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The Effect of Different Implant Sizes on The Bone Resorption After Retain Prosthesis (Fixed Bridge or Overdenture)

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Abstract:
In this article we will explain the effect between different implant sizes, in the term of its effect on bone resorption about implant and trying to clarify many factors related to success of teeth implant with less bone resorption in addition to trying to focus on most important success factors which would decrease resorption of bone around implant which is often by increase friction between bone and implant whether this friction by increasing length of implant and or increasing diameter of implant and determine which one is better in term of reducing pressure on the bone.

Keywords: Implant Sizes, fixed Bridge, Overdenture, Fixed bridge.

تأثير اختلاف أحجام الزرعات على امتصاص العظم بعد زراعة الأسنان (الجسر الثابت أو طقم الأسنان فوق السني)

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الملخص
في هذه المقالة سوف نشرح التأثير بين أحجام الزرعات المختلفة، من حيث تأثيرها على امتصاص العظم حول الزرعة ومحاولة توضيح العديد من العوامل المتعلقة بنجاح زراعة الاسنان مع امتصاص العظم بنسبة أقل بالإضافة الى محاولة التركيز على أهم عوامل النجاح التي من شأنها تقليل امتصاص العظم حول الزرعة والتي تكون غالبا عن طريق زيادة الاحتكاك بين العظم والزرعة سواء كان هذا الاحتكاك عن طريق زيادة طول الزرعة أو زيادة قطر الزرعة وتحديد ايهما افضل من حيث تقليل الضغط على العظم.

الكلمات المفتاحية: حجام الزرعات، الجسر الثابت، طقم الأسنان فوق السنية، الجسر الثابت.

Introduction

Bone resorption occur primary in the crestal area due to two reasons, firstly peri-implantitis induced by plaque, secondly overload at occlusal surface. Excessive loads placed on the implant causes pathological stresses and strains in the apical bone, which in turn stimulate resorption. The implants' length and diameter are crucial dimensions because the load is transmitted to the bone through them, they are considered the main factor to achieving the appropriate pressure distribution in the bones.
In order to enhance the contact area between the implant and the bone, the majority of attempts have concentrated on altering the implant's form and design and expanding its diameter and/or length. For cylindrical implants, the diameter and length must be greater than 3.9 mm diameter and 10.0 mm length, respectively, to generate the least amount of stress. [(1)]

The length and diameter of the implant must be raised in order to decrease bone resorption and stress on the alveolar ridge. The diameter of the implant is the primary factor in lowering bone resorption and stress.

In order to decrease apical bone erosion, numerous earlier researchers have tried to increase the contact area of the implant interface with the bone, which would lessen the strain on the alveolar crest. [2] Increasing the length and/or diameter of the implant, altering its form or shape, and modifying the surface's characteristics are the most crucial ways to expand the area of contact between the implant and the bone.

Stress on the cortical bone at the alveolar ridge apex is more dependent on the implant's diameter than its length. Altering the implant's diameter alters the amount of frictional contact areas, which in turn alters the degree of retention and, ultimately, the load transfer surrounding the implants. Further research is required to determine how implant diameter affects peri-implant strain retention. We need more investigations to study the effect on the peri-implant strain in different implant diameters.

The best choice for patient is implants retained fixed prosthesis either single unit crown or bridge, short or long span.

The second choice are implants retained removable prosthodontics, overdenture in edentulous patients in cases of high cost, inability to put implants due to bone resorption or patient desire to fabricate overdenture.

Firstly: Implants retained fixed prosthodontics (single unit or bridge).

Definition of fixed prosthodontics:

It's a dental restoration that is permanently cemented or otherwise attached to a patient's natural teeth or dental implants, designed to replace lost or damaged teeth. Unlike removable prostheses (such as dentures), fixed prostheses are not meant to be taken out by the patient, but instead are permanently affixed by a dentist. [3]

Types of Fixed Prostheses:

1. **Crowns**: These cover a single damaged or decayed tooth.
2. **Bridges**: These attach the prosthesis to nearby natural teeth or implants to replace one or more lost teeth.
3. **Implants**: A dental implant is a titanium post surgically inserted into the jawbone, onto which a crown or bridge is fixed.
4. **Full-mouth restorations**: Comprehensive fixed restorations replacing most or all of a patient’s teeth. [3]

Characteristics:

- Fixed prostheses are designed to restore function and aesthetics.
- They are usually made from materials like porcelain, ceramic, gold, or composite resins, which are durable and closely mimic the appearance of natural teeth. [4]

Benefits:

- **Improved functionality**: Restores the ability to chew and speak properly.
- **Aesthetic enhancement**: Mimics natural teeth, enhancing appearance.
- **Durability**: Provides long-term solutions, especially if well-maintained. [5]

Indications of fixed prostheses:

1. **Replacement of Missing Teeth**: When one or more teeth are lost and cannot be restored with a removable prosthesis or other methods, a fixed prosthesis (e.g., crowns, bridges) can be used to restore function and appearance.
2. **Preservation of Function and Aesthetics**: Fixed prostheses help in restoring the ability to chew, speak, and smile naturally, preventing the shifting of adjacent teeth and maintaining the integrity of the bite.
3. **Support for Adjacent Teeth**: In cases where adjacent teeth are weakened or damaged, a fixed prosthesis can help stabilize them and prevent further complications.
4. **Improvement of Oral Health**: A fixed prosthesis, when properly placed, can help in maintaining optimal oral hygiene and health by preventing the drifting of remaining teeth into the edentulous space, which can lead to misalignment or malocclusion. [6]

Contraindications of fixed prostheses:

1. **Insufficient remaining tooth structure**: If the remaining teeth are too compromised (e.g., due to extensive caries, trauma, or previous root canal therapy), they may not provide a stable foundation for a fixed prosthesis.
2. **Poor periodontal health**: Active periodontal disease or insufficient bone support can lead to the failure of fixed prostheses.
3. **Bruxism (teeth grinding)**: This condition can lead to excessive wear or fracture of the prosthesis, making fixed restorations less viable in patients with severe bruxism.
4. **Severe malocclusion**: If the bite is misaligned or there are other occlusal issues, fixed prostheses may not function properly or may cause discomfort.
5. **Inadequate oral hygiene**: Patients who cannot maintain proper oral hygiene are at higher risk for caries, gingivitis, or peri-implantitis, making fixed prostheses less suitable.

- **Medical conditions**: Certain systemic health issues (e.g., uncontrolled diabetes, immunosuppressive disorders, or bleeding disorders) can affect healing or the success of the restoration. [7]

Figure (1) Implant retained fixed prosthesis

Secondly; **Implants retained removable prosthesis (overdenture).**

Definition overdenture

A glossary According to prosthodontic terminology, an overdenture is a removable dental prosthesis that covers and rests on one or more natural teeth, their roots, and/or dental implants. A different kind of dental prosthesis is one that is supported in part by dental implants, natural teeth, and/or their roots. [(8)]

The parts of the implant- retained overdenture are:

- The implant is one of the components of the implant-retained overdenture.
- The abutment, which is one of the mating male or female attachment components, depending on the system in use.
- The overdenture contains the matching attachment component. [(9)]

When a patient complains about the instability of their mandibular denture, an overdenture on two implants is typically the first course of treatment. [(10)]

Because the entire surgery may be completed chairside without the need for laboratory work, restoring an edentulous patient with an overdenture on two or four implants may be regarded as state of the art in recent years. This lessens the discomfort of a bar-retained four-implant overdenture. In older individuals with inadequate financial and physical resources. [(11)]

Indications of overdenture

In the following situations, combined implant and tissue-supported removable overdentures are recommended:

1) patients unable to afford a fixed implant-supported prosthesis.
2) as a feasible substitute for bone grafting for patients with medical conditions, in order to enhance masticatory function, nutritional balance, and to lower the risk of lengthy surgery or general anesthesia
3) In order to minimize any further maintenance expenses, economic considerations may require the use of an overdenture supported by a few implants.
4) an overdenture with tissue support is a better option if the prosthesis needs a lot of cantilevers to achieve the required occlusal contact.
5) unsuitable arch relationships with moderate to advanced resorption. [(12)]

Advantages of overdenture

An implant-supported prosthesis might be more significant than an implant-retained overdenture in terms of prosthetic administration, surgery, and economics. The benefits of this type of rehabilitation are adequate face support even in cases of advanced mandibular resorption, the operation is less costly because fewer implants are required, strong occlusal stability for oppositional prosthesis stability and ease of removal, which promotes oral hygiene practices. [(13)]

Disadvantages of overdenture

The implant retained mandibular overdenture requires adequate space for prosthetic components of the implant attachment system to avoid over-contoured prostheses, excessive occlusal vertical dimension, fractured teeth near attachments, attachments separating from the denture, prosthesis fracture, and overall patient dissatisfaction. [(14)]

Figure (2) Implant retained over denture.

Implant size (diameter and length)

Both exogenous and endogenous factors affect dental implant success. Implant diameter and length are exogenous, while bone quality and quantity are endogenous. Each of these elements seems to have a major impact on implant success rates. [15]

In general, the number and quality of local bones, surgical technique, and implant design all influence the success of dental implants. It is recognized that implant diameter and length are important variables. [2]

The diameter and/or length of the implant, as well as modifications to the fixture's shape and design, have been the primary targets of attempts by various researchers to increase the contact area of the bone-to-implant interface in an attempt to limit crestal bone loss by reducing stress at the cortical alveolar crest. [16][17]

The diameter of the implant is crucial for ensuring sufficient bone-to-implant contact; it should be mentioned that bone that is at least 1 mm thick must encircle the entire implant area. The implants can be divided into the following categories based on their diameter:

- (< 3 mm), Narrow
- (3.75-4 mm), standard
- (> 4mm) wide. [18]

Narrow-diameter implants (< 3.75mm) are advised when alveolar bone loss occurs prior to tooth extraction as a result of periodontal disease, periapical pathology, or trauma to teeth and bone. Furthermore, an inadequate implantation bed for implants of standard size may result from bone atrophy or injury to the bone tissues following traumatic teeth extractions. [18]

However, compared to narrow-diameter implants, it has been demonstrated that wider diameter implants are mechanically more resistant, lower the maximum stress values in the bone, and have larger removal torque values. [19]

The biomechanical behavior of the implants and prosthetic components may be affected if implants with a narrow diameter are used since this could reduce the osseointegration surface. Furthermore, there was a greater mechanical resistance in implants with a bigger diameter. [20]

The mini-diameter implants were specifically designed to replace mandibular and maxillary lateral incisive in regions with weak occlusal forces, limited inter-occlusal space, and buccolingual ridge widths that are too small to accept conventional implants. [21]

In addition, one may question if osseointegration is adequate to support the loading forces in this scenario as a smaller diameter result in a reduced surface area of contact between the implant and the bone. [19]

Because of the increased danger of overload and decreased mechanical stability, decreasing the diameter also increases the risk of implant breakage. [21]

Prior studies have concentrated on reducing crestal bone stress by using implants with larger diameters or lengths. A number of earlier studies have tried to reduce crestal bone resorption by expanding the area of contact between the implant and bone, which lowers stress at the cortical alveolar crest. [2]

An attempt has been made to increase the contact area of the bone to implant interface by varying the diameter and/or length of the implant, the form and characteristics of the implant surface, or the design/shape of the fixture. [16][17][19]

How much load is transferred from implants to the surrounding bone depends on a number of factors, including the type of loading, the bone–implant interface, the diameter and length of the implants, the prosthesis type, the form and properties of the implant surface, and the quantity and quality of the surrounding bone. The most frequently used implant design variables of clinical interest are implant diameter and implant length. [15]

The crestal bone surrounding the implant neck is susceptible to increased mechanical loads, according to multiple independent investigations, regardless of differences in implant design, loading conditions, and/or bone characteristics. [22]

Short implants may have less bone support than lengthy implants, and thus implant diameter affects the stress concentrations surrounding implants. [23]

Some articles found that using wider-diameter implants in partially edentulous arches increased the implant success rate because broader implants diffuse occlusal force more efficiently, they are advised in the posterior parts of an arch particularly where heavy occlusal forces applied. (24)
By Using 3D finite-element models, Petrie and Williams examine and contrast the relative and combined effects of implant diameter, length, and taper on computed crestal bone strains of a 20 mm premolar section of the mandible with a single endosseous implant embedded in either high- or low-density cancellous bone and cortical bone. With 16 different implant designs, the researchers discovered that increasing the implant diameter reduced crestal strain by up to 3.5 times. The implant diameter ranged from 3.5 to 6 mm, the overall implant length from 5.75 to 23.5 mm, and the taper from 0 to 14 o. In contrast to taper, which increased crestal strain, particularly in narrow and short implants, increasing length resulted in a reduction of up to 1.65 times. The researchers found that because of their combined effects on crestal bone strain, diameter, length, and taper must be taken into account. A wide, relatively long, untapered implant seems to be the best option for reducing peri-implant strain in the crestal alveolar bone. They stated that, particularly in low density bone, thin, short implants with taper in the crestal region should be avoided. (25)

Methodology

The diameter, length, and size of dental implants embedded in alveolar bone that are used to hold in place either fixed or removable dental prostheses will be the focus of this article.
After the teeth are partially or completely extracted, the alveolar bone will be exposed to resorption and deformation, and the implant must be inserted to bone with prosthesis to maintain it from resorption.
In this article we will focus on what implant sizes are best and more maintenance on bone.

Conclusion:

- Length and diameter of implants are considered as an important factor in resorption of bone which result from load on implants.
- Increase diameter and length of implants lead to decrease load and stress on the alveolar ridge, so bone resorption will be decreased.
- In implant size, the diameter of implant is more important than length in reduce bone resorption.
- The relation between implant size and bone is inverse relationship where, whenever implant diameter and length increased, bone resorption will be decreased.
- Ultimately, large diameter implants showed the lowest bone resorption, followed by medium diameter implants, and small diameter implants showed the most bone resorption.

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