues damage, with 2 patients suffering complications from sublingual branch of the lingual artery, 1 patient with facial artery damage

and 1 patient that suffered severe bleeding in the maxillary region. We also have 3 patients that have mandibular body implant insertion and loss of the implant in this bony cavity. Then we have soft tissues tears, with 2 patients concerned with complications on the buccal mucosa due to tears. Nerve tissues are involved, with 1 complication on inferior alveolar nerve and 1 complication on mental and lingual nerves. One complication is not related to a tissue but related to the implant itself, being over-torqued, resulting in implant fracture. Finally, we have 1 complication in an anatomical space, the pterygomandibular space and 1 patient that suffered a bone complication with buccal plate fracture.

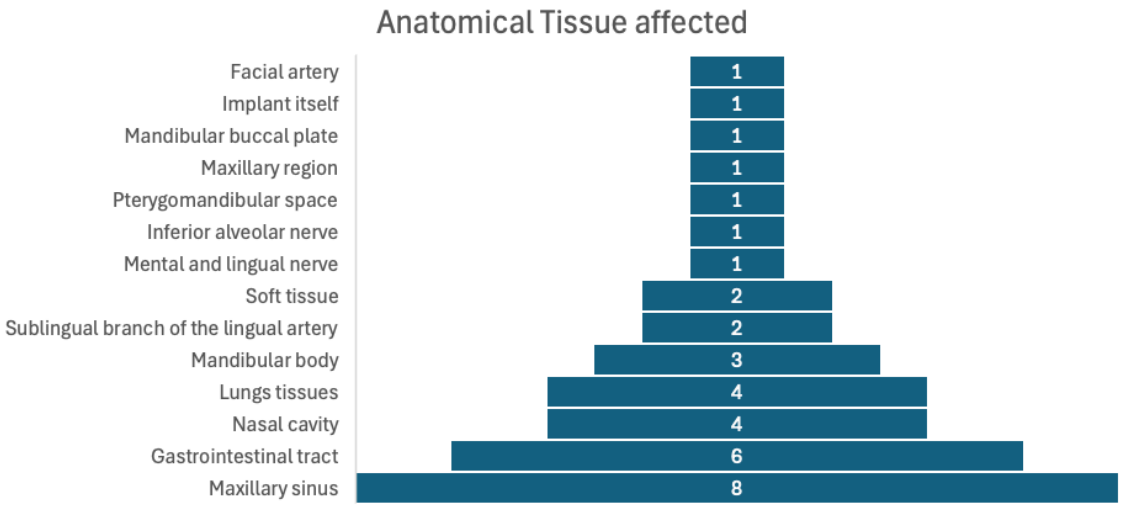


Figure (4): Diagram of the complications related to the affected anatomical tissues.

We have decided to unify some tissues into categories to obtained simplified and generalized data on the different tissues of the body and to obtain more relatable data to analyze. To proceed, we unified the maxillary sinus, mandibular body and nasal cavity as bone cavities where the implant could get trapped during an intervention giving us 42% of complications for this category. Then we included the gastrointestinal tract and airways into the same category as they relate to aspiration complications, giving us a total of 28%. We unified vascular tissues complications, including the facial artery, maxillary region bleeding and sublingual branch of the lingual artery together to group blood complications, resulting in 11% complications on this category. For the soft tissue tears, we kept the same as previously because no other subcategory was able to be included into it. We obtained 5% for the soft tissues category. Regarding the nervous tissues, we included mental and lingual nerve complications

with inferior alveolar nerve complications, giving us a total of 5% occurrence of complication for the nervous tissues. We classified the pterygomandibular space as an anatomical space for reason of understanding and simplification with 3%. The buccal plate complication was called a bone complication due to the fracture of a bone, with a total of 3%. And finally for the complication that occurred on the implant itself with the breakage of it in the tissue, we called this subsection implant with a 3% complication.

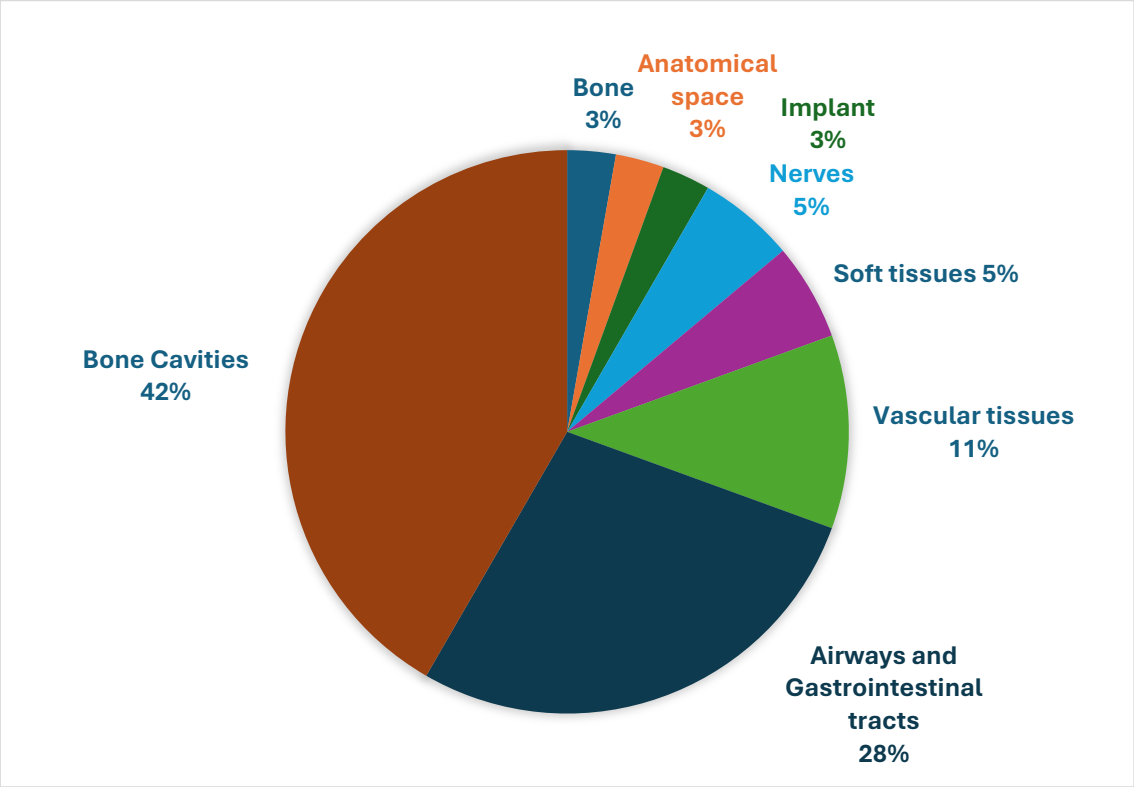


Figure (5): Diagram of the proportion of complications according to anatomical tissues after simplification and unification into general tissue categories rather than tissue subgroups.

4.5 Complication itself:

The next step in the results section is the precise description of the complications that occurred. In the study, out of the 36 patients included, we obtained a total of 8 patients that suffered implant insertion into the maxillary sinus. Then we have 6 patients that swallowed the implant, where the implant was directed into the gastrointestinal tract. We have 4 patients that suffered implant insertion into the nasal cavity, and 4 that aspired the implant into the airways. Three patients had implants inserted incorrectly into the medullary space of mandibular body ,

with difficulty in removal during the surgery after the missed insertion. We also have 2 patients with a hemorrhagic condition, and 2 patients with flap perforation or tears during the implant surgery. One patient suffered nerve injury, 1 experienced neurotoxicity, and 1 had breakage of the anesthetic needle during the inferior alveolar nerve block. One patient experienced maxillary bleeding with bone exposure, and 1 patient suffered injection into a vessel during an inferior alveolar nerve block due to injection of local anesthesia into the facial artery caused by lack of aspiration. One patient reported breakage of the screwdriver into the implant while torquing, and finally, 1 patient suffered a bone fracture with breakage of the buccal plate during implant placement.

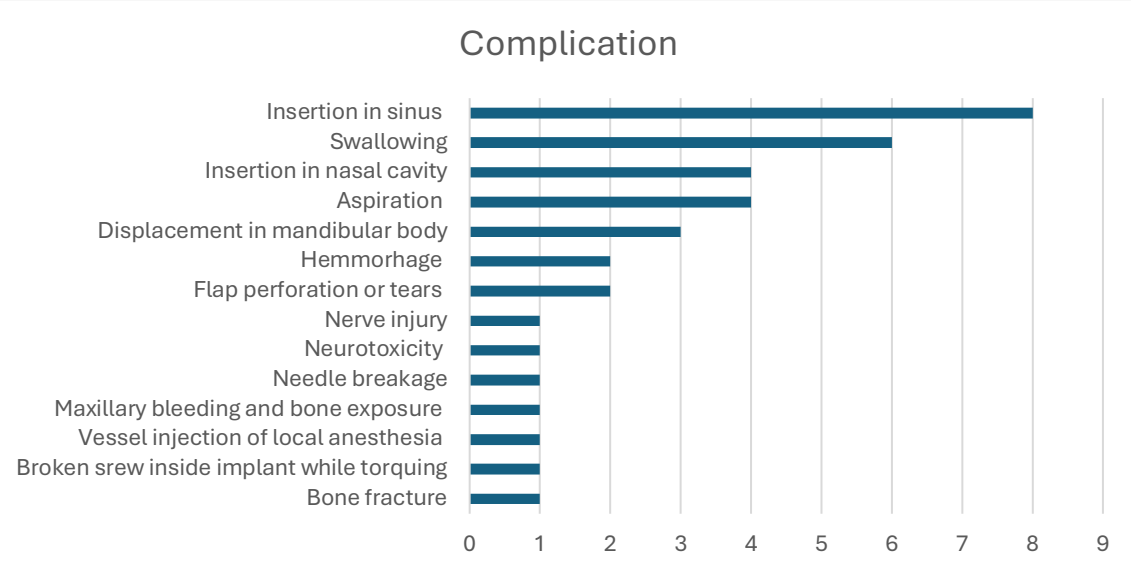


Figure (6): Diagram showing the complications experienced by the patients included in the study.

4.6 Medical condition of the patient suffering the complication:

For the results of this subsection, we decided to group the patients into categories of diseases to have unification and more reliable results instead of having multiples diseases and one patient per systemic condition, throughout the study we obtained 15 patients where the systemic condition was mentioned out of the 36 patients that suffered complications. And out of the different medical conditions a total of 14 systemic conditions including healthy patients were underlined. To clarify we also decided to separate all the disease even though a patient could have more than one systemic condition, so we started with 15 patients, but we have a total of 22 conditions out of the 15 patients. Regarding the categories that we created we

proceed by including into the category cardiac patients all the following conditions, myocardial infarction, hypertension, ischemic heart disease and atrial fibrillation giving us a total of 6. Then we have the metabolic condition that includes diabetic patient and dyslipidemia, this category includes a total of 2. Then we have a category for neurological patients including 1 patient suffering Guilhem Barre syndrome. We also have anticoagulated patients that is included in its own category of blood disorder, being present on this category only 1 patient. We also keep in his own category the heavy smoker's patients as this condition is part of their lifestyle and as it is the only condition that can be included in the lifestyle part, we obtained 2 for this category. Then we have the anxious patient that have been placed in its own category as well because no other subcategory could have been included with it giving us 1 for this category. For another category we decided to create the gastrointestinal patient giving us a category that unifies acute pancreatitis and choledocholithiasis giving us a total of 2. The last category of this part is the one of the healthy patients including the healthy patients themselves and the patient with benign prostate hypertrophy. This patient having a benign condition we consider that it was pertinent to include him in this category as he does not suffer any symptoms or bad condition being dangerous for his physical integrity. And this category gives us a number of 7.

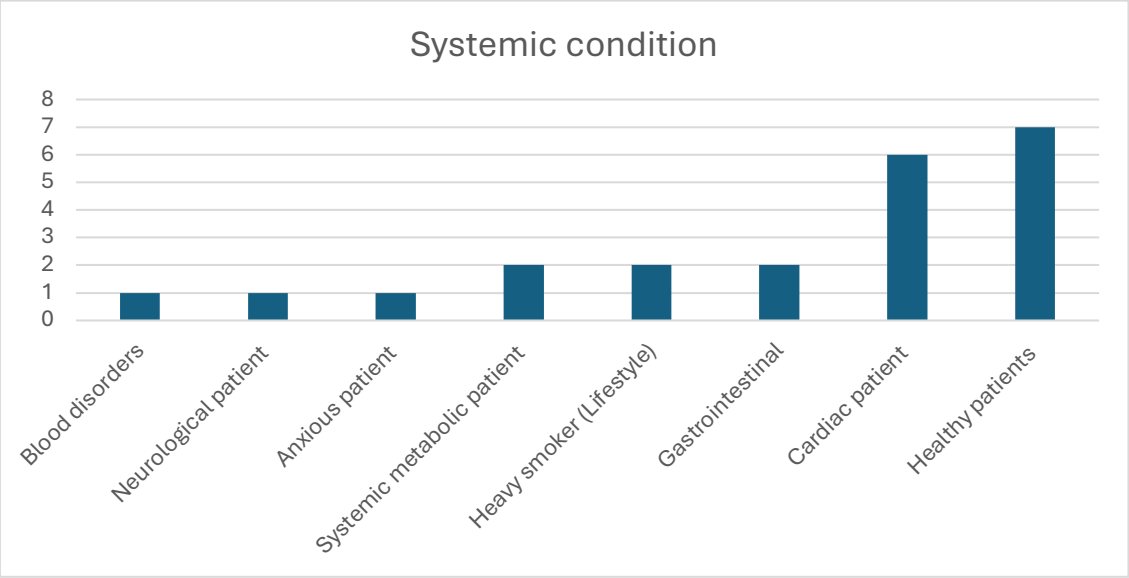


Figure (7): Classification of systemic conditions in patients who experienced complications in the study.

5. DISCUSION

The study focused only on intraoperative complications in implant dentistry, and during the research we realized that intraoral complications were not very frequent, or at least not well represented in the literature, probably due to the desire to not reveal when bad treatment procedures happen and therefore not wanting to be discredited by other clinicians or patients. Basically, in the last 5 five years, we found that it was complicated to obtain relevant articles about this subject even though it may initially appear common to have intraoperative complications during an implant surgery. As it is a surgical procedure that includes anesthesia, incision and flap realization and bone drilling, we could have thought that finding articles would be easier, but this was not the case, contrary to other intra surgical or post-surgical complications in implant cases that are more represented in the scientific literature. A good example of difference in the findings of complications is the contrast with the reported cases or systematic review for the subject of third molar extraction, which are more represented in the scientific literature (38). Considering that, we arrived to three possible hypothesis that are that intraoperative complications can be more prevalent in other types of surgical procedures compared to implant surgery, the second can be that the intra surgical complications in implantology are less documented for a goal of credibility of operators and to avoid revealing these problems in the literature and finally that implant surgery can be less frequent that other surgical procedures such as 3rd molars extraction being therefore less represented.

To come back to the study and by comparing with the actual scientific literature we will now focus on the results to see if it exists correlation or difference in other articles. The first results that we studied is the age and we obtained a mean age of 59,62 years old. We can relate it to an article that has studied the outcome of implants in a sample of 339 patients and where the mean age of implant procedures was 54 years old. So, as implants are used in this mean age for this study, we can relate it with the result of the mean age of complications that happen being close to the mean of the article. So as implant procedures are mainly done in this age category of patients the occurrence of complications should happen in the same range of age of patient giving a logical association between the other article and the study made (39).

Then the second part of the result section was the analysis of the gender of the patients who suffered dental implant intraoperative complications, and we found a near perfect fifty-fifty percent ratio with 48% males and 52% females. To compare it with the literature, we decided to use the same article as the one for the age, because he was giving us information about gender of the patients. The article of Funda Goker about outcomes of dental implant that was studying the 339 implants placement was composed of 168 males and 171 females giving us almost the same ratio as the one that we obtained in the study with a near fifty-fifty percent of ratio regarding the sex of the patients (39).

The following part of the result was the time of the surgery when the complications occurred and more precisely the surgical step when it happened. In this subcategory we observed that the most critical surgical step affected by complications was the implant placement itself when it was screwed in the bone followed by flap procedure complications and anesthesia complications. To compare the result with other scientific literature we decided to select the article of Torsten Jemt talking about implant placement problems and the relation with following peri-implantitis. In the analysis of this article, we only focused on the surgical problems that occurred to the operators (40). The results of this article were focusing on the complications during implant procedures happening in the drilling and in the implant placement mainly. We observed that in their study among all the problems observed a bad insertion of the implant when screwing it was responsible of 4% of problems, followed by bone drilling that was responsible of an addition of percentage of 0,9% of hemorrhages, 0,5% of drilling into sinus, 0,5% of nerve injury due to drilling. These results are different than the one that we obtained in the results section. This is because the drilling and the implant screwing were included together in a manner of simplification for the results section. Also, as the articles included in the study were lacking very precise information on when the complications occurred during the implant placement the results obtained in the study are therefore different.

Another axis of the result was the anatomical tissues affected by the complications in the implant procedures. In the scientific literature that we used to compare with the results we decided to take 2 articles with results on the injury of anatomical structures linked to a complication during an implant surgery. The first one was about prevalence and management of nervous injury following a dental implant insertion in the mandibular region (41), this one was focusing on nerve injuries. And the second article that we will use to discuss about anatomical

structure is going to be the one talking about errors of position in implant insertion. This article gives information and results about the bone dehiscence, insertion inside or close to anatomical sensible structures such as the nasal cavity, maxillary sinus, mandibular canal or mental foramen (42). The first article about nervous structure was focusing mainly on paresthesia that happen after implant placement reflecting a difference with the lesion that we found on nerve that were called neurotoxicity and nerve injury. Regarding the bone article he was showing a big proportion of fenestration and dehiscence with exposed thread after the implant placement of 37,73%. Then this article was presenting a big proportion of implant wrongly placed into or very near the maxillary sinus 27,67% or nasal cavity with 1,89% being in correlation with the results obtained of the study. We understood thanks to these 2 articles that the position of the implant is crucial to avoid complications and that a precise planification is mandatory to avoid them. Compared to the study we found these results pertinent and in correlation to the one we obtained with a big proportion of sinus insertion of 27,67% in the article (42), compared to these of the study with the 22% of maxillary sinus insertion being the most affected anatomical tissue of the study. However, concerning fenestration and dehiscence with exposed thread after implant placement the study that we made was lacking this kind of information for the bone tissue and the results were different from the one of the study being a limitation for the study realized compared to other literature showing a big amount of complications for this one with a total of 37,73%. Also, another limitation was the amount of insertion in the nasal cavity that was higher in the study with 11% compared to the 1,89% of the article.

The following part of the results section was the complication itself. To discuss this part of the results section we decided to focus on accidental complications with the aspiration and ingestion that was representing a big percentage of complications that we found. When we add these complications together (aspiration and ingestion), we obtain a total of 28%. For this section we decided to re-use one article that was part of the results. But during the study we only focused on the implant part of this article, now we are going to relate the results on implant with the one in other dentistry field that are exposed to ingestion and aspiration. This article is the retrospective study of aspiration and ingestion in the dental clinic by Jison Huh (23). The results that we used were the one about implants with a total of 5 aspirations cases in implantology giving out of the 39 complications reported in the article a total of 13% for intraoperative procedures of implant. Then the article shows a big percentage for the prosthesis specialty with 25 aspirations and ingestions of prosthesis of different types such as inlay, crowns, implant fixed prothesis … Therefore, prosthesis is representing the main specialty were

aspirations and ingestions happen with 65% for this dental field. So implantology is way less represented for the aspirations and ingestions of materials compared to other specialty such as prothesis. Aspiration and ingestion in implantology are ranked almost at the same level as the surgical extraction with 4 out of 39 patients for this field of dentistry. These 2 fields in which rubber dam cannot be used are therefore being more exposed to aspirations and ingestions. These results could be explained by the advancement of technology in dental implantology because for example nowadays the screwdriver for removing the cap of the implant after its placement are manufactured with holes sometimes to allow the passage of dental floss as a protection in case of ingestion and most of the implantology material that is used can be hold by rotatories instruments and wrenches with multiple adaptors to fit almost every material. Therefore, making the aspirations and ingestions scarcer. This shows another limitation of our study that showed a big proportion of ingestions and aspirations compared to the literature which present it as a rarer event for the field of implantology with only 13% of case mentioned in the article.

With all that we said we understood that most of the results of the study were due to a bad planification, operator mistakes or accidental manipulations for most of them. So, regarding the last part of the study with the medical complications showing for most of them a good state of health or cardiac condition we can understand that their physical health was not related to the complications pointed in the study. These values could have been corelated if in the results part we would have founded big hemorrhage with anticoagulated patient or if the complications for the cardiac patients would have been angina pectoris for example. Anyway, we decided to include an article that relate these kinds of complications that can become emergencies and that are linked to dental treatments and medical history and therefore that can happen in aggressive surgeries such as implant procedures. The article selected is the one about dental practice medical emergency that show the occurrence of emergencies associated to dental practice. Emergencies are scarce and usually don’t happen for years instead of the syncope being idiopathic usually, and not associated to any medical condition (43).

Regarding implant procedure itself, the prevalence of post-surgical complications in implant dentistry is way more represented in the literature being more prevalent because being less predictable and being influenced by much more factor than the intra surgical complications being mainly affected by the operator and planification of the cases. Also, the measurement is

easier than the intraoperative complications, because for post-surgical complication such as implant failure or peri-implantitis, prospectives longitudinal or retrospectives studies can be realized. These kind of studies are more complicated to applied for surgery complications that happen in a moment and that are nor predictable (44,45). We can also understand these results in terms of a lack of information and being mainly limited to case report articles, because nowadays implant surgery are very well planned thanks to an increase of precision of the technologies such as implant themselves that have evolved and are more ergonomic. Also, nowadays we have a systematic use of CBCT in the planification to see bone level, anatomical structures such as inferior alveolar nerve or maxillary sinus (46). These new methods used in combination with classical methods such as panoramic X-rays and periapical X-rays, help us to significantly reduce the frequency of complications. Another parameter that is part of routine planning and treatment realization is the use of surgical guide during the surgery to avoid mispositions and complications on anatomical structures during the implant surgery (47). Therefore, being another reason why, the complications prevalence is reduced in the last five years that we studied. This explains why we observed that a lot of complications in the study were accidental things such as aspiration or ingestion of implants and implants tools such as screwdrivers. These complications are due to the clumsiness of the operator, rather than a bad planification conducting to more severe problems related to blood tissues or nervous tissue for example. Considering all these parameters, we understood the limitations of the study, which were the lack of more valuable information that could have been founded into cohort study for example, rather than a lot of case reports to achieve the results.

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6. CONCLUSIONS

The study showed that intraoperative complications in implantology were multiples and concerning almost every tissues of the mouth and even further from the mouth. However, we also understood that they were not very prevalent and were usually rare and isolated cases.

We observed that complications were generally correlated with the age at which patients had lost teeth and were therefore patients are undergoing implant surgeries, typically in middle to advanced age, around 60 years old. We also found that complications were not related to sex, affecting both females and males equally.

Then for the investigation of the tissues affected by complications we found that the tissues most affected were bone cavities with wrong insertion of implants in the maxillary sinus mainly. Then the second tissue mostly affected by complications was gastrointestinal tract with ingestion of instruments.

The surgical stage which was mostly affected by the complications was the implant placement that is a critical stage. In this stage pieces can be swallowed, and a lack of preparation of the cases was responsible of mispositions or insertions in bone cavities or anatomical spaces. Flap and anesthesia steps were also prevalent surgical steps in which complications occur.

For the different type of complications, we observed that they were varying from clumsiness of the operators with cases of aspiration, ingestion or anesthetic insertion into artery to more severe cases with acute bleeding, bone fracture or insertion of implants into anatomical spaces such as nasal cavity, mandibular body or maxillary sinus.

Finally for the study of correlation between systemic factors and complications we saw that they were two parameters not related. Indeed, the complications are not usually related to the systemic condition of the patient and most of the patient studied for complications were healthy patients.

7. SUSTAINIBILITY

The analysis of the intraoperative complications is nowadays of great importance in healthcare system mainly in a social and economic way. Preventing and managing these complications are contributing to well-being of patient and being part of quality of treatment that the patients expected when they are treated with implants allowing them to regain function and aesthetics without future limitations, problems or disabilities. This social part anchored itself in the WHO definition of health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”.

Regarding the economic perspective, the prevention of complications is important in a manner of avoiding additional treatments, corrective surgeries and interdisciplinary avoidable treatments as hospital management of complications for example. Also avoiding extended clinical time and therefore lowering costs for the professionals, the patients and the healthcare system.

Regarding these economic and social point of view we understand another time the importance of prevention, treatment planning and knowledge of the professionals for implants treatments.

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