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METHODS OF SOFT TISSUE FORMATION AROUND DENTAL IMPLANTS

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Relevance: In today's world, people are increasingly concerned about dental aesthetics. Edentulism can affect a person's appearance, proper occlusion, and even mental well-being. Various options exist for replacing missing teeth, such as removable dentures, fixed crowns and bridges, as well as resin-bonded bridges. Before selecting a suitable prosthetic option for missing teeth, various factors are evaluated. Dental implants are highly desirable for patients as they offer high success rates and long-term survival when used to replace missing teeth. However, several challenges related to treatment planning errors, surgical complications, care for soft and hard tissues, and infections may compromise the effectiveness of implant therapy.

Research increasingly shows that long-term clinical stability and aesthetics significantly depend on the stability of the soft tissues around osseointegrated dental implants. Consequently, when planning implant therapy, the oral surgeon must possess the necessary knowledge to appropriately address potential complications and take the required measures to maintain or develop stable soft tissues. Various augmentation procedures can be performed to correct any soft tissue deficiencies or deformities.

Osseointegration is a fundamental part of the success of implant treatment. It refers to the biological and functional connection between the bone and implant, enhancing the stability of the implant-supported prosthesis. After treatment, patients should be advised to adopt proper and regular oral hygiene methods suitable for implants. Adequate follow-up care is also essential after implant treatment. Any postoperative soft tissue complications, such as peri-implantitis or peri-implant mucositis, must be addressed immediately, and appropriate treatment provided. This article discusses pre- and post-implantation procedures to prevent or manage soft tissue complications, ultimately ensuring implant success.

Keywords: dental implant, soft tissue treatment, peri-implantitis, peri-implant mucositis, osseointegration, augmentation, implant.

Introduction

Dental implants are considered an excellent option for restoring missing teeth. They offer significant advantages over traditional alternatives by providing greater stability and retention. For individuals with compromised bone or mucosa, dry mouth, allergies to denture materials, a strong gag reflex, susceptibility to candidiasis, conditions affecting craniofacial motor control, or for patients requiring the best biting force, aesthetics, and functionality, endosseous dental implants are often preferred over conventional dentures [1]. However, since implants rely on the support of the surrounding bone and soft tissues, the risk of failure

remains undeniable.

Successful treatment requires consideration of several factors, including patient selection, implant loading, tissue management, and regular follow-up care [2]. Adequate soft and hard tissue volume with minimal occlusion is necessary for effective treatment. According to recent studies, the stability of soft tissues around osseointegrated dental implants plays a crucial role in achieving long-term clinical stability and aesthetics. Therefore, while planning implant therapy, the clinician must not only be able to perform the necessary actions to maintain or develop stable soft tissues but also be aware of potential future complications and possess the knowledge required to address them appropriately [3]. Proper reconstruction and management of soft tissues, combined with osseointegration, lead to good aesthetics.

A functional implant must include a part that traverses the oral mucosa, creating a biological interface with living tissues. This interface should form during the healing process following implant placement. Biological differences arise due to the insertion of a foreign body (the implant component), which must be addressed using proper surgical techniques and biomaterial design. The resulting soft tissue barrier is intended to protect the underlying bone structures [4].

For better implant stability, adequate keratinized gingiva is also necessary. Therefore, this review aimed to conduct a systematic analysis of methods to improve the health of soft tissues around the implant site and to provide foundational knowledge about potential complications and their treatment.

Case Selection and Treatment Planning

The primary goal of treatment is to achieve osseointegration and ensure overall supportive anatomy at the implant site for the prosthesis. Patients must be in good physical condition for implant placement, taking into account systemic health, bone condition, and local factors around the implant site.

As bone resorption rates are higher in younger individuals, it is advisable to initiate implant treatment after complete maturation of the maxillofacial structure. Smoking is contraindicated for implant recipients as it hinders healing and subsequent osseointegration. While osteoporosis causes bone fragility and resorption, it is not a complete contraindication for implantation. Implant placement is undesirable in patients undergoing cytotoxic chemotherapy.

Consultation with the patient's primary care physician is recommended prior to treatment planning, especially if systemic medications are involved. Patients with oral lichen planus or those at high risk of cancer have lower success rates, making alternative implant treatment options preferable [5]. Adequate radiological evaluation is necessary for assessment and selection. Periapical radiographs provide insights into bone structure and local pathologies. If the residual bone is insufficient in length or density, various bone augmentation procedures may be planned. A diagnostic model is fabricated, and planning is conducted based on radiological findings [5, 6].

Features of Soft Tissues

Healthy soft tissues around the implant site not only ensure treatment success but also contribute to the aesthetic outcome. The mucosa surrounding the implant must envelop the prosthetic neck to ensure functionality and aesthetics.

The ideal mucosal thickness averages 3–4 mm. Reduced mucosal thickness leads to bone resorption and angular defects. The coronal portion of the mucosa should measure 2–2.2 mm in thickness, while the apical part should measure 1.1–1.7 mm. A vertical component of 1–1.5 mm is required between teeth and implants [15].

Adequate thickness of keratinized attached mucosa is essential for improved prosthetic stability [4]. Around the implant site, an average of 2 mm of keratinized mucosa and 1 mm of attached gingiva are necessary [16]. Reduced mucosal thickness can result in bone resorption and angular defects [15]. This minimizes plaque accumulation, soft tissue recession, and the incidence of peri-implant mucositis.

Ridge augmentation procedures must be performed before implant placement if any ridge resorption is present. The blood supply to the implant site differs from that of natural teeth due to the absence of the periodontal ligament at the bone-implant junction. Complete blood supply is provided by supraperiosteal vessels from the osseointegrated bone [4].

Osseointegration

Osseointegration is the process of forming a biological and functional relationship between the implant and the surrounding vital bone structure. When this connection is established, there is no relative movement between the two structures. Once osseointegration is achieved, it indicates that the implant is biocompatible with the surrounding tissues, minimizing the risk of systemic or local irritation [17].

Bone healing and osseointegration occur through a series of events. Implant placement and cementless fixation are facilitated by adjacent mesenchymal cells and hematoma formation. This is followed by the formation of woven and lamellar bone.

Woven bone is formed intramembranously, while lamellar bone is located within the spicules of woven bone. These stages of osseointegration are coordinated by blood cells at the bone-implant interface, which generate growth and differentiation factors to mediate the process.

Osseointegration is confirmed by the appearance of bone marrow spaces containing healthy bone cells, such as osteoclasts, osteoblasts, and osteocytes, along with mesenchymal cells and neovascularization [18]. Thus, osseointegration is gradually achieved through the inflammatory, bone formation, and remodeling phases. However, if the mucosa around the implant is not healthy enough, healing and osseointegration may be compromised.

Postoperative Soft Tissue Complications and Their Treatment

The failure of a dental implant is often associated with a lack of osseointegration. If the dental implant shifts, becomes displaced, or there is bone loss around the implant exceeding 1.0 mm in the first year and more than 0.2 mm in subsequent years, it is considered a failure. Bone loss around the implant and, ultimately, implant failure can result from peri-implantitis [19]. Regular monitoring is necessary to evaluate the health of tissues surrounding the implant. Possible complications around the implant include peripheral giant cell granuloma, pyogenic granuloma, squamous cell carcinoma, metastatic carcinomas, malignant melanoma, etc. The most common complications following implant placement are peri-implantitis and peri-implant mucositis [20].

Peri-implant mucositis and peri-implantitis are two conditions classified under peri-implant diseases. Peri-implant mucositis is a reversible inflammatory reaction in the soft tissues around the implant [21]. Peri-implantitis is an inflammatory reaction accompanied by bone loss in the tissues surrounding the implant [22]. Primarily, these are inflammatory conditions leading to complications in peri-implant tissues. They are detected by bleeding or even exudate on probing, increased probing depth, and lack of osseointegration. Inflammation can also be identified using various inflammatory biomarkers [23].

The most significant factor in the rejection of dental implants is bacterial infections. Studies have shown that the bacterial flora associated with peri-implantitis is nearly identical to that found in periodontal diseases [24]. Causes of infection can include excess cement, plaque accumulation, infections, or even

overloading due to occlusal stress from the prosthesis. Plaque accumulation is the primary cause of peri-implant mucositis and can be eliminated. Thus, mucositis complications due to plaque buildup can be prevented through regular oral hygiene, proper brushing, and flossing after meals [25].

The oral microbiota appears to be a determining factor in whether a dental implant will succeed or fail. When an implant is introduced into the oral cavity, the saliva film, protein coating, and oral microbes instantly colonize it, forming a microbial biofilm. Instead of specific scientific outcomes, therapeutic approaches for peri-implant diseases seem primarily based on existing periodontal treatment methods or clinical empirical values.

A study conducted by Schwarz et al. [26] demonstrated that antiseptic therapy (0.2% chlorhexidine) combined with mechanical debridement using plastic curettes for peri-implant infection treatment led to significant improvements in clinical attachment levels, probing pocket depths, and bleeding on probing within six months compared to baseline levels. The primary component of treatment for both periodontitis and peri-implantitis is surface debridement [27]. However, in more complex cases, flap surgeries, the application of nanocrystalline hydroxyapatite (NHA), and other surgical procedures may also be performed [28].

To clean a dental implant, tools softer than titanium should be used, such as plastic scalers, floss, interdental brushes, or polishing cups and pastes. Unlike metal and ultrasonic scalers, these tools have been shown not to cause surface roughness on implants [29]. Sometimes, even with proper hygiene, infection occurs. The formation of plaque and bacterial biofilm may be facilitated by the screw shape of implants and various titanium surface modifications [30]. On such surfaces, mechanical debridement may have limited impact and may not completely eradicate all adhered microbes.

Regenerative approaches, including membrane and bone graft substitutes, have been proposed for treating bone defects in advanced peri-implantitis cases [27]. In these situations, early treatment yields the best outcomes. For patients without additional infections who have localized peri-implantitis problems, localized drug delivery devices can be a viable therapy option. A prolonged high dose of antibacterial agents can be locally applied for many days by inserting tetracycline fibers into the affected site for 10 days.

Chronic peri-implant mucositis may lead to peri-implantitis, which affects the bone around the implant and is more severe. While mucositis only affects the mucosal lining [31], prevention of these conditions through regular monitoring and professional and self-implant cleaning is recommended. Peri-implant mucositis can be treated non-surgically and has a good prognosis. However, peri-implantitis requires surgical treatment and has a poor prognosis [25]. Surface and mechanical debridement may have limited impact and are unlikely to eradicate all adhered microbes [32].

Surgical Methods

Following surgical treatment, defects corrected using membrane-covered autogenous bone demonstrated significantly greater bone regeneration and re-osseointegration compared to those treated with four other methods: (1) membrane-covered autografts, (2) autogenous bone grafts only, (3) membranes only, and (4) control access flap techniques [33]. However, membrane exposure is a common consequence of such treatments. When exposed expanded polytetrafluoroethylene (ePTFE) membranes are involved, microbes can penetrate and cause disease [34].

Reconstructive surgical techniques combined with implantoplasty can improve clinical peri-implant characteristics such as probing pocket depth, suppuration, and groove bleeding, in addition to enhancing the durability of rough-surfaced implants affected by peri-implantitis [29].

After six months of submerged healing, a study by Schwarz et al. showed that guided bone regeneration and

nanocrystalline hydroxyapatite both yielded clinically significant improvements in clinical parameters [35].

Conclusions

For successful implant treatment, comprehensive management is recommended. This includes patient selection, augmentation procedures performed by the clinician, and proper follow-up and oral hygiene maintenance by the patient, forming an appropriate treatment plan. Soft tissue issues must be monitored and prevented to avoid adverse outcomes in implant dentistry. The clinical features of each case, as well as the patient's preferences and needs, determine the type and timing of treatment.

Before any soft tissue surgery, a thorough examination of the patient's medical history, periodontal condition, bone tissue quality and quantity, and restoration requirements should be conducted. The amount and quality of soft or hard tissues should be maintained surgically. Implant site hygiene is essential for preventing peri-implant mucositis and peri-implantitis. In the event of complications, prompt intervention is necessary.

Here is the English translation of the bibliographic references:

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