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Managing failures in implant dentistry

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Abstract
Osseo-integrated dental implants have emerged as a widely embraced and established treatment approach for replacing missing teeth in partially and totally edentulous areas. Failures do occur despite the commendable success rates and stability of dental implants. The consequences of failure in dental implants are often perceived by many clinicians as a significant impediment to implant treatment, jeopardizing the clinician's efforts to accomplish satisfactory function and aesthetics. These failures challenge the clinician's endeavours and cast a shadow on the overall success of implant treatments. Therefore, this article provides a brief insight into the frequent complications of dental implants and their management. It also helps clinicians understand how to best prevent them from enhancing favourable treatment outcomes and long-term patient implant survival rates.

Keywords: Management, prevention, complications, failures in implants, implant dentistry

Introduction
Understanding the dynamics of tooth loss within a population is a crucial metric for evaluating the quality of dental healthcare, a facet that exhibits considerable geographical and cultural variation globally. Research indicates that dental caries and periodontal diseases are causative factors for tooth extraction [1]. Upon losing a tooth, individuals often seek replacements to restore function and aesthetics. Over the past decade, clinical prosthodontics has seen significant advancements in response to scientific progress and evolving patient demands. Traditional prosthodontic options for replacing a single missing tooth included partial dentures that are removable, partial and full arch dental prostheses, and resin-bonded bridges [2].

The landscape of prosthodontics witnessed a transformative shift with the introduction of dental implants as an alternative to conventional dentures and bridges. Presently, individuals can choose single–tooth crowns or implant-supported fixed prostheses. The essence of dental implants lies in the concept of osseointegration, wherein osteoblasts seamlessly merge with the titanium implant surface positioned surgically within the alveolar process [3]. The widespread popularity of dental implants stems from their ability to reinstate near-normal function, whether in partially or completely edentate arches.

Several review studies have thoroughly analysed the longevity and complication rates of fixed prostheses supported by implants, revealing consistently favourable survival rates for single [4] and multi-unit [5, 6] implant-supported fixed prostheses over a decade. While fixed implant-supported restorations are now widely accepted as robust treatment options for replacing individual or multiple missing teeth, it is essential to note that high survival rates don't necessarily equate to a complication-free experience as dental implants ascend to prominence in the realm of tooth replacement, challenges to emerge. This review aims to delve into the specific complications associated with dental implants. It addresses management protocols and briefly explores preventive measures to mitigate potential complications, providing a comprehensive overview for clinicians and patients alike.

Discussion
Periodontal complications
Peri-implant mucositis: This condition resembles gingivitis and involves a reversible inflammatory reaction in the soft tissues encircling an Osseo-integrated implant [7]. This is prompted by the accumulation of microorganisms and food debris around dental implants and

the gingival tissues, triggering a reactive state. The genesis of this condition is rooted in the formation of a tenacious layer of plaque or biofilm on the implant surface, a critical factor contributing to the progression of peri-implantitis.

Management

The initial phase of managing peri-implant mucositis involves Mechanical debridement of the surface of an implant, typically performed using scalers and curettes made of either titanium or stainless steel. In Contemporary Practice, Ultrasonic scalers equipped with Polyether - ether ketone-coated tips, comprising high-tech plastic material and a stainless-steel core, have emerged as an alternative [8]. The main objective of this device is to meticulously remove plaque and calculus from the implant neck and abutment, achieving a pristine, smooth surface. Complementing mechanical debridement, antimicrobials play a crucial role in preventing the re-establishment of bacterial colonization post-treatment. Chlorhexidine-based products, alongside other antimicrobial agents, are used as supplements to improve the effectiveness of mechanical debridement and contribute to the sustained suppression of bacterial activity around the implant site.

Peri-Implantitis: This condition is identified as an inflammatory response correlated with the deterioration of surrounding bone around the dental implant. Bacterial colonization is considered to be one of the prime factors responsible for causing Peri-implantitis.

Management

Based on the clinical assessment and radiographic findings, a plan of therapeutic interventions has been formulated, which is collectively known as Cumulative Interceptive Supportive Therapy (CIST) [9]. The initial phase involves mechanical debridement of the implant surface, employing carbon fiber curettes or those crafted from titanium and steel to chip away calculus. Simultaneously, plaque removal is accomplished through polishing using rubber cups and polishing pastes. Complementing mechanical debridement, an antiseptic regimen involving the application of Chlorhexidine gluconate, either as a daily mouth rinses with a concentration of 0.1%, or as a topical substance should be administered twice daily to the intended area or target site for one month.

In instances where a peri-implant lesion is evident radiographically or Probing measurements around the implant exceed beyond normal range, systemic administration of antibiotics (Metronidazole 400 mg three times a day and Ornidazole 500 mg twice a day) is recommended to eliminate the pathogens residing within the submucosal ecosystem. Recently, an alternative to systemic antibiotics has emerged in the form of local antibiotic application through the use of Controlled release drug delivery systems as a viable treatment approach for peri - implantitis where tetracycline periodontal fibers (Actisite), Chlorhexidine Chips (PerioChips), Minocycline hydrochloride (Arestin) are administered to the peri-implant sulcus via syringe [9, 10].

Laser decontamination presents itself as a viable option, utilizing either CO2 or erbium-yttrium aluminium-garnet (Er: YAG) laser with a frequency of 1.5 W. This procedure aims to eliminate the titanium oxide layer contaminated with bacteria, fostering re-osseointegration and promoting healthy integration of soft tissue around the compromised implant.[10]

Photodynamic therapy introduces a non-invasive treatment modality for peri-implantitis [11]. This approach involves the use of low-power diode laser operating at a wavelength of 660 nm and an intensity of 100 mW for 10 seconds, combined with a photosensitizer dye (Phenothiazine Chloride) application for 3 minutes followed by subsequent irrigation with 3% Hydrogen Peroxide [12]. In cases where evident bone loss is observed, depending upon the size and morphological characteristics of the lesions, a regenerative or resective surgical procedure such as Implantoplasty may be desirable in conjunction with mechanical devices, including high-pressure air powder abrasion/lasers.

Nerve Complications

Nerve injuries: Nerve injuries related to implant placement can arise during administration of local anaesthesia, the preparation of the osteotomy site, and after implantation. Among these, one of the most serious complications is inferior alveolar nerve injury causing an altered sensation. This ranges from mild paraesthesia to complete anaesthesia.

Prevention & Management: Prevention of inferior alveolar nerve injury hinges on meticulous and comprehensive preoperative implant planning. Cone beam Computerized tomograms (CBCT) / Computed tomography (CT) scans play a pivotal role in the treatment planning phase helping determine implant size, location, and vector of placement while avoiding the mandibular canal. Whenever a panoramic radiograph is being used to visualize the course of the inferior alveolar nerve along the mandibular body and para symphysis areas, one must account for up to a 25% magnification (magnification factor of 1.25) [13] while measuring the distance from the alveolar ridge to mandibular nerve canal. This can be precisely measured by applying the formula:

Radiographic bone height / Magnification factor = Clinical bone height

Where radiographic bone height represents the distance from the ridge crest to the superior margin of the inferior alveolar canal on the radiograph. After determining the Clinical bone height, it is crucial for the surgeon to always deduct the 2mm safety zone between the implant and the upper border of the inferior alveolar nerve.

Intraoperatively, employing tools like CT-based surgical guides, stents, Prefabricated navigation systems, and drill guards along with trans alveolar implant techniques to slant the implant laterally, aids in avoiding nerve injury.

If a radiograph indicates that the implant is exerting pressing on the nerve, it should either be removed or backed out slightly to alleviate the nerve compression. In cases where the problematic implant is already Osseo integrated, removal can be achieved using a trephine bur that cuts circumferentially around the implant.

For recently placed non-Osseo integrated implants, removal can be done using a torque wrench/drill. In instances where there is no injury to the canal, but the paraesthesia persists and the implant appears close to the canal, then mechanical decompression is advised. This involves either backing out / removing the implant. But if the condition deteriorates and the CT shows that the canal has been transected, then, in such cases, the inferior alveolar nerve can be repaired with the implant still left in place [14].

Surgical procedures for inferior alveolar nerve injuries:

1. **External decompression:** This procedure entails the removal of adjacent bone, soft tissue framework, and other foreign objects close to the nerve.
2. **Internal Neurolysis:** It is the opening of the epineurium

to inspect the internal nerve structure and decompress the nerve fascicles. If there is a discontinuity defect of one or more of the fascicles, then neurorrhaphy/nerve graft reconstruction is indicated. If the nerve is found to be intact, external decompression and internal neurolysis procedures are indicated.

3. **Neuroma Excision:** It involves the surgical resection of a neuroma in close association with a nerve.
4. **Neurorrhaphy:** Involves surgical anastomosis of a severed nerve.
5. **Nerve Grafts:** Involves placing a graft, either from a donor or from the patient's own body, to reconstruct the nerve between the two ends. The Greater auricular and sural nerves are frequently utilized as preferred autologous grafts for nerve regeneration.
6. **Nerve Sharing:** Involves microsurgical joining of a terminal nerve to a distinct adjacent nerve using an interposed nerve conduit.
7. **Guided Nerve Regeneration:** Involves positioning a conduit to facilitate axon extension and reinnervation across a nerve gap from adjacent to terminal segments of a nerve.
8. **Neurectomy:** Involves microsurgical severing and excision of portions of a nerve tract.
9. **Nerve Capping:** This procedure entails encapsulating the initial segment of a sectioned nerve with its neural sheath to suppress neuroma growth.
10. **Nerve Redirection:** Includes redirecting the sensory innervation of a nerve to a different anatomical site, often nearby muscle, to alleviate deafferentation.
11. **Nerve Repositioning / Lateralization:** This procedure entails decorticating the lateral cortex along the inferior alveolar canal, extending it to the mental foramen. Later, the decorticated area is extended anteriorly to expose the incisive branch of the inferior alveolar nerve. Subsequently, the incisive branch is then sectioned to facilitate the mobility of the inferior alveolar trunk and mental branch for lateralization.

Once the nerve is repositioned, implants are strategically positioned at the central aspect of the alveolus, medial to the repositioned nerve. To safeguard the nerve trunk, an autogenous bone graft / Type I, III Collagen tubes / Polyglycolic acid tubes can be placed between the repositioned nerve and the associated implants [15].

Neuropathic pain after implant placement

Management

Primary treatment involves pharmacotherapy, with NSAIDs like Ibuprofen (800mg), Amoxicillin (500 mg), and Prednisolone (50 mg) recommended for patients. The standard treatment regimen consists of taking Ibuprofen and Amoxicillin thrice daily along with Prednisolone once per day for the next 5 days, with a taper to 10 mg for the subsequent 5 days [16].

Injections for persistent dysesthesia: Patients who continue to suffer from ongoing dysesthesia post-implantation may benefit from a regimen of injections comprising dexamethasone (4 mg/ml) and 2% lidocaine with a concentration of 1:100,000 epinephrine administered into the most affected area. Continue with the treatment as needed until the discomfort subsides.

Topical application for known trauma/ compression: In cases where known trauma or compression of the nerve occurs during implant osteotomy, Misch and Resnik recommended applying 1 to 2 ml of dexamethasone externally on the surface for 1 to 2 minutes to mitigate neuroinflammation and swelling in the soft tissues, which could potentially constrict the nerve.

Other pharmacologic medications: For patients with nerve injuries, various pharmacologic medications are recommended:

1. Tricyclic antidepressant drugs like Amitriptyline, Desipramine, and Nortriptyline.
2. Norepinephrine - serotonin reuptake inhibitors
3. Anti-convulsant drugs like Gabapentin and Pregabalin.
4. Topical medications like Lidocaine/Benzocaine, with combinations including Ketamine, Carbamazepine, and Capsaicin.
5. Opioids should be reserved as a treatment option only when all other medications have been proven ineffective [16].

Surgical complications

Schneiderian membrane perforation

The most frequent intraoperative complication in sinus floor augmentation is injury to the Schneiderian membrane. A Profound understanding of the sinus 3D anatomy is crucial to minimizing the perforation rate. A CT analysis will provide vital information about sinus membrane wall thickness, and dimensions, any disruptions or irregularities in the bony walls, the angle of the sinus wall, and the position, extent, and size of the septa.

Prevention

In recent times, advancements in surgical techniques led to the development of two methods for window preparation that have effectively minimized membrane damage rates, as reported by most clinicians. These methods involve either using Piezoelectric Surgical inserts or Dentium Advanced Sinus Kit drills. These inserts are known for their safe operation near soft tissues because of their low-frequency ultrasonic vibration. However, their effectiveness may vary depending on the width and morphology of the sinus wall.
The alternative surgical technique (DASK) employs a dome-shaped diamond drill, typically with a diameter of 6 to 8mm, to create the lateral window. The window can be formed into a circular shape through an up-and-down motion or adjusted to any desired fashion by moving laterally. The drill precisely removes the bone, preserving the integrity of the exposed membrane. Subsequently, membrane elevation commences using either motor or hand–driven instruments resembling a classic "trumpet-shaped "piezoelectric elevator [17].

Management

The predominant approach for repairing a perforated Sinus membrane involves utilizing bioresorbable collagen-based scaffold membranes, lamellar bone sheets, and sutures to close the perforation or growth factor-enriched biologic barrier membranes such as Leukocyte and Platelet-rich fibrin (L- PRF) [17, 18]. In extreme cases with insufficient membrane fragments remaining to retain a suture, the Loma Linda Pouch technique can be employed [19]. This technique involves inserting a large Bio Gide membrane (30 x 40 mm), through the window to form a sinus pocket for containing graft material. The membrane edges are left outside the window to secure its position.

Implant displacement into the maxillary sinus
Implant displacement may arise during surgery or shortly after, owing to surgical technique or anatomical variations. Such incidents have been reported in various locations, including the maxillary, sphenoid, and ethmoid sinuses, and may even lead to perforation of the nasal floor.

Management: When implants migrate into the sinuses, signs or symptoms of infection may or may not be present, but an Oro - antral communication is likely to be present. To verify the presence of a displaced dental implant in the maxillary sinus, a Valsalva test can be carried out to identify any secondary communication between the oral cavity and the sinus [20].

Surgical approaches
Surgical management is often the first-line treatment in the majority of cases. Two primary approaches, namely the Caldwell-Luc and Lateral approach are often recommended as primary interventions in cases of implant migration into the sinus or when the surgical site has not fully healed. The antrostomy procedure involves removing the implant through the canine fossa, considered the gold standard technique. The adapted version of the antrostomy procedure, known as the lateral approach, facilitates implant removal through the creation of a bony window in the anterolateral aspect of the sinus cavity [21].
A newer technique, the trans-nasal approach with functional endoscopic sinus surgery is now increasingly preferred for removing implants displaced into the maxillary sinus. This method is considered to be reliable and safe with low morbidity. An alternative approach involves using intraoral video laparoscopic trocars, termed the double barrier approach. This method utilizes two trocars, with the first trocar aligned along the same axis as the sagittal plane to puncture the front wall of the maxillary sinus. The trocar is then withdrawn from the sheath, and a sinus inspection is carried out using a 45-degree endoscope. Following this, the second trocar is carefully inserted through the anterior wall adjacent to the first, under direct visualization using biopsy forceps. The implant is then firmly grasped under the guidance of an endoscope and extracted by withdrawing the forceps and trocar cannula [22].

Prosthetic complications
Prosthetic screw loosening
Causes: This is more frequently reported than screw fracture and often occurs when the prosthesis does not fit adequately. It has been suggested that when using a torque wrench to tighten a screw, it should be rotated approximately one-fourth of a turn to ensure a proper fit.

Management
Addressed by retightening and torquing the screw using either a hand / electronic torque device. However, for screws that have been in service for an extended period, it is recommended to replace them with new ones. In instances where access to the abutment screw is not available for retightening, then the use of lingual retaining screws is advisable to permit future retrieval of the crown [23].
Other options include fabricating the crown with threaded tubes intended for small screws that can be turned and used to unseat the crown via contact between the end of the screw and the underlying abutment [24] or else a cylindrical hole can be incorporated in the crown, along with a corresponding slot in the abutment. This configuration enables a specialized instrument to be inserted into the crown hole, facilitating rotation until the screw becomes loose [25]. Another alternative approach for removal is to use a vacuum-formed template as a guide for drilling a hole through the crown or prosthesis, providing access to the screw [26].

Implant abutment screw fracture
Causes: Abutment Screw fracture can occur due to various factors including occlusal overload, parafunctional habits, design of implant-abutment connection, abutment screw design, material properties, and inadequate preload. They frequently occur at the junction of the screw head and the shank / at the junction where the threaded section begins.

Management
If the screw fractures near the top of its threaded portion, it can be rotated counterclockwise until it can be grasped and removed. For screw fragments that cannot be rotated or grasped easily by a hand instrument, methods of removal include running a drill with cutting blades oriented in a reverse direction or creating a slot into the top of the screw fragment and modifying the instrument so that it fits into the slot and the fragment can thereby be unscrewed easily [27]. Although the above methods of removal fail, other screw modification techniques such as a combination of cutting a groove, creating a dimple, a custom-made driver, and a fork-shaped instrument can also be used for retrieving the fractured abutment.

Implant Fracture
Causes: This often results from using standard diameter implants in the areas subjected to heavy occlusal forces or the presence of substantial cantilevers on the crown/prosthesis.

Management
In the event of implant fracture, consider using trephine drills for its removal. These drills fit over the implant and remove a bony core along with the fractured segment [28]. The other alternatives include the use of a thin diamond / piezoelectric surgical tip to cut a channel around the implant so that it can be removed using reverse torque. So, after the implant has been removed, a graft material and membrane barrier can be used to fill in the defect. Eventually, after healing, a new implant can be placed again.

Implant Failures
This term is used to describe situations in which the implant loses integration at any time after its placement.
This can be further classified into:

1. **Early failures:** These refer to failures observed during the initial stages of the bone integration phase, typically attributed to surgical or post-operative complications.
2. **Late failures:** These refer to failures occurring after the completion of osseointegration, often during or after the prosthetic phase [29].

The clinical manifestations include - Mobility, swelling, discomfort, discharge, bleeding, and evidence of peri-implant bone loss radiographically.

Management
The initial step in addressing failed implants is to diagnose them accurately. In instances where there is more than 50% bone loss and noticeable mobility, immediate removal of the

implant is recommended. Several methods can be utilized for implant removal, such as Counter-torque ratchet, High-speed burs, Elevators, Piezo tips, Reverse screws, Forceps, Trephine bur, or a combination of these techniques [30]. If the implant connections are intact, the Counter-torque ratchet is usually the first choice. However, for compromised implant connections, the reverse screw technique serves as an alternative solution [31, 32]. In situations necessitating bone reduction, Piezo tips, Trephine burs, and High-speed burs are utilized to fully remove the bone encasing the implant, until at least half of the bone is cleared. Following sufficient bone removal, the implant can be loosened with forceps or extracted using elevators.

The Treatment strategies for addressing implant failure encompass several options such as

1. Immediately replacing the failed implant with a broader diameter – offers the advantage of increased surface area, enhancing bone-implant contact.
2. Simultaneous replacement of a failed implant following removal with guided bone regeneration and
3. A staged approach, where lost tissue is first rebuilt before implant placement [33].

Conclusion

The widespread adoption of implants, with a projected increase in the coming years, implies a heightened likelihood of encountering implant failures among dental professionals. Addressing such failures necessitates a thorough identification of their causes, facilitating effective treatment and providing insights for future therapeutic approaches. Routine checkups play a pivotal role in enabling timely interventions, ensuring that emerging issues are promptly addressed. To mitigate the frequency and severity of inevitable challenges, a continuous commitment to knowledge acquisition, learning, and experience is crucial. Dental professionals must stay abreast of advancements in implantology, refining their skills to navigate the complexities associated with implant failures. In essence, managing failures in implant dentistry is a dynamic process requiring a blend of proactive prevention, precise identification, and tailored interventions. The journey from detection to resolution involves a spectrum of strategies that, when seamlessly integrated, pave the way for enhanced patient outcomes and sustained success in implant dentistry.

Conflict of Interest
Not available.

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