The Role of Implants in Orthodontics

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Abstract:

The use of dental implants has greatly increased over the last three decades, largely as a consequence of their successful long-term osseo-integration. This has led to increased orthodontic use, with appropriate modifications in the design when required. This article will concentrate on the use of implants during orthodontics, with particular reference to the use of Implants as a source of absolute anchorage.

Key words: Implants, Orthodontics, Osseo-integration, Anchorage.

Introduction:

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Background to implants:

Osseo-integration:

The work of Branemark in the 1960s on osseo-integrated implants is well known¹². His definition of ‘a direct contact between living bone and an implant, on the light microscope level’¹ describes the objective of osseo-integration, but the essence of its clinical success is the reliability of long-term implant fixation, even in the presence of functional loading. This has been supported by many studies, including a meta-analysis³ which reported a 90 per cent success rate for osseo-integrated implants.

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Types of implants:
The rise in the use of dental implants has led to a great diversity in their design and manufacture. The classification of implants can be based on their position, material of construction, or design.

1) Position of the implant:
   a) Subperiosteal
   b) Transosseous
   c) Endosseous

2) Material of implant:
   a) Titanium
   b) Gold alloys
   c) Vitallium
   d) Cobalt-chromium
   e) Vitreous carbon
   f) Aluminium oxide ceramics
   g) Nickel-chromium-vanadium alloys

3) Implant designs:
   a) Threaded
   b) Smooth surface implants

Protocol of placement:
The technique for successful osseo-integration of an implant, as historically described by Branemark[2] involves a two-stage surgical procedure. First, the implant fixture is countersunk into position and a cover screw is located over it during the required 4–6-month healing period. The second stage involves the fitting of an abutment to the osseo-integrated implant after it has been uncovered. A 2-week period is allowed for resolution of the gingiva after this procedure and, subsequent to this, restorative work can begin. There is a trend towards earlier loading of implants and possible immediate loading, to minimize the delay that results from the extensive healing period required. However, there are no long-term follow up studies of this approach as it is still in its infancy.

Suitability for implants:
Prior to commencing any implant treatment, factors that need to be considered include-

1) The quality and quantity of bone present, the age of the patient, and the reasoning behind their seeking implant treatment.

2) Age of the patient.

3) Reason behind seeking.

The age of the patient is an important consideration, as implants are problematic if inserted in growing children for the following reasons[5].

1) The use of implants in the anterior maxilla is contraindicated due to the possibility of the mid-palatal suture being open

2) Resorption in the posterior part of the maxilla, resulting from growth changes, could lead to the exposure of the implant into the sinus

3) The posterior aspect of the mandible continues to undergo growth changes in all three planes of space and, as such, definitive implant placement in this area would be difficult to estimate.

Implants as a source of absolute anchorage:
During active treatment, orthodontic anchorage aims to limit the extent of detrimental, unwanted tooth movement. There are methods available to reduce anchorage loss during treatment. However, these techniques are often only partially

successful, for example, transpalatal arches or headgear. The ability of osseo-integrated implants to remain stable under occlusal loading has led orthodontists to use them as anchorage units without patient compliance.

**Osseo-integrated implants and orthodontics:**

In malocclusions requiring a high level of anchorage control, osseo-integrated implants can be used on a temporary basis to minimize loss of anchorage.

Implant-based anchorage can be of particular benefit in treating certain aspects of malocclusions, for example:

1) Retracting and realigning anterior teeth with no posterior support.

2) Closing edentulous spaces in first molar extraction sites.

3) Centre-line correction when missing posterior teeth.

4) Reestablishing proper transverse and antero-posterior position of isolated molar abutments.

5) Intruding/extruding teeth.

6) Protraction or retraction of one arch.

7) Stabilization of teeth with reduced bone support.

8) Orthopaedic traction.

**Design of orthodontic implants:**

One of the obvious disadvantages of two-stage implants for orthodontic anchorage is the need for a long healing period of 4–6 months, which adds significantly to the treatment time. The bone height required for traditional endosseous implants may also restrict the locations available for implant placement. As a result of these problems, implants have been designed specifically for orthodontic purposes. Ideally, an implant used to enhance orthodontic anchorage should be biocompatible, inexpensive, easily inserted and removed under local anaesthesia, and be small enough to locate in multiple sites in the mouth. It should also osseo-integrate in a few days, and would be stable to orthodontic loading in all planes of space.

Block and Hoffman[6] addressed the issue of bone height by developing a disc-like structure called an ‘onplant’, which is designed to be placed under local anaesthetic. This hydroxyapatite-coated disc is 10 mm in diameter by 3 mm thick, and is placed subperiosteally on the posterior aspect of the hard palate, using a ‘tunnelling’ surgical procedure. The latter minimizes the potential for infection to occur around the onplant. After a 10-week healing period, the onplant is surgically exposed and a ball-shaped abutment (which replaces the cover screw) is attached. This is subsequently connected to orthodontic bands on the maxillary molar teeth by a transpalatal arch. This mechanism has been shown to resist greater than 300 g of continuous orthodontic force, which is comparable to the force required for conventional space closure of orthodontic extraction sites. Although the onplant requires less bone depth compared to conventional endosseous implants and the period of consolidation is approximately half as long, the complex surgical procedure.

The anterior region of the hard palate is an area that Triaca[7] first reported as having potential for orthodontic implant placement. The hard tissue in this area comprises the mid-palatal suture and a zone of compact bone adjacent to this. A suture of narrow width, combined with a high degree of interdigitation provides the best environment for one-stage surgery and, therefore, earlier orthodontic loading.

Wehrbein and Merz[8] have investigated the depth of bone in the mid-palatal area by measuring lateral cephalograms and have subsequently developed the Straumann Orthosystem implant (Institut Straumann AG, Waldenburg, Switzerland), which can...
be up to 6mm in height, based on the potential bone depth available. The Orthosystem implant is a one-piece device with an 8-week healing period. It is composed of a screw-type endosseous section of between 4mm and 6mm in length (depending on palatal depth), a cylindrical transmucosal neck and an abutment, to which a transpalatal arch attaches. It is different from previously described mid-palatal implants due to its dimensions: it has a smaller width and greater length that result in less soft tissue trauma at the time of surgery. To maximize stability, the implant uses a self-tapping screw with a sandblasted acid-etched surface. This results in a high level of direct bone contact, when osseo-integrated, which helps to maintain anchorage control when supporting the length of the TPA, despite the minimal implant design.

The placement or removal of this implant takes about 15 minutes under local anaesthetic, and is more straightforward than the onplant procedure of Block and Hoffman.

Bernhart[9], using multi-planar CT reconstruction, has identified regions 3–6 mm lateral to the midline of the anterior hard palate, that consistently have an adequate depth of bone to accept insertion of these 6-mm implants.

The increasing desire for early loading of implants used for orthodontic anchorage led Melsen to develop the Aarhus implant[10]. Due to its small dimensions (6 mm length), this titanium anchorage screw can be located in multiple sites, including between the roots of teeth. It is said to allow osseo-integration to occur even in the presence of immediate orthodontic loading, providing the orthodontic forces (25–50 g from Sentalloy springs) pass through the screw. The strain that develops in the bone surrounding the loaded screw leads to a local environment in which increased bone formation results. Due to the size of the screw it can be used in a number of different locations and can be easily removed when no longer required.

In an attempt to produce an implant that is small and easy to place and remove, Kanomi[11] has described a mini-implant, which is 6 mm in length and 1.2 mm in diameter. This implant, which was developed from a mini-bone screw used for fixing bone plates, is screwed into the alveolus under local anaesthetic, to within 3 mm of the apices of the teeth. Subsequent to healing and osseo-integration, a titanium bone plate is fixed to the screw, and acts as a hook for the attachment of an orthodontic ligature wire to aid intrusion of the respective teeth. This implant can also be used for orthodontic space closure and molar distalization.

Orthopaedic traction:

Implants have been suggested in treatment aimed at orthopaedic change. One study describes osseo-integrated implants inserted into the zygomatic buttress. These were used in combination with intra-oral extensions, to act as attachments for facemask therapy[12]. The orthopaedic changes observed in the maxilla over an 8-month treatment time occurred without any dental change. Implants may therefore be used to provide an alternative to conventional orthopaedic facemask therapy, while avoiding potentially unwanted dental movements.

If orthodontic treatment is necessary to create space prior to the implant being placed, then the roots of the adjacent teeth should be upright and parallel once this is complete. Adequate space is important, not only in the mesio-distal dimension, but also for the bucco-lingual width of the implant.

Orthodontic implant attachments:

Once successfully implanted and after the bone has consolidated, the implant must be incorporated into the orthodontic appliance. It is possible to attach an orthodontic archwire directly to the implant cover
screws, but movement of the teeth is faster and better controlled if single crowns or denture teeth are used as superstructures\textsuperscript{[13]}. The type of attachment used depends on factors such as:

1) The magnitude of force required.
2) The need for aesthetics.
3) The method of force application.

The most durable options are all metal or bonded metal crowns. The incorporation of a Class V cavity in the fabrication of these prior to casting, allows a mechanism for orthodontic bracket retention with composite resin. Other options include soldering the orthodontic bracket to a second-stage, non-rotating implant abutment or bending a loop in the orthodontic archwire to secure it to part of the implant.

It is important that endosseous implants required for restorative management are not compromised during their use for orthodontic anchorage. To ensure maintenance of osseo-integration during and beyond treatment, orthodontic loading of a single two-stage endosseous implant should not commence for 6 months in the mandibular arch. However, if multiple implants are placed, occlusal loading of the implants can start sooner. This is because the cross-arch splinting that result from loading the prosthesis allows integration to occur around the functioning implants.

**Stability of implants:**

Concern regarding the stability of osseo-integrated implants undergoing orthodontic loading has been addressed by Hurzeler et al\textsuperscript{[14]}. This team looked at the bone implant interface of implants used for orthodontic anchorage in healthy mouths. Their histological findings indicated that repetitive mechanical trauma did not result in increased peri-implant bone loss. In addition, the application of any lateral load did not cause marginal bone loss, but in fact led to a compensatory increase in density of the peri-implant bone through structural adaptation.

Histologically, there is no statistically significant difference in the response of peri-implant bone to orthodontic loading, (as measured by the bone to implant contact length) for either pressure or tension forces, when compared to control sites. Even in implants used for orthopaedic traction, with non-axial loading of 500 g, perfect osseo-integration has been demonstrated.

From a clinical standpoint, up to 400 g of orthodontic force (which is greater than the normal range required for conventional orthodontic tooth movement), has been successfully anchored against an osseo-integrated dental implant in several malocclusions.

**Conclusion:**

Osseo-integrated implants may now be used to enhance more traditional orthodontic techniques. In particular, they may have the potential to provide a useful method of anchorage reinforcement, particularly in cases otherwise dependent on patient compliance. The continuing development of orthodontic implants has led to the production of smaller designs which are easy to insert and remove, and do not require a long healing period prior to loading.

**References:**


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