Miniscrew implants: AIIMS protocol and contemporary clinical and research studies

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Miniscrew implants (MSIs) have appeared to be the boon to orthodontists with wide range of applications in management of complex malocclusions. However, MSI failures remains the most common problem affecting their successful utilization. Researches are oriented towards improving the stability and minimizing their failure rate. This article presents the brief review of MSI development, their use in anchorage management and update on development of protocol and current status of research at AIIMS, New Delhi. This knowledge will be helpful in exploring possible research approaches in bone and soft tissue adaptation to MSIs and possible modification of current design of MSI for improving its success rate.

Pre TAD Era

Very early in the history of fixed orthodontic treatment, orthodontists realized the limitations of using teeth as anchorage and felt the need of stable anchorage system. Efforts for stable anchorage were made as early as in 1945, when Gainsforth and Highley (1945) used 13 mm long vitallium screw in dogs to move the teeth. Though unsuccessful, his efforts led to interest in further research with implant anchorage. Soon after the introduction of concept of osseointegration by Branemark and his coworkers, Linkow (1969) used a blade implant in the mandibular 1st molar region as a partial abutment for a bridge that was restored before orthodontics and subsequently used for application of class II elastics to facilitate tooth movement.

The first successful orthodontic treatment with osseointegrated implant was documented by Creekmore and Eklund (1983) who used vitallium bone screw in anterior nasal spine to intrude the upper incisors. But, due to lack of acceptance of surgical procedures and fear of complications using implantable materials, traditional anchoage systems continued to be the main treatment modality.

However, in1990s, protocols were developed for simultaneous use of implant for restorative as well as orthodontic purpose. The need for orthodontic treatment requiring minimal patient compliance has encouraged research into the use of implants as tools to reinforce anchorage. Block and Hoffman (1995) discussed the use of onplant coated on one side with hydroxyapatite that was placed against palatal bone and used for anchorage. Wehrbein *et al.* (1996) developed the palatal implant called Straumann Orthosystem which was specifically designed for orthodontic anchorage.

TAD Era: Concept of mechanical stability and direct loading

Implants gained widespread attention and acceptance after Kanomi (1997) reported use of smaller implant called mini implant for orthodontic anchorage. He implanted mini-bone screw of 1.2 mm diameter and 6 mm length in the alveolar bone between root apices of mandibular incisors and reported intrusion of mandibular incisors by 6 mm in 4 months. But still there was apprehension regarding its stability and true usefulness. His case paved the way to clinical and laboratory researches in last two decades and has evolved successful use of miniscrew implants which have been advocated for use as absolute anchorage savers in the treatment of various malocclusions.

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A variety of miniscrew implants in combinations of varying length, diameter, and shapes have been designed. More so, these are commercially available for use by the orthodontists.

Mini implants or miniscrew implants referred as MSIs are different from dental implants. They are relatively smaller in size so don't impose limitations for use in dentate areas. Also they are not meant to remain for longer period in oral cavity, they are smooth surfaced. The surface of dental implant is roughened and chemically treated to facilitate osseointegration whereas the MSIs are mechanically retained.

Genuine anchorage control benefits

The MSIs have found multiple clinical applications in orthodontic practice. They have been successfully used as stable anchorage for complex tooth movements including enmass retraction of anterior teeth, enmass distalization of maxillary arch and mandibular molar protraction. For successful treatment, MSIs must have primary stability and be able to withstand orthodontic force levels. The overall success rate of MSIs has been reported to be 86.5%. (Xu and Xie, 2016) It is proved that MSIs remain clinically stable under orthodontic loading, (Upadhyay *et al.*, 2008; Al-Sibaie and Hajeer, 2014; Monga *et al.*, 2016) with some histologic osseointegration ranging from 10-58%. (Cornelis *et al*, 2007)

Development of AIIMS MSI protocol for treatment of bimaxillary protrusion/ Class II div 1 cases

AIIMS MSI protocol **(fig. 1)** is based on the extensive clinical experience and research work conducted at Department of Orthodontics and Dentofacial Deformities, Centre for Dental Education and Research, All India Institute of Medical Sciences (AIIMS), New Delhi. Before choosing the patient for treatment with MSI implant, strict case selection criteria is used (Table 1).

Table 1. Case selection criteria for MSI anchorage

1.	Conventional anchorage is insufficient
2.	There is need for complex tooth movement such as molar intrusion
3.	Patient is free from medical problems
4.	Good bone density
5.	Excellent oral hygiene

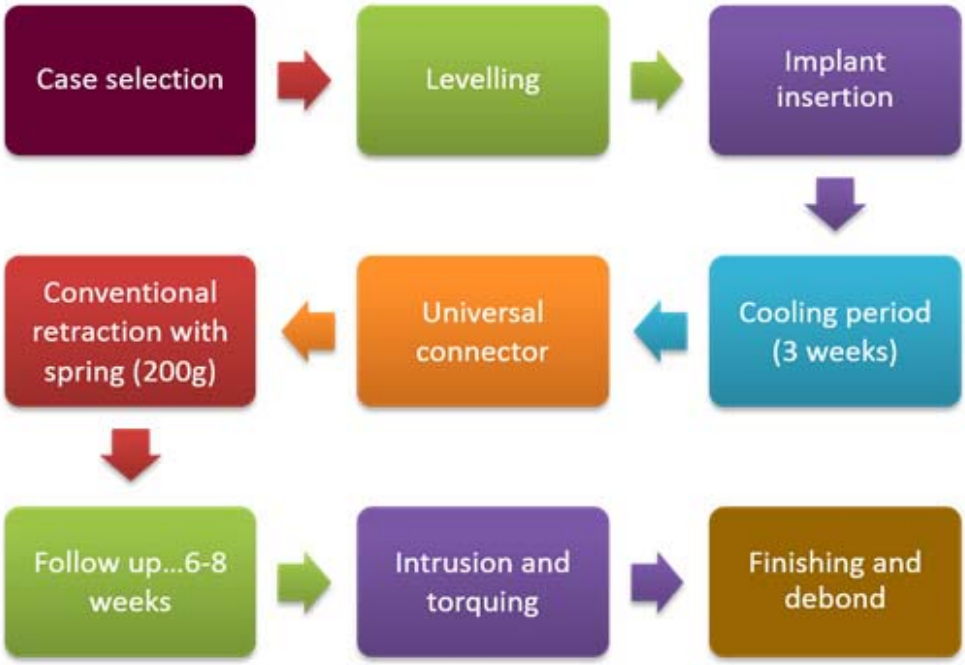

Fig 1. A schematic diagram of AIIMS protocol for MSI anchorage

There must be a definite indication for use of MSI and should have low risk-benefit ratio. Enthusiastic use of an invasive and costly procedure like MSI anchorage in all patients is not recommended.

A fully bonded 022" preadjusted appliance is used. Upper molars receive triple buccal tubes and lower double buccal tube. If there is no crowding in the arches, extraction of premolars (both upper and lower premolars in bimaxillary protrusion cases and upper premolars only in Class II div 1 cases) is deferred till alignment is completed. A sequence of wires is used for levelling and alignment until a 0.019"x0.025" stainless steel wire is passively engaged. Extractions of premolars is performed as needed. The most common site for MSI placement is buccal interradicular space between second premolar and first molar in attached gingiva 4-5 mm apical to the alveolar crest. MSIs are placed in identified locations in the mouth under local infiltration and anti-inflammatory drugs for next three days and strict oral hygiene programme is prescribed.

A time lapse of 3 weeks is suggested so that the inflammation around the MSI subside. Before loading the MSIs, an auxiliary wire framework AIIMS universal connector (Kharbanda *et al*., 2013)) is fabricated in 0.017"x0.025" stainless steel wire which connects the molar at its auxiliary slot and the bracket head of the MSI so that the MSIs are indirectly loaded during retraction of the anterior teeth. **(fig. 2)** The connector is so fabricated that it is passively fitted in slots on the MSI or the connected molar without exerting any force at both the ends. The enmass retraction of the anterior teeth is carried out using conventional mechanics. **(fig. 3)** The patient is followed every 6-8 weeks. Once the extraction spaces are closed, the MSIs along with connector is removed and finishing is carried out in the usual manner.

Direct vs indirect loading

In clinical practice and most of the research studies, the MSIs are directly loaded. However, in cases where enmass retraction is carried out by direct loading, MSIs on both sides of the jaw should be placed at the same height or location. This may not be possible in all cases because of varied level of the mucogingival junction and differences in bone height, thereby leading to canting of occlusal plane. In such cases, indirect loading can serve the purpose. It has been proved that anchorage control with indirect loading is comparable with direct loading method and it is suggested that in clinical situations when directly loaded MSIs are not preferable, indirectly loaded MSIs can be considered as a robust option. (Monga *et al*., 2016)

According to recent FEM studies, direct loading can overload the MSIs and the peri implant bone, sometimes, leading to MSI failure. (Holberg *et al*., 2013, 2014) Indirect loading technique allows the clinician to vary the position of MSI at preferable site. At the same time, good biomechanical control of the teeth can be obtained by applying standard orthodontic mechanics.

MSI failure and biological basis

MSI failure can be attributed to number of factors including biological, implant related or technique related factors. (Kharbanda *et al*., 2013) Biological factors include age and gender of the patient, bone quantity and quality, nature of soft tissue, periodontal condition and oral hygiene maintenance. Dimensions and shape of the MSI, type (predrilled or self-drilling) constitute the factors related to the MSI. Angulation of the MSI, proximity to dental roots, loading protocol and amount of load applied also affect the stability of the MSI. They have been extensively researched to identify their role in MSI failure.

Bone quality is considered to be an important factor affecting MSI stability and greater failure is reported in low density bone (Chen *et al*., 2008). In addition to bone availability in interradicualar region between second premolar and first molar, this site has good bone quality for MSI insertion. (Poggio *et al*., 2006; Samrit *et al*, 2012). Local inflammation i.e., peri implantitis is also identified to be one of the major factor contributing to MSI failure accounting for about 30% of MSI failures. (Miyawaki *et al*., 2003; Park *et al*., 2006; Samrit *et al*., 2012)

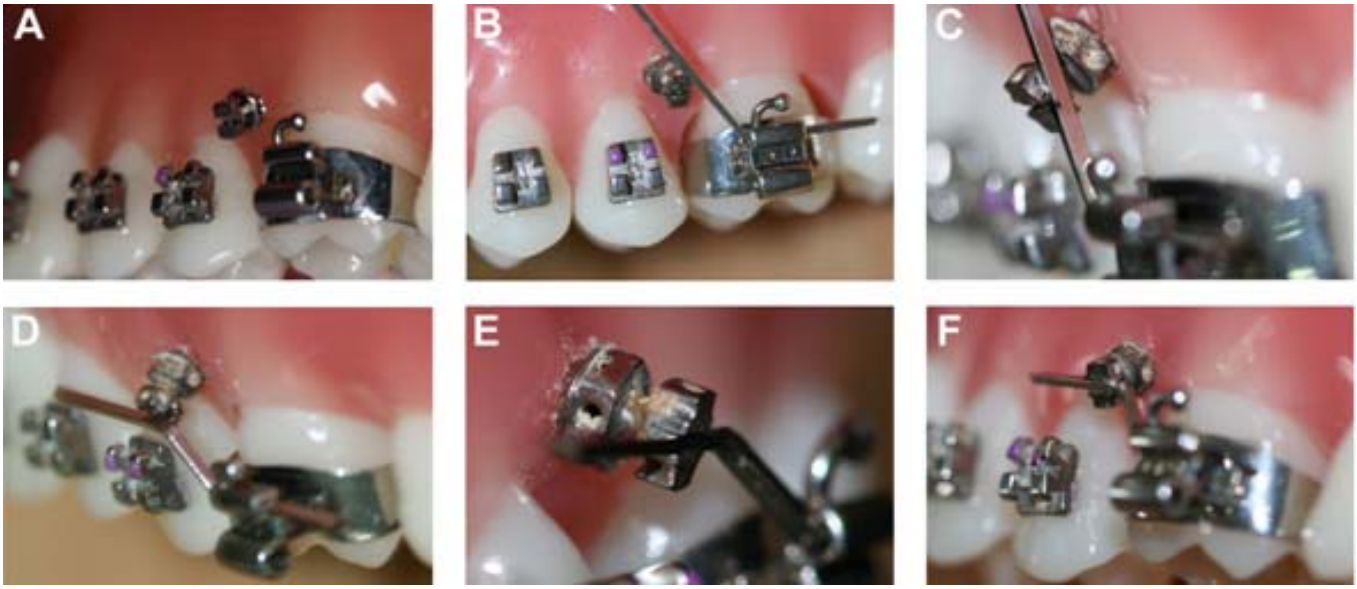

Fig 2. Steps in fabrication of AIIMS Universal Connector

A. MSI inserted into the buccal interradicular bone between second premolar and first molar

B. 0.017"x 0.025" stainless steel wire is bent gingivally immediately mesial to the molar auxiliary tube so that the free end passes distal to MSI head touching it

C. A point is marked on the wire at the level of the MSI slot

D. A bend is given in the wire at the marked point so that now the wire is paralled to the MSI slot

E, F. Now the torque in the horizontal segments of the wire is so adjusted that the wire framework can be passively seated in position

Fig 3. Enmass retraction of anterior teeth using indirect anchorage and conventional sliding mechanics

The focus of research now shifted towards minimizing the peri implant inflammation. Human study was conducted at AIIMS to explore the inflammatory response and found that there is significant rise in level of inflammatory marker during MSI insertion and on loading. (Monga *et al*., 2014) These levels gradually decrease towards baseline over the period after loading. This led to the conclusion that at least 3 weeks of cooling period is necessary after MSI insertion for the inflammation to subside. Another research at AIIMS on surface characterization of retrieved MSIs has led to the new area for exploration which would help in reduction of peri implantitis and thereby reduction in failure rate. (Patil *et al*., 2015).

Summary

The MSIs are useful addition to orthodontic armamentarium. When used judiciously, these can certainly add to effective anchorage control and improved treatment outcome.

They have also helped in management of complex tooth movements. While mechanical and design related factors have been a major research interest, lately, focus has shifted towards 'biological' studies. AIIMS protocol of use of MSI supported indirect anchorage and cooling period of three weeks before loading is based on sound biological basis. Further research is in progress to induce implant- soft tissue interface to minimize peri-implantitis.

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