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Review Article

A Mini-review on the Effect of Mini-implants on Contemporary Orthodontic Science

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Abstract:

The purpose of this literature review was to screen the valuable published articles regarding to the impacts of mini-implants on orthodontic science, briefly. The searching category was performed on the Pubmed using MeSH words such as "dental (mini) implants, orthodontic anchorage procedures, and orthodontic appliances." After preliminary sketch, they were grouped as follow: Those evaluating (a) common appliances for providing orthodontic anchorage, (b) biomechanical details of mini-implants and their insertion, (c) clinical application of mini-implants for orthognathic treatments, (d) limitations and possible complications. In conclusion, mini-implant evolved the orthodontic treatment plans and compromised the required orthognathic surgery. Malocclusion treatment and pure orthodontic or orthopedic movements in the three-dimensions have become recently possible by using mini-implant to provide skeletal anchorage.

Key Words: Dental implants, orthodontic anchorage procedures, orthodontic appliances

Introduction

Anchorage plays a significant role in the success of orthodontic treatment outcomes.[1] Some efforts have been made to gain the optimum anchorage intra or extra orally such as using chin cap, headgear, and multiple brackets.[2] Both anchorage devices and techniques are accompanied by some deficiencies. Extra oral anchorage requires remarkable patient's cooperation which is not mostly achieved.[3] Intra-oral anchorage (specially tooth supported) cannot provide optimum anchorage, also needs sufficient dentition.[3,4] Absolute anchorage can only gain by ankylosed teeth or conventional implants. However, their anchoring ability depends on their bone structure.[5] Temporary anchorage devices (TADs) can provide skeletal anchorage.[6] TADs are used to gain maximum anchorage without full-time patient's cooperation,[7] but multidirectional and heavy forces weaken them gradually.[8] They can be easily inserted and removed[9] thought their insertion needs specific caution because root damages are possible to happen.[10] Currently, mini-implants are increasingly used in comparison to other TADs due to their low cost and less invasion.[6,11] A survey in USA among orthodontic practitioners and residency programs revealed that majority of them used TADs and mini-implants in their practice.[12] Interestingly, mini-implants helped many patients with complex problems, to avoid orthognathic surgery by using fixed appliance therapy and mini-implants.[13]

Implant Criteria

Osseointegration of titanium to the bone, with no adverse tissue response, was observed in 1969. Since then, dental implants have been used to reconstruct human jaws.[14]

Bing resistance to stress, strain, and corrosion are essential for an implant fixture.[15] Because titanium alloy is non-allergic with no immunological reactions, it designated as an ideal material for mini-implants.[16] One study observed the increased osteoblast proliferation on the surface of mini-implants after 72 h.[17] Another nano observation on osseointegration of titanium implants revealed existence of crystalline hydroxyapatite, integration of bone, and TiO_2, and the possibility of presence of $CaTiO_3$.[18] Nevertheless, the insertion depth affect the primary stability remarkably more than implant material.[19]

With respect to all types of implants, mini-plates, micro-implant (MI,) and micro-screws provide an absolute anchorage for tooth movement.[11]

In 1997, the first MI with 1.2 mm diameter and 6 mm length were introduced by orthodontics[20] and they have been gained popularity over implants, on-plants, and mini-plates because of their versatility, minimally invasive surgery with no damage to the dental roots, ease of insertion and removal, ready to

be loaded after initial wound healing, and their low costs.[21,22] Retention of mini-implants depends on many different factors such as: Implant dimensions,[23] implant surface characteristics,[24] insertion angle,[25] insertion torque,[26] site of insertion,[23] soft tissue characteristics,[27] bone quality,[28] risk of inflammation,[25] and root proximity.[22]

Primary stability is another important factor, which is defined as implant stability immediately after insertion, whereas secondary stability is due to bone remodeling.[22] Hnece, mini-implants do not need a waiting period because their primary stability is generally sufficient to sustain normal orthodontic loading.[17]

There are no specific maximum insertion torque levels to bring about higher success rates for orthodontic mini-implants.[29] It has been reported that excessive insertion torque forces can cause necrosis of the surrounding bone.[30,31] 5-10 N cm insertion torque is adequate for mini-implants with a diameter of 1.6 mm to minimize the risk of failure.[30]

The optimal site for mini-implant placement is posterior region of both jaws specially between the second premolar and first molar, and between the first and second molars.[32]

Mini-implant's Type and Shapes

Self-tapping and self-drilling are two common types of mini-implants that predrilling differ them from each other.[33,34] The self-tapping system needs predrilling and it is indicated for a prolong treatment schedule. However, the predrilling might result in inevitable complications such as: Thermal damage, root damage, and drill fractures. In the other hand, placement of the self-drilling type is proceeded in lesser time, thermal damage, and risk of fractures.[33] Furthermore, insertion of self-drilling mini-implants is executed with manual pressure without considerable irrigation.[35] Self-drilling system is advantageous with better stability, especially in sites with low bone density like maxilla, and adolescent patients.[36] In contrast, in high-density bone or thick cortical bone, the self-drilling system is less advantageous as gaining adequate primary stability needs excessive pressure in that sites so the risk of microfracture is higher.[34]

Mini-implants are mostly consists of three components: Threaded shaft, cervical area, and a head for loading orthodontic forces. The head design differs according to two different concepts.[37] One type with screw head, which attaches to tension springs or round wires by means of hooks, spherical heads, eyelets, and bore holes. This mentioned type covers a wide range of indications[32] except for anchoring rectangular wires.[37] The second head design has a slot or a cross-slot. Clinically, the second design seems to be more universal in application and can be indicated for all types of skeletal anchorage, however, the limitation of using rectangular wires should be noticed.[37]

Clinical Application

Anchorage reinforcements

Anchorage is defined by the resistance against displacement of anatomical structures. Controlling the anchorage sometimes limits orthodontic treatment and conventional intraoral anchorage reinforcement might bring about values of anchorage loss.[38] Mesial movements of maxillary first molar, for instance, is unwanted anchorage loss during retraction of anterior teeth. The emergence of mini-implants provided a possible and reliable "direct anchorage" in all three dimensions even for complicated orthodontic treatments.[39] Direct anchorages can easily be enhanced by inserted mini-implants in the buccal site between the first molar and second premolar roots or palatal site.[40]

Intrusion

The intrusion of the tooth is administered for several purposes. Jain *et al*. compared mini-implant, J hook headgear and utility arch appliances for deep bite treatment. The highest intrusion amount of maxillary incisors was observed in mini-implant group which was described as true intrusion without any significant side effects.[7] Nevertheless reversible, but not significant, changes of pulpal tissue was observed following intrusion by mini-implants.[41] Another study confirmed the benefits of administering mini-implants for deep bite correction.[42]

Intrusion of the maxillary molar tooth is another indication of using mini-implants specially in patients with anterior open bite with excessive maxillary posterior dentoalveolar height. It has been stated that maxillary molars can be successfully intruded by using skeletal anchorage and controlling eruption or extrusion of the mandibular molars.[43]

Bodily movements

Distally movement of maxillary molar may often provide a treatment solution for the correction of a malocclusion. The anchorage loss is the main concern during bodily movements of molar teeth, however, mini-implants enhanced the anchorage stability. Hence, Class II patients or Class III individuals, who needs decomposition prior to orthognathic surgery, may get advantages of using mini-implants. The success of pendulum appliance seemed to be increased by adding mini-implants for distalization purposes.[44] One study demonstrated hopeful result in treatment of Class II patients when mini-implants provided palatal anchorage for distalization of maxillary molars.[45] In general, literature support the fact that mini-implants can reinforce the anchorage of different maxillary distalize appliances.[44,46,47]

The Class III malocclusion might go under camouflage orthodontic treatments by using mini-implants. Distalization of mandibular molars would be possible by the help of mini-implants.[48] Based on treatment plans, the mini-implants might be placed in maxillary[40] or mandibular arch[48] for Class III treatments.

Pure retraction of anterior segments of both mandibular and maxillary arch can be facilitate by using mini-implants. Ruellas *et al*. tried different mechanisms (vertical hooks; elastic chain attached to mini-implants + 3 mm, or 6 mm stainless steel hooks) for retracting maxillary incisors. The results revealed that mini-implants were more efficient in retraction without extrusion.[48] In another clinical study, patients with dentoalveolar protrusion were treated by headgear and a transpalatal arch; mini-plate; and mini-implant. The three dimensional analysis showed a higher amount of incisor retraction for skeletal anchorage devices groups.[49] Other studies showed similar results, too.[50]

Extrusion

Teeth are subjected to extrusive forces due to different occasions. Mini-implants represented a remarkable achievement in the removal of complicated impacted teeth. Park *et al*. simplified removal of a complex impacted third mandibular tooth, due to proximity to inferior alveolar nerve, by using mini-implants for applying extrusive force prior to extraction.[51]

Severely impacted tooth might become functional by relying on a stable anchorage and inducing extrusive forces. Nienkemper *et al*. extruded maxillary incisors, which were deeply impacted in maxilla by means of mini-implant anchorages. Depending on the anchorage needs and the location of the teeth to be moved, various types of implant mechanics were used and hopeful results were achieved.[52]

Treatments of rare dentoskeletal disorders

Ectodermal dysplasia is a rare congenital X-linked disease which affects the several structures of ectodermal originated organs. Dental prosthesis is administered for these patients however, some modifications are needed due to lack of the retention and stability.[53] Hence, mini-implants might be indicated to elevate the support or retention of the definitive prostheses. Some case reports manifested patient's satisfaction and well adaptation of prostheses after mini-implant treatments.[54-56]

Maxillary hypoplasia is another disorder which is mainly caused by skeletal deficiency at height, width, and anteroposterior relationships and requires multiple corrections. These patients mostly complain about psychological problems, physical deformities, mastication and speech abnormalities, and nasal pharyngeal airway constriction. One of the proper treatments is to protract maxillary arch by helps of palatal anchored mini-implants.[57,58]

Furthermore, congenitally missing maxillary lateral incisor might be well replaced with titanium mini-implants. This treatment offers benefits of lower cost, simplified insertion, faster healing period, and less post-operative complications.[59]

Limitations and side effects

Inflammation, which mostly tends to occur in non-keratinized tissue, can decline the success rate of mini-implants. Immediate loaded mini-implants seemed to not remain stable under occlusal forces. Another complications are loosening of mini-implants, pain, and swelling around the placement site.[60]

Conclusion

Mini-implants have influenced orthodontic treatment plans by providing possible management of complicated discrepancies than those treatable by conventional biomechanics. By the help of mini-implants, force can be applied directly to the bone-borne anchor unit. Therefore, mini-Implants not only eliminated concerns about anchorage-demanding cases, but they also have enabled clinicians to overcome tooth movement in three dimensions. Furthermore, adjunctive orthodontic treatments in adults, and treatment for impacted teeth are the other indication of mini-implant treatment.

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