

# Implantable Devices: A Review of Current Treatment Modalities

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## ABSTRACT

The use of implantable devices as direct adjuncts to orthodontic treatment as compared to the use of conventional dental implants is relatively less in number. Currently, a limited number of such devices are used to aid in orthodontic treatment. The options include conventional titanium endosseous dental implants, palatal implants, titanium miniscrews (also known as micro- or mini-implants), and mini-bone plates. Integration of dental implants or implantable devices into contemporary orthodontic practice has the following possible advantages: Serving as a means of increasing orthodontic anchorage, virtually eliminating patient compliance issues with regard to wearing of appliances, decreasing overall treatment time, and occasionally permitting orthodontic treatments previously thought to be impossible without surgery. This article is a review of the currently available options for use of implantable devices as sources of temporary skeletal anchorage in orthodontics.

**Keywords:** Implantable devices, Conventional titanium endosseous dental implants, Palatal implants, Titanium miniscrews, Mini-bone plates.

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## INTRODUCTION

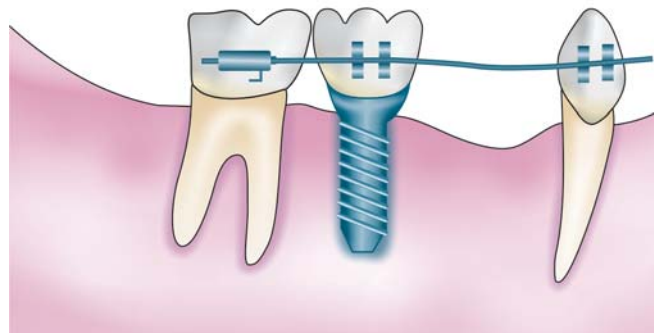
The use of dental implants as a direct adjunct to orthodontic treatment has been more limited until recently, but the potential exists for implants to play an important role in enhancing successful treatment outcomes. Integration of dental implants or implantable devices into contemporary orthodontic practice has the following possible advantages: Serving as a method of increasing orthodontic anchorage, virtually eliminating patient compliance issues with regard to wearing of appliances, decreasing overall treatment time, and occasionally permitting orthodontic treatments previously thought to be impossible without surgery. The practice of clinical orthodontics is largely dependent on the availability of anchorage. Anchorage, by definition, is a body's resistance to displacement. Newton's third law states that for every action there is an equal and opposite reaction. According to Proffit, in treatment planning of orthodontics, it is simply not possible to consider only the teeth whose movement is desired. Reciprocal effects throughout the

dental arches must be carefully analyzed, evaluated and controlled. An important aspect of treatment is maximizing the tooth movement that is desired, while minimizing undesirable side effects.<sup>1</sup> Dental implants have the ability to aid in anchorage either directly or indirectly. Celenza and Hochman described two different types of anchorage as pertaining to the use of implants in orthodontics.<sup>2</sup> Direct anchorage refers to any situation in which forces that originate from the actual implant itself are used to augment anchorage. An example would be a restored dental implant with an orthodontic bracket bonded to the restoration. If conventional orthodontic appliances are used in conjunction with the surrounding teeth and the restored implant, the implant will serve as a stable 'anchor'. That is, the implant will not respond to the forces generated by the orthodontic wires in the same way that the natural teeth do. The implant simply remains stationary while surrounding teeth move. The second type of anchorage, as described by Celenza and Hochman, is known as indirect anchorage, which refers to a situation in which a dental implant stabilizes multiple teeth, which then serve as an anchor unit. The most common method of achieving indirect anchorage is by placing a dental implant, commonly in the midpalatal or retromolar regions, and then linking the implant to the natural teeth by means of a wire or other rigid fixation device, such as a transpalatal arch. The result is a stable anchorage unit composed of multiple teeth that are tethered together by means of a dental implant that serves as additional anchorage. The high level of stability provided by either approach makes it promising for the practice of orthodontics. There are numerous situations in which additional anchorage would enhance treatment success. Examples of orthodontic treatment of malocclusions that would particularly benefit from dental implant use are as follows: Closing edentulous spaces in first molar extraction sites, midline correction when no posterior teeth are present, retracting and realigning anterior teeth with no posterior teeth present, intruding or extruding teeth, stabilization of teeth with reduced bone support, reestablishing the proper transverse and anterior or posterior position of isolated molar abutments, protraction or retraction of one arch, and perhaps many more applications.<sup>3</sup> The high level of stability gained from the types of implants placed in retromolar or midpalatal regions is derived largely from the fact that the implants are osseointegrated. Initial concerns about disruption of

osseointegration by orthodontic loading were proven to be unfounded by several studies. Roberts et al reported using two-stage conventional titanium implants in the retromolar region to help augment anchorage while protracting molars to close extraction sites.<sup>4</sup> The implants were removed using a trephine following the conclusion of orthodontic treatment and were subsequently histologically analyzed. Roberts et al found that approximately 80% of the endosseous portions of the implants were in direct contact with mature bone. Thus, this case study indicated that a relatively high level of osseointegration was maintained despite loading the implant with orthodontic forces. Another study by Turley et al also pointed to the stability of two-stage titanium implants used for orthodontic traction in dogs.<sup>5</sup> A later study by Wehrbein et al used the Straumann Orthosystem (Straumann Holding AG, Basel, Switzerland) in midpalatal and retromolar areas in humans for anchorage purposes.<sup>6</sup> The implants were subjected to continuous orthodontic loading and were removed and analyzed following treatment. The findings from the histologic evaluation indicated that they had been well integrated, again despite orthodontic loading. It seems apparent that when subjected to the relatively low continuous forces that are used in orthodontic therapy, implants have little difficulty maintaining osseointegration. Currently, only a limited number of implantable devices may be used in orthodontic treatment. The options include conventional titanium endosseous dental implants, palatal implants, [such as onplants and the Straumann Orthosystem (Andover, MA, USA)], titanium miniscrews (also known as micro- or mini-implants) and mini-bone plates.

### Conventional Implants

Conventional titanium endosseous dental implants can be used as sources of absolute or direct anchorage for orthodontic treatment. This approach can be used when edentulous spaces exist within an arch and adjacent or opposing teeth are not positioned ideally. In such cases, when the restorative treatment plan involves a dental implant, it may be beneficial to use the implant itself as anchorage for treating concomitant orthodontic problems (Fig. 1). Schweizer et al reported the use of conventional endosseous implants in orthodontic therapy in 1996.<sup>7</sup> The authors stressed the importance of double use (combined orthodontic and prosthodontic treatment modalities) of the implant system because once the implant has been placed, no movement will occur owing to osseointegration. The Schweizer et al article suggests several specific situations that are ideally suited for using dental implants in this manner, e.g. cases in which teeth are supererupted after the

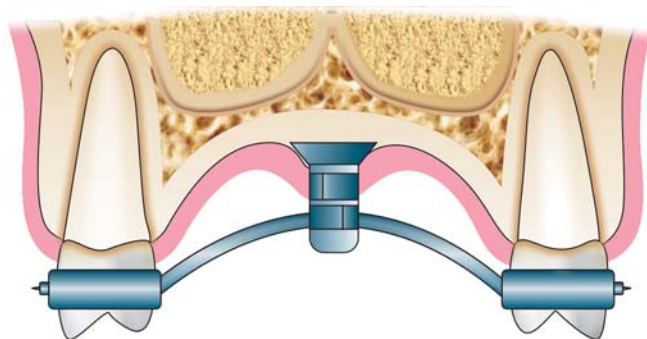


**Fig. 1:** A conventional endosseous implant used as a source of direct anchorage

loss of opposing teeth. In such cases, orthodontic intrusion is required in addition to the prosthodontic replacement of the missing teeth. Once the implant(s) is placed, it can be used for anchorage to achieve intrusion and to obtain adequate occlusal clearance for future restorations. The advantage of this method of treatment is that the definitive restorations can also facilitate orthodontic treatment. The disadvantage of this modality is that implants can be inserted only in edentulous areas with adequate bony support. Also, since this treatment must be coordinated by multiple specialists (including a periodontist or surgeon, a prosthodontist or restorative dentist and an orthodontist), this option is more complex and perhaps more time consuming. In 1995 Smalley noted the importance of using a pretreatment diagnostic wax-up to aid in the precise placement of implant(s) prior to orthodontic treatment.<sup>8</sup> The wax-up must simulate the position of the teeth following orthodontic treatment, and from this information a surgical stent may be fabricated to aid in the placement of the implant(s).

### Palatal Implants

One of the limitations of using implants for orthodontic anchorage is having adequate bone. Conventional root-form implants require adequate thickness of bone for placement, thus limiting their use to edentulous areas. Several authors have reported the midsagittal area of the hard palate as a suitable site for a short implant. Block and Hoffman devised a system that allowed placement of osseointegrated implant anchors in the midpalatal region of the maxilla.<sup>9</sup> In 1989 they designed the Onplant system (Nobel Biocare, Göteborg, Sweden). Onplants are placed subperiosteally on the posterior aspect of the hard palate. A 'tunneling' procedure is used to place these anchors. A full thickness muco-periosteal incision is made on the anterior aspect of the hard

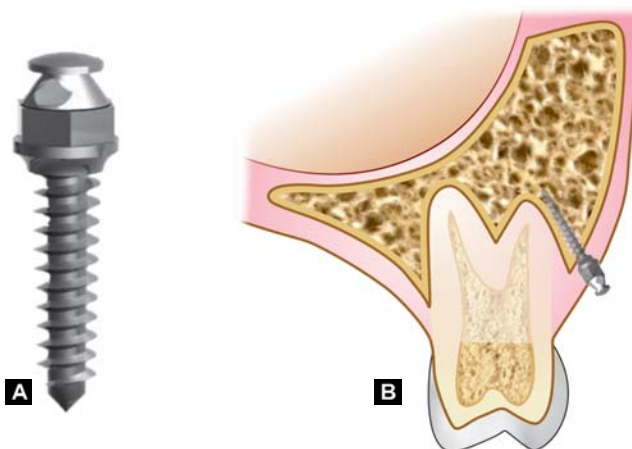


**Fig. 2:** Placement of the onplant connected to a transpalatal arch

palate, and tunnels are reflected posteriorly. These tunnels allow the onplant to be placed away from the incision, thus reducing the potential for soft-tissue reactions that prevent osseointegration. A healing screw is placed, and 10 to 12 weeks are allowed for integration. After this healing period, a small amount of tissue is removed over the healing screw, which is replaced by an abutment (Fig. 2). According to Wehrbein et al, the advantages of the orthosystem are that it can be placed in areas that conventional implants cannot, soft-tissue irritation is minimal, and anchorage is stable owing to sound osseointegration.<sup>10</sup> The disadvantages are that the placement process requires a surgeon, loading is not typically done immediately, and removal of the device often requires the use of a trephine owing to the extent of osseointegration.

### Miniscrews

An alternative approach to achieving anchorage is the use of titanium miniscrews. These devices are very small and can be placed in areas where other implantable devices cannot. For example, some miniscrews are so small that they can actually be placed in bone between the roots of individual teeth. The screws themselves are similar or identical to those used for osteotomy fixation following orthognathic surgery. These miniscrews are unique because unlike restorative endosseous implants they do not require osseointegration. Instead, these devices rely on mechanical retention to maintain rigidity, which also makes their removal relatively simple and noninvasive. They may be loaded immediately, but biomechanical factors must be taken into consideration owing to the increased chance of loosening associated with the lack of integration and torquing or rotational forces that may occur under loading. In 2003, Kyung et al reported the development of a microimplant for orthodontic anchorage.<sup>11</sup> This implant is a small titanium screw known as the Absoanchor and is manufactured by a Korean company called Dentos Inc. (Taegu, Korea). According to Kyung and Dentos, the

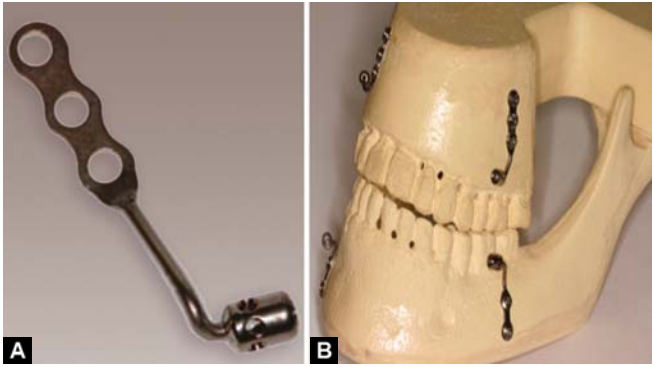


**Figs 3A and B:** (A) An example of a miniscrew, the Absoanchor (Courtesy of Dentos Inc, Taegu, Korea), (B) diagram of a possible placement location of a miniscrew (Courtesy of Dentos Inc)

Absoanchor is a particularly attractive member of the family of mini-implants because it has been designed specifically for orthodontic use and has a button-like head with a small hole that accepts ligatures and elastomers. The Absoanchor's small diameter allows its insertion into many areas of the maxilla and mandible previously unavailable even between roots of adjacent teeth (Figs 3A and B).<sup>12</sup> The stated advantages of miniscrews for use in orthodontic treatment are primarily the ease of insertion and removal. Compared with other systems the surgical procedure for placing and removing miniscrews is very simple and noninvasive. This can allow the procedures to be performed by an orthodontist, thereby eliminating the need for a surgical referral. Additional advantages are that loading can occur immediately, which has the potential to shorten treatment time, and local soft tissue irritation is reported to be limited compared with other transmucosal types of anchorage and, when present, is easily controlled with local application of chlorhexidine. The stated disadvantages of the miniscrews as used in the Costa et al article were the potential for infection or local soft tissue irritation, the potential for maxillary sinus perforation, infringement upon tooth roots, especially when placed in the infrazygomatic crest region and, perhaps most importantly, loosening of the miniscrew.<sup>13</sup>

### Miniplates

A further approach to the use of implantable devices in conjunction with orthodontic treatment has been the use of titanium miniplates. Miniplates are frequently used in orthognathic surgery for osteotomy fixation or in the fixation of fractures. In 2002 De Clerck et al introduced and reported success in the treatment of class II malocclusion using the zygoma anchorage system.<sup>14</sup> The authors adapted a Surgitec zygoma anchor miniplate (Surgitec, Bruges, Belgium)



**Figs 4A and B:** (A) Surgitec bone anchor miniplate (Surgitec, Bruges, Belgium), (B) possible placement locations of miniplates

secured with three screws that had a round extension arm carrying an attachment mechanism (Figs 4A and B). These devices were placed in the inferior surface of the zygomaticomaxillary buttress. The surgical procedure for placement was similar to that discussed for the other miniplate systems; however, in this case the devices were loaded immediately after placement. The tooth movements reported in this case were retraction and intrusion for correction of class II malocclusion. The specific points addressed by De Clerck et al were the design of the extension arm, the exit of the extension arm at the mucogingival junction, and the versatility of the attachment apparatus. The apparent advantages for using a miniplate system as declared by the above authors are as follows: Along history of biocompatibility, a variety of shapes and sizes, a minimally invasive surgical procedure and little risk of damaging nerves or tooth roots. This approach is indicated by various authors as being valuable in aiding patients needing intrusion of individual or groups of teeth, correction of severe crowding, correction of skeletal class II malocclusion and management of an anterior open bite.<sup>14</sup> The disadvantages are that placement of miniplates is more invasive than the placement of miniscrews and requires a surgeon for the procedure. In the reports of miniplate use as temporary skeletal anchorage, patients experience loosening of the plates secondary to inflammation or excessive shearing or torsional forces from the archwire.

## CONCLUSION

The incorporation of dental implants into dental treatment plans has had a tremendous impact on virtually the entire field of dentistry. With the increased interest in the area of implantology has come a great deal of credible research exploring the use of dental implants. Indeed, evidence-based dentistry is the basis for sound clinical decision making and

treatment planning modalities. Whereas the conventional use of dental implants has been studied for some time now, the use of implants and implantable devices as described in this article is relatively new by comparison. Therefore, the literature is limited in clinical trials and other more rigorous evaluation methods. At this time, the body of research associated with this subject is composed largely of case reports and a few small time limited trials in animals. There is no doubt that this area will continue to be explored and researched and will probably become an indispensable part of contemporary orthodontic therapy in the future. Purely as a matter of opinion, it seems that the extent to which the use of implants or implantable devices is accepted by the field of orthodontics on a broad basis will depend on a few specific factors. It seems that the devices themselves will continue to evolve but will probably move in a direction that supports the best combination of ease of placement (able to be placed by orthodontist), least invasive procedure, and best physical design properties to deliver optimum mechanical forces. Perhaps the use of dental implants will prove to be as useful to the field of orthodontics as it has been for other areas of dentistry.

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