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Review Article

Orthodontic mini-implants: A narrative review

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***ABSTRACT*:**
Orthodontic miniscrews are loaded immediately unlike the dental implants, but, using light forces only., mini-implants are stable source of anchorage, but did not remain absolutely stationary, throughout the period of orthodontic loading and sometimes move according to the direction of orthodontic force in some patients. This makes them as a necessary treatment option in cases with critical anchorage that would have otherwise resulted in anchorage loss if treated with conventional means of anchorage. Hence; the present review was planned for highlighting literature of orthodontic mini-implants.
Key words: Orthodontic, Mini-implants

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Introduction
The extraoral anchorage is a bit cumbersome to use & causes injury which in then affects patients compliance to use it. Also, the term 'Absolute anchorage' can be achieved when the anchorage unit remains completely stable, which is doubtful in traditional orthodontics mechanics. The skeletal Anchorage is Absolute anchorage which is achieved with the advent of mini-implants. With the use of Mini-implants for the anchorage, maximum anchorage is possible with the reduction in the unwanted side-effects. The osseointegrated implant (endosteal) was the first one to be used for the purpose of orthodontic anchorage. They worked well providing the orthodontic anchorage, but they have limited application in terms of orthodontic use. They were basically needed to be used in edentulous spaces, which were not available in routine orthodontic cases. The generally accepted protocol for successful and predictable placement of mini-implants includes atraumatic surgical technique, short healing period, biocompatible materials, and patient management. To encourage regeneration and osseointegration, rather than repair with fibrous encapsulation, a primary healing environment at the bone-implant surface should be created.[1-3]

Properties
The main differences between the currently available miniscrew implants relate to their composition, size, design and include: (1) the alloy or metal used for their fabrication, (2) the diameter of threaded portion, (3) the length of the implant and (4) the design of the head.[4]

Biocompatibility: All implant systems are made of grade V titanium alloy except for orthodontic mini-implant which is fabricated from stainless steel.[5-7]

Osseointegration: Because complete osseointegration of screws used in orthodontic applications is a disadvantage that complicates the removal process, most of these devices are manufactured with a smooth surface, thereby minimizing the development of bone ingrowth and promoting soft tissue attachment at ordinary conditions and in the absence of special surface treatment regimens.[8-10]

Types of Anchorage: The miniscrew implants can provide 2 different types of anchorage: direct and indirect anchorage means that they are connected through bars or wires to the reactive unit, whereas direct anchorage means that they directly receive the reactive forces by acting as an anchor unit.[9]

Head Design: The most frequent is the button like design with a sphere or a double sphere like shape or a hexagonal shape. With a hole through the head or neck of the screw, usually 0.8 mm in diameter, this design is mostly used for direct anchorage. Further a bracket like design and a hook like design is also available which can be used both for direct and indirect anchorage.[10]

Thread design: The thread body can be either conical as in miniscrew anchorage system or parallel tapering only at the end as in orthodontic mini-implant. They are available in different lengths but it is that suggested 4 to 6 mm as safe in most regions. Most miniscrew implants have a thread diameter ranging from 1.2 to 2.0 mm and a length from 4.0 to 12.0 mm although some of them are also available at lengths of 14 or even 21 mm.[11-15]

Review of literature

Park HS et al examined the success rates and factors affecting the clinical success of screw implants used as orthodontic anchorage. Eighty-seven consecutive patients (35 male, 52 female; mean age, 15.5 years) with a total of 227 screw implants of 4 types were examined. Success rates during a 15-month period of force application were determined according to 18 clinical variables seen the overall success rate was 91.6%. The clinical variables of screw-implant factors (type, diameter, and length), local host factors (occlusogingival positioning), and management factors (angle of placement, onset and method of force application, ligature wire extension, exposure of screw head, and oral hygiene) did not show any statistical differences in success rates. General host factors (age, sex) had no statistical significance. Mobility, jaw (maxilla or mandible), and side of placement (right or left), and inflammation showed significant differences in success rates. Mobility, the right side of the jaw, and the mandible were the relative risk factors in the logistic regression analysis when excluding mobility, inflammation around the screw implants was added to the risk factors. Concluded that to minimize the failure of screw implants, inflammation around the implant must be controlled, especially for screws placed in the right side of the mandible.[12]

Kravitz ND et al studied the risks and complications associated with miniscrew placement. Complications can arise during miniscrew placement and after orthodontic loading that affect stability and patient safety. They found that, thorough understanding of proper placement technique, bone density and landscape, peri-implant soft-tissue, regional anatomic structures, are imperative for optimal patient safety and miniscrew success.[13]

Barlow M et al conducted a systematic review of prospective clinical trials from 1966 to 2006 of several database, regarding the factors influencing efficiency of sliding mechanics to close extraction space. They considered the arch wire properties, bracket design, force delivery system (Nickel-Titanium spring, active ligatures, elastics, elastomeric chains) and rate of space closure using sliding mechanics. They concluded that: Elastomeric power-chain produces similar rates of retraction as 150 and 200 gms Nickel-titanium springs. Nickel-titanium springs of 150 and 200 gms are more effective at closing space than active ligatures.[14]

Wilmes B et al analyzed the impact of the insertion angle on the primary stability of mini-implants. A total of 28 ilium bone segments of pigs were embedded in resin. Two different mini-implant sizes (Dual-Top Screw 1.6 8 mm and 2.0 10 mm) were inserted at seven different angles (30, 40, 50, 60, 70, 80, and 90). The insertion torque was recorded to assess primary stability. In each bone, five Dual-Top Screws were used to compensate for differences in local bone quality and concluded to achieve the best primary stability, an insertion angle ranging from 60 to 70 is advisable. If the available space between two adjacent roots is small, a more oblique direction of insertion seems to be favorable to minimize the risk of root contact.[15]

Upadhyay M et al analyzed the treatment effects of en-masse retraction of anterior teeth with mini-implants as anchor units in bialveolar dental protrusion patients undergoing extraction of all 4 first premolars. A total of 40 patients (mean age, 17.5 years; SD, 3.2 years) were randomly assigned either to group 1 (G 1), anterior space closure with mini-implants as anchor units, or group 2 (G2), anterior space closure with conventional methods of anchorage(without mini-implants). Skeletal, dental, and soft-tissue changes were analyzed in both groups on lateral cephalograms taken before retraction and after space closure. Student paired and unpaired t tests were used to analyze the treatment changes in the 2 groups. Seen for the skeletal parameters, a statistically significant decrease in the facial vertical dimensions was seen in al, but the variables in G2 showed no significant differences. Anchorage loss, in both the horizontal and vertical directions, was noted in G2, whereas G1 showed distalisation (anchorage gain) and intrusion of molars. Although the soft-tissue response was variable, facial convexity angle, nasolabialangle, and lower lip protrusion had greater changes in G1. No differences were found in the amount of upper lip retraction between the groups). They concluded that mini-implants provided absolute anchorage to allow greater skeletal, dental, and esthetical changes in patients requiring maximum anterior retraction, when compared with other conventional methods of space closure. The treatment changes were favorable. However, no differences in the mean retraction time were noted between the 2 groups.[16]

Sia S et al stated that the height of the retraction force on the power arm could modify the location of the center of rotation of the anterior teeth during anterior space closure with sliding mechanics. It was estimated that, during anterior tooth retraction in Angle Class II Division 1 malocclusion patients, controlled lingual-crown tipping could be achieved by attaching a power arm of 3 to 5 mm in length (height of retraction force) with sliding mechanics.[17]

Sung SJ discussed the strategic design of an appliance for correcting a bialveolar protrusion by using orthodontic mini-implant anchorage and sliding mechanics must take into account the position and height of the mini-implant, the height of the anterior retraction hook and compensating Curve, and midline vertical traction. In this study, we used finite element analysis to examine effective en-masse retraction with orthodontic mini-implant anchorage and sought to identify a better combination of the above factors. Base models were constructed from a dental study model. Models with labially and lingually inclined incisors were also constructed. The center of resistance for the 6 anterior teeth in the base model was 9 mm superiorly and 13.5 mm posteriorly from the midpoint of the labial splinting wire. The 0.016 x .022-in stainless steel archwire showed more tipping of teeth compared with the 0.019 x .025-in archwire. For high mini-implant traction and 8-mm anterior retraction hook condition, the retraction force vector was applied above the center of resistance for the 6 anterior teeth, but no bodily retraction of the 6 anterior teeth occurred. For high mini-implant traction, 2-mm anterior retraction hook, and 100gms midline vertical traction condition, the 6 anterior teeth were intruded and tipped slightly labially.[18]

Liu TC et al investigated the roles of bone quality, loading conditions, screw effects, and implanted depth on the biomechanics of an orthodontic miniscrew system by using finite element analysis.A 3-dimensional model with a bone block integrated with a miniscrew was constructed to simulate various cortex thicknesses, cancellous bone densities, force magnitudes and directions, screw diameters and lengths, and implanted depths of miniscrews and concluded that the screw diameter was the dominant factor for minscrew mechanical responses. Both bone stress and screw displacement decreased with increasing screw diameter and cortex thickness, and decreasing exposed length of the screw, force magnitude, and oblique loading direction.[19]

Vijyalakshmi PS et al noted Finite element analysis of stress and strain distribution in the bone around the implants used for orthodontic anchorage. Biomechanical influences on bone structure play an important role in the longevity of bone around implant. The quality and direction of applied force influence the implant and cause deformation of the bone. FEA was used to analyze the changes in the bone on loading the implant with orthodontic force in oblique and vertical direction of orthopedic force. The mini implant used in the present study efficiently resisted the oblique loading. But their use, for the purpose of orthopedic loading is questionable. Finite element models showed the area with the highest stress and strain to be around the neck of the implant and surrounding bone at the cervical margin.[20]

Jasmine IF et al conducted a 3-dimensional finite element analysis for analysis of stress in bone and microimplants during en-masse retraction of maxillary and mandibular anterior teeth with different insertion angulations. Finite element models of a maxilla and a mandible with types D3 and D2 bone quality, and of microimplants with a diameter of 1.3 mm and lengths of 8 and 7 mm were generated. The microimplants were inserted at 30, 45, 60, and 90 to the bone surface. A simulated horizontal orthodontic force of 200 g was applied to the center of the microimplant head, and stress distribution and its magnitude were analysed and concluded that placement of microimplants at a 90 angulation in the bone reduces the stress concentration, thereby increasing the likelihood of implant stabilization. Perpendicular insertion offers more stability to orthodontic loading.[21]

Chetan S et al conducted a finite element analysis to find out if it is possible to control maxillary anterior teeth in sagittal and vertical plane during retraction by altering the vertical levels of force application in the posterior region, i.e. identifying the type of movement of the maxillary anterior teeth which occurs when force would be applied from four different levels i.e. High, Medium, and Low pull Implants and from a conventional Molar hook and also to quantify the retraction and intrusion components of force thus setting a guideline for the implant height placement and concluded that that by changing the position of implant in vertical plane one will have very little effect on the type of tooth movement. As the point of force application moves apically, type of tooth movement in the sagittal plane remained almost constant and in vertical plane intrusion is slightly increased.[22]

Yang L et al discussed the purpose of this study was to propose a protocol for safe bicortical placement of mini-implants by measuring the inter-radicular spaces of the maxillary teeth and the bone quality. Cone-beam computed tomography data were obtained from 50 adults. Three-dimensional reconstructions and measurements were made with Simplant Prosoftware . For each inter-radicular site, the bone thicknesses and inter-radicular distances at the planes 1.5, 3, 6, and 9 mm above the Cement-enamel junction were measured. Standard bone units were defined to evaluate the influences of bone density and the different placement patterns on the stability of the mini-implants. The safe buccal sites of the 6- and 9-mm planes were between the first and second molars, and the safe buccal sites of the 3-, 6-, and 9-mm planes were between the canine and thefirst premolar. Most bone thicknesses were from 8 to 12 mm. The optimal placement angle between the second premolar and the first molar was 58˚ Bicortical placement could have more standard bone units than unicortical placement in the maxilla Bicortical placement would be more stable in the maxilla. For the site between the molars, special care should be taken at a plane higher than 6 mm to prevent maxillary sinuspenetration. The most favorable inter-radicular area in the maxilla was between the second premolar and the first molar.[23]

Conclusion

The introduction of dental implants into dental treatment plans has had a tremendous impact on the field of dentistry miniscrew implants offers many advantages when used as temporary anchorage devices like, easy placement and removal, immediate loading, can be used in a variety of locations, provide absolute anchorage, economic and requires less patient cooperation.

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