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Review Article

Mini implant 'Safe Zones' in orthodontics: A comprehensive review

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ABSTRACT

In prosthetic dentistry the quality of life of patients with tooth loss have been significantly enhanced with the use of dental implants likewise in Orthodontics mini implants has been instrumental in expanding the envelope of treatment possibility. The incorporation of mini implants into orthodontic treatment planning has allowed for predictable anchorage control and has increased the ability to correct severe skeletal and dental discrepancies. Despite the great interest in anchorage control with Mini Implants, the safe implantation of the mini implant in different regions is of major concern. Thus learning about the anatomy and safe zones for placing Mini Implants are of paramount importance.

1. Introduction

Anchorage is the resistance to unwanted tooth movement and the control of anchorage is one of the most critical factors in orthodontic treatment.[1] The traditional anchorage devices which have been used had their own limitations, In prosthetic dentistry the quality of life of patients with tooth loss have been significantly enhanced with the use of dental implants[2] likewise in Orthodontics mini implants has been instrumental in expanding the envelope of treatment possibility.

The incorporation of mini implants into orthodontic treatment planning has allowed for predictable anchorage control and has increased the ability to correct severe skeletal and dental discrepancies.[3] Despite the great interest in anchorage control with Mini Implants,[4] Placing the mini-implant without root injury or puncturing important local anatomical structures is of utmost importance to an orthodontist; thus finding safe zones placing mini implants carefully in different regions has become an area of interest to lot of clinicians. Thus multiple literature has come up with saze zones protocol for mini implant placement at different regions. Thus with this article we would like to do a evidence based comprehensive review of the anatomical safe zones for placing Mini Implants as better quality of healthcare can be achieved by reviewing and practicing current evidences[5] and to improve the quality of service is an undeniably crucial factor.[6]

2. Safe Zones for Buccal Mini Implants

2.1. *Buccal interradicular mini implants*

2.1.1. *Anatomical consideration*

Main anatomic consideration of placing Interdental Mini Implant is the risk of root, periodontal ligament injury and Soft tissue injury.[7]

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Table 1: Specificprinciples for safe placement of maxillary buccal interradicular mini-implants

S.No.	Author	Placement Site and Angulation	Soft tissue consideration	Mini-Implant Dimension
1	Poggio et al[4]	interradicular space between the first molar and second premolar, from five to eight mm from the alveolar crest. Between the second and first premolar, between five and 11 mm from the alveolar crest. Between the first premolar and canine, between five and 11 mm from the alveolar crest.		
2	Pajongjit Chaimanee[8]	Space between the second premolar and the first molar		
3	Deguchi T et al[9]	On the buccal position of posterior maxilla, an angled placement of 30^0 to the long axis of the tooth was recommended.		
4	Baumgaertel et al[10]		Attached gingiva is superior to mucosa, as the latter moves around the mini-implant under function leading to Inflammation and screw failure	
5	Choi et al[11]			The diameter of commonly used miniscrew implants is 1.2-1.6 mm. Considering the interdental root distance, this diameter poses no problem for maxillary anterior implants; however, especially for placement in the U1-U2 region, miniscrew implants with a diameter of 1.2 mm or 1.0 mm will be safer.
6	Naik et al[12]			Recommendation by the Author Between 2nd premolar and 1st molar 1.2 to 1.3mm diameter and 7-8mm of length Between Incisor 1.3 to 1.6mm diameter and 6-7mm of length

Table 2: Specificprinciples for safe placement of mandibular buccal interradicular mini-implants

S.No.	Author	Placement Site and Angulation	Soft tissue consideration	Mini-Implant Dimension
1	Poggio et al[4]	Interradicular spaces between the second and first molar. Interradicular spaces between the second and first premolar. Interradicular spaces between the first molar and second premolar at 11 mm from the alveolar crest. Interradicular spaces between the first premolar and canine at 11 mm from the alveolar crest.		
2	Naik et al[12]			Recommendation by the Author Between 2nd premolar and 1st molar 1.3 to 1.6 mm diameter 5 to 7 mm length

Table 3: Specificprinciples for safe placement of palatal interradicular mini-implants

S.No.	Author	Placement Site and Angulation	Soft tissue consideration	Mini-Implant Dimension
1	Poggio et al [4]	Interradicular space between the first molar and second premolar, from 2 to 8 mm from the alveolar crest. Interradicular space between the maxillary second and first molars, from 2 to 5 mm from the alveolar crest. Between the second and first premolar, between five and 11 mm from the alveolar crest. Between the first premolar and canine, between five and 11 mm from the alveolar crest.		
2	Jeong-Ah Lee [13]	1) According to this study palatal inter-radicular distance was the widest between the 2nd premolar and the 1st molar, followed by between the 1st and 2nd molars, the canine and the 1st premolar, and the first and second premolars, at the same vertical level 2) At the same vertical level among interdental sites, the palatal bone was the thickest between the 1st and 2nd premolars, followed by that between the canine and the 1st premolar, the 2nd premolar and the 1st molar, and the 1st and 2nd molars.		
3	Cha et al [14]		Maximum Mini Implant retention can be expected with thin soft tissue and thick cortical bone.	
4	Naik et al [12]			Recommendation by the Author Between 2nd premolar and 1st molar 1.3 to 1.6mm diameter and 10-12mm length

Table 4:

S.No.	Author	Placement Site and Angulation	Soft Tissue Consideration	Mini-Implant Dimension
1	Liou et al[15]	Liou suggested orienting screws about 55-70 degrees inferior to the horizontal plane to achieve maximal buccal bone engagement and to avoid root contact He also suggested the upper 1st molar region (IZC 6) to be a preferred site of placement.		Suggested 2x10mm screw dimension
2	Lin et al[16]	Lin et al[16] research pointed out that the alveolar bone is thicker on the buccal surface of the 2nd molar than 1st molar region in most populations, thus the upper 2nd molar region (IZC 7) site is usually preferable for TADs.		
3	Almir Lima[15]	The safe zones for IZC miniscrew insertion are located 11 mm from the alveolar crest between the maxillary first and second molars and on the mesial root of the second molar for all the 3 facial types.		
4	Chang[17]		Soft tissue irritation is a common problem if the inferior aspect contacts or near the mucosa. To control this problem the IZC TADs are placed in attached gingiva with ~1.5mm of clearance from soft tissue to the base of the TAD platform	
5	Baumgaertel et al[10]		The mucosa is attached at the mucogingival junction (MGJ), where it has no mobility, making the regions coronal to the MGJ suitable for insertions of miniimplants. As the mobility increases with distance to the MGJ, side effects should also increase, reaching their maximum at maximum distances, in the depth of the vestibule	

Continued on next page

Table 4 continued

6	Chris Chang et al [18]	This Study found no significant difference in the failure rate between movable mucosa and attached gingiva if the platform of the screw is at least 5mm away from the soft tissue surface, but the disadvantages of this approach are a longer screw is required (~12mm) and it must be carefully positioned for patient comfort.	
7	Ghosh [19]		Orthodontic bone screws in the maxilla (IZC) are available in two sizes commonly (manufacturer specific) – 12 and 14 mm in length and 2 mm in diameter. When the soft tissue in the buccal vestibule is thick as in most clinical situations, the preferred choice is a 14 mm screw which have 7 mm of head and collar area and 7 mm of cutting spiral. Orthodontic bone screws of 12 mm length are preferred in cases of thin soft tissue at the vestibule. The length of cutting spiral, head, and collar dimensions may vary according to the choice of manufacturer.
8	John Jin-Jong Lin et al [20]		The average thickness of the attached gingiva in the maxillary first molar is about 1.0mm, and the cortical bone thickness is about 1.1-1.3mm. The screw threads must engage cortical bone to ensure primary stability. Generalizing the widths, for soft tissue clearance, attached gingiva and cortical bone at 1.5mm each, which points us that 8-12mm IZC screws penetrate the medullary bone or sinus from 3.5-7.5mm. Under most clinical conditions, an 8mm screw is adequate to engage the cortical plate and secure primary stability

2.2. General Principles for safe placement of interdental mini-implants

Minimal clearance of 1 mm of alveolar bone around the screw has been recommended to preserve the periodontal health.[4] Therefore, when the diameter of the miniscrew and the minimum clearance of alveolar bone are considered, interradicular placement.[4,25]

Mini-Implants should also satisfy the biocompatibility specifications because most of them are indicated for a considerable period of time in the treatment.[26] Also to follow proper decontamination process which maintains the standard of treatment and to avoid implant failure.[27]

The maintenance and condition of implants post treatment plays an important role in survival rate and controlling the harmful effects.[28]

3. Palatal interradicular mini implants

3.1. Anatomical consideration

1. **Greater palatine foramen:** Approximately located about 15 mm lateral to the midpalatal suture at the level of the maxillary second or third molars.[29]
2. **Greater palatine neurovascular bundle and blood vessels:** Extending anteriorly from the greater palatine foramen to the canine area; depending on the height of the palatal vault, it may be 7-17mm above the cementoenamel junctions of the premolars and molars.
3. **Roots:** Risk of damaging the roots or the periodontium when placing them on the palatal shelves.[30]

4. Safe Zones for Buccal Extra Radicular Mini Implants

4.1. Infra zygomatic mini implant

4.1.1. Anatomical consideration

1. **Maxillary Sinus:** Insertion into the inferior portion of the Zygomatic arch carries the risk of maxillary sinus perforation,[31] such perforations can carry various risks, including infection, and therefore should be avoided[32] as it could lead to inflammation of the sinuses resulting in the common signs and symptoms that include thick nasal mucus, a plugged nose, and facial pain.[33] But small penetration (<2 mm) through the Schneiderian membrane heals spontaneously.[34] Jia et al. recommends a penetration of <1 mm into the sinus as optimal[16] also Bicortical engagement with the floor of the sinus is thought to enhance postoperative stability for dental implants. inflammation of the sinuses resulting in the common signs and symptoms that include thick nasal mucus, a plugged nose, and facial pain
2. **Dental roots:** Risk of damaging the roots or the periodontium when IZC mini-implants are not placed in proper angulation.

Specific principles for safe placement of infra zygomatic mini implant

5. Buccal Shelf Mini implants

5.1. Anatomical Consideration

1. **Dental roots:** Risk of damaging the roots or the periodontium when Buccal shelf mini-implants are not placed in proper angulation.
2. **Inferior alveolar nerve and blood vessels:** The general course of the IAC changes smoothly from lingual to buccal from the mandibular second molar to the second premolar and exits from the mental foramen, at the buccal part of the mandible bone,[35] Thus when placing the buccal shelf mini implant lower 2nd molar mesiobuccal region, angulation and considering the length of the screw poses less risk in puncturing the nerve. But Individual variations must be taken into account before placing.

6. Ramal Screw

6.1. Anatomical consideration

1. **Inferior Alveolar Nerve:** The anatomical structure presenting the most serious risk for complication, is the neurovascular bundle of the inferior alveolar (mandibular) canal. Under usual clinical conditions, the ramus TAD site is about 15 to 20 mm away from the neurovascular bundle.

7. Safe Zones for Extra Radicular palatal Mini Implant

7.1. Anatomical consideration

1. **Incisive canal foramen, Nerves and blood vessels:** including the nasopalatine bundle, Midpalatal suture (in growing patients), Nasal floor and maxillary sinuses.
2. **Nasal cavity:** The midpalatal area within 1 mm of the midsagittal suture had the thickest bone available in the whole palate. The thickness tended to decrease laterally and posteriorly, Thus to avoid puncturing into the nasal cavity a CBCT assessment of nasal floor is recommended.[38]

8. Source of Funding

None.

9. Conflicts of Interest

None.

Table 5: Specificprinciples for safe placement of buccal shelf mini implants

S.No.	Author	Placement Site and Angulation	Soft Tissue Consideration	Mini-Implant Dimension
1	Liu et al [21]	The region between the mandibular first and second molars (L6db– L7mb) should be the first choice for miniscrew implantation in the buccal alveolar bone in the Mandibular Buccal Shelf for the distalization of the entire mandibular dentition, As this site should provide good stability for the distalization of mandibular dentition without affecting the distal movement of teeth and the overall periodontal health.		
2	Riccardo Nucera et al [22]	The insertion site of the MBS with the optimal anatomic characteristics is the buccal bone lateral to the distal root of the second molar, with screw insertion located 4 mm buccal to the CEJ and for particular biomechanical needs, it is possible to consider an insertion site lateral to the mesial root. The second molar, but insertion will likely need to be more apical to attain adequate buccal bone thickness. Because of anatomical variation among individuals, potential insertion sites should always be evaluated on an individual basis.		
3	Liu, H., Wu, X et al [23]	The Lower 6 distobuccal root–Lower 7mesio mesiobuccal root region should be the first choice for miniscrew implantation in the Mandibular Buccal Shelf for the distalization of mandibular dentition.		
4	Ghosh [19]	The self-drilling screw is directed at 90° to the occlusal plane at this point. After the initial notch in the bone is created after couple of turns to the driver, the bone screw driver direction is changed by 60°– 75° toward the tooth, upward, which aid in bypassing the roots of the teeth and directing the screw to the buccal shelf area of the mandible.		Bone screws in the mandible are available in two sizes commonly (manufacturer specific) – 10 mm and 12 mm in length and 2 mm in diameter. Buccal shelf area in the Indian population is mostly found to be thin and deep; therefore, the preferred choice will be a 12-mm screw. The head and collar sizes of both the variants (10 and 12 mm) are almost the same but may vary according to the choice of the manufacturer.
5	Chang et al [24]		Mandibular Buccal Shelf miniscrews were highly successful (approximately 93%), but there was no significant difference between placement in Movable mucosa or Attached Gingiva.	

Table 6: Specificprinciples for safe placement of buccal shelf mini implants

S.No.	Author	Placement Site and Angulation	Soft Tissue Consideration	Mini-Implant Dimension
1	Patni et al[36]	The 'N angle' between the constructed line of insertion and the occlusal line, was 19.04 (SD ± 6.89) degrees. The proximity of the neurovascular bundle from the screw is 7.1773 (SD ± 1.73988) mm. 'N angle' can be used as an clinical Indicator for Predictable Insertion of Ramal Bone Screws.		
2	Chang et al[37]		It is critical to maintain at least 5 mm clearance from the soft tissue to the screw head for facilitating oral hygiene to control soft tissue irritation.	Recommendation by the Author 2mm in diameter and 14mm in length. As a ramus screw must penetrate thicker soft tissue before engaging the dense cortical bone of the mandible. A 14-mm screw was necessary to provide at least 5 mm of soft tissue clearance, after the bone has been penetrated 3 mm or more

Table 7: Specific principles for safe placement of extra alveolar palatal mini implant

S.No.	Author	Placement Site and Angulation	Soft Tissue Consideration	Mini-Implant Dimension
1.	Bjorn Ludwig[39]	The anterior palate appears to be one of the best sites for orthodontic miniscrews or palatal implants. Cortical bone is typically thicker in the palate than at buccal interradicular insertion sites, and favorable attached gingiva is readily available, ensuring high success rates. In addition, miniscrews placed in this area will not contact dental roots and anterior palatal region has lower blood-vessel density than in posterior region.		
2	Gracco et al[40]	According to the thickest vertical bone is located 3-4mm distal to the incisive foramen and 3mm paramedian to the palatal suture. It is also suggests that midpalatal suture might appear to be the best insertion site,		
3	Heymann, G.C[41]	the mentalis region is better suited for miniscrews and miniplates.		
4	Choi et al[11]			The palatal vault is deep, miniscrews with a length about 6-7 mm would be best for fixing miniscrew implants in the U1-U2 and U2-U3 regions.
5	Nienkemper[39]			Long 11 mm mini-implants provide a high level of stability when inserted at the midpalatal region.
6	Naik et al[12]			Recommendation by the Author Mid palatal area 1.5 to 1.8 mm diameter 5 to 6 mm length

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