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Infrazygomatic crest zone regarding orthodontic mini-implants – A Review

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Cover Page Footnote

Its purpose is to thank all of the people who helped with the research but did not qualify for authorship.

REVIEW

Infrazygomatic Crest Zone Regarding Orthodontic Mini-implants − A Review

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Abstract

Background: **Temporary anchorage devices have revolutionized fixed orthodontic appliance treatment through anchorage controlling in the clinic and play an essential role in resolving many complex cases. There is a possible risk for roots injury while using inter-radicular micro-implants, this is due to limited space. Therefore, the infrazygomatic crest area can be an alternative mini-implant insertion site in upper arch.**

Objectives: **To review orthodontic temporary anchorage devices (mini-implants) used in infrazygomatic crest in terms of: method of application, material, size of mini-implants, failure rate and advantage over inter-radicular mini-implants.**

Sources: **Internet sources, such as Google and Scholar PubMed. Selection of study: studies about the IZC regarding the use of orthodontic mini-implants.**

Conclusions: **Infrazygomatic crest region is selected to be alternative mini-implant insertion position in the upper arch. Infrazygomatic crest bone has a double-layered cortex and it in position close to the maxillary center of resistance, which is appropriate for mini-implant insertion and offers a strong and stable anchorage site, which could offer advantages over inter-radicular mini-implants.**

Keywords: Mini-implants, Infrazygomatic crest, Orthodontics screws, TADs

1. Introduction

Orthodontic treatment mainly depends on two mechanics: facilitating the desired teeth movement to the new position and preventing unwanted teeth movement, which requires anchorage control. Anchorage enhancement has progressed greatly over the past century, and one of these milestones was the development of mini-implants placed inter-radicularly. Recently introduced extra-radicular mini-implants, including temporary anchorage devices (TADs), which inserted in infrazygomatic crest (IZC) region in upper arch and buccal shelf (BS) in lower arch [1]. Inter-radicular and extra-radicular mini-implants have accompanied a renaissance in orthodontics over the last decade, introducing the concept of absolute or maximum anchorage, in addition to anchorage recently used to accelerate tooth movement [2]. These advancements serve as additional tools for orthodontists, enabling them to address more challenging cases and transform borderline cases (surgical cases) into non-surgical ones without compromising the achieved results [3].

2. Extra radicular mini-implants and their difference with inter-radicular mini-implants

Inter-radicular TADs have many limitations, such as root proximity, which carries the risk of root damage, a major risk factor for TAD failure [4]. Their placement between roots may also restrict the full arch movement as it interferes with mesiodistal root movements [5]. To reduce possible failures rate due to roots proximity and enable orthodontic mechanics to gain essential teeth movement, orthodontists have attempted to insert TADs into

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extra-alveolar sites such as IZC and BS [6]. Studies have shown that, from a clinical perception, IZC offer stable site for TADs and can be efficiently used as anchorage to improve and enhance orthodontic tooth movements [7].

Furthermore, inserting TADs into the IZC has many advantages, such as thicker bone, which allows the insertion of longer mini-implants, more bone contact, and improved primary stability [8]. In addition, the bi-cortical plates (the sinus floor and the buccal cortical plate) have greater bone density (an anatomical advantage), which may provide better primary stability for the mini-implant due to bi-cortical fixation. Moreover, TADs inserted into the IZC have another advantage over inter-radicular mini-implants: they allow full arch distalization without root contact issues [9].

3. Infrazygomatic crest anatomy

The infra-zygomatic crest zone is defined as a rectangular osseous volume with distinct boundaries. The buccal border of this region (Fig. 1) is determined by the outer layer of the zygomatic process of the maxillary arch along with the most apical part of the alveolar process. Cranial boundary is marked by the maxillary sinus floor and/or the nasal cavity floor. The medial border comprises the lingual root of upper first molar, lingual surface of the alveolar process, and nasal cavity surfaces. Caudal border is formed by the mesio-buccal and disto-buccal roots of upper first molar [10,11].

4. IZC TADs and sinus penetration

Maxillary sinus perforation is considered a major issue when using TADs inserted into the IZC [12].

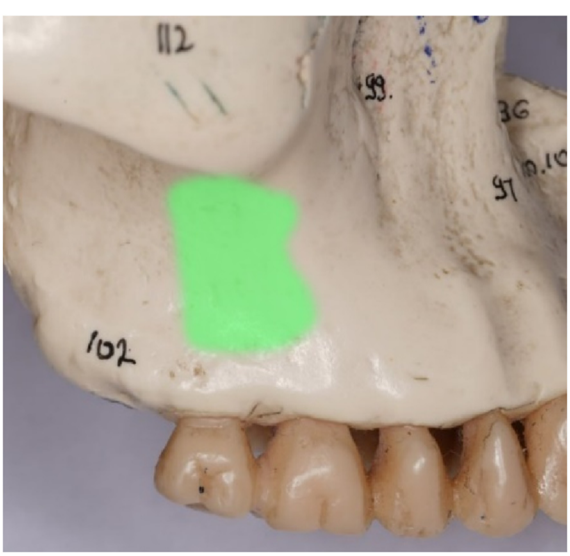

Fig. 1. Topographic anatomical borders for the infrazygomatic crest.

However, Chang et al. reported that it does not affect the six-month postinsertion survival rate and, thus, the failure rate of TADs inserted into the IZC [12]. Nonetheless, sinus penetration is still regarded as a vital structure damage. Moreover, evidence suggests that involving the sinus to enhance primary stability is unnecessary, where larger TADs could be compromising bone integrity over a greater area than smaller TADs; therefore, larger TADs may be better avoided when possible [11].

5. Primary stability and cortical plate effect

Mini-implant stability classified as primary (mechanical) and late stability [1]. Long-term dental implant success depends mainly on osseointegration [13]. Orthodontic mini-implant success primarily depends on mechanical stability, so any signs of mini-implant loosening and lack of primary stability within the bone may result in imminent failure of the orthodontic treatment; therefore, stability must be checked early [14,15]. Primary stability needs a good mechanical interlocking between the mini-implant and the bone and it does not demand a time for osseointegration.

Primary stability, relies on the mechanical engagement of the mini-implant to the bone surface and is influenced by factors such as bone quantity and quality, mini-implant design, and the specific site where mini-implants are inserted. While the definition of bone quality lacks clarity in the literature, some authors in the realm of orthodontic mini-implants associate cortical bone thickness with bone quality [16].

According to Marquezan et al.'s meta-analysis, results showed a good correlation between cortical primary stability and bone thickness. This implies that the thicker the cortical bone, the better the primary stability. From a clinical standpoint, orthodontists should be mindful that the thin cortical bone may result in low primary stability for orthodontic anchorage mini-implants. Notably, the mandibular buccal shelf is highlighted as having greater cortical thickness compared to other sites in the mandible. Consequently, placing implants in the mandibular buccal shelf is suggested to offer superior primary stability and contribute to implant success [17,18].

6. Insertion method for IZC TADs

Liou proposed an orientation of mini-implants at approximately 55°-70° inferior to the horizontal plane to achieve optimal buccal bone engagement. However, a common challenge associated with IZC placement is the risk of injury to the mesio-buccal root of the maxillary first molar. To mitigate this risk, it is suggested to insert mini-implants higher position rather than lower, as the interseptal bone tends to be thicker, reducing the likelihood of root injury [9].

The suggested insertion point is initially interdentally in between upper first and second molars, positioned 2 mm apical to mucogingival junction in the alveolar mucosa. At this stage, the mini-implant is directed perpendicularly 90° to buccal surface. As initial bone notch is created after a few turns, the screwdriver bone direction is changed by 55°-70° toward the tooth, downward direction. This adjustment aids to bypass roots of the teeth and guides the mini-implant toward the infra-zygomatic area of the maxillary arch (Fig. 2). The mini-implant is advanced till just the head is visible outside alveolar mucosa. This technique allows for immediate loading, and a single orthodontic mini-implant could be withstanding a force up to 300−350 g [9,19,20].

7. TADs materials

The majority of micro-implants currently accessible in the market are crafted from a titanium-aluminium-vanadium alloy, specifically Ti6Al4V. Similarly, bone mini-implants with pure stainless-steel material are available. The selection of stainless steel for mini-implants is attributed to its superior fracture resistance, a crucial factor given that these mini-implants are typically deployed in regions characterized by a higher bone density (DI > 1250 HU, in IZC and BS areas). This choice ensures better resilience against fractures compared to the Ti alloy alternative [21].

8. IZC Mini-implants recommended size

Orthodontic mini-implants designed for the maxilla (specifically, IZC) commonly come in two sizes, typically manufacturer-specific, with lengths of 12/14 mm and 2 mm diameter. In cases where the buccal vestibule come with thick soft tissue, which is typical for many clinical scenarios, 14 mm mini-implants are the preferrable option. These mini-implants feature a 7 mm head and collar area with a 7 mm cutting spiral part. Conversely, in cases while the vestibule is thin soft tissue, orthodontic mini-implants with a 12 mm length of are favourable. It's important to note that the dimensions of the head, cutting spart, and collar may differ depending on manufacturer's specifications [22].

9. Discussion

9.1. Why the IZC should be considered?

Osseointegration plays a crucial role in providing stability to dental implants, and the absence of this integration can manifest clinically as mobility, signalling implant failure. Conversely, the mini-implants retention not relies on osseointegration but rather than on mechanical interlocking at the mini-implant-bone edge. Therefore, the cortical bone thickness of regard as essential factor determining the primary stability after the mini-implants insertion [23].

Anatomically, infra-zygomatic crest zone is a cortical bone pillar located at the zygomatic process of the maxilla. Clinically, it is a bony ridge curvature running between the alveolar and zygomatic processes of the maxillary arch, positioned buccal to the zygomatic process above the upper first molar.

According to Lin et al., the IZC is situated lateral and higher to upper first and second molar region. They advocate for bone mini-implant insertion in the maxillary first and second molar region, earlier to the mesio-buccal root of the first molar (Fig. 3). For adults, it is positioned above the upper first molar, while for younger individuals, it is situated between upper second premolar and first molar [11].

The infra-zygomatic crest is characterized by thicker cortical bone, making it an optimal location

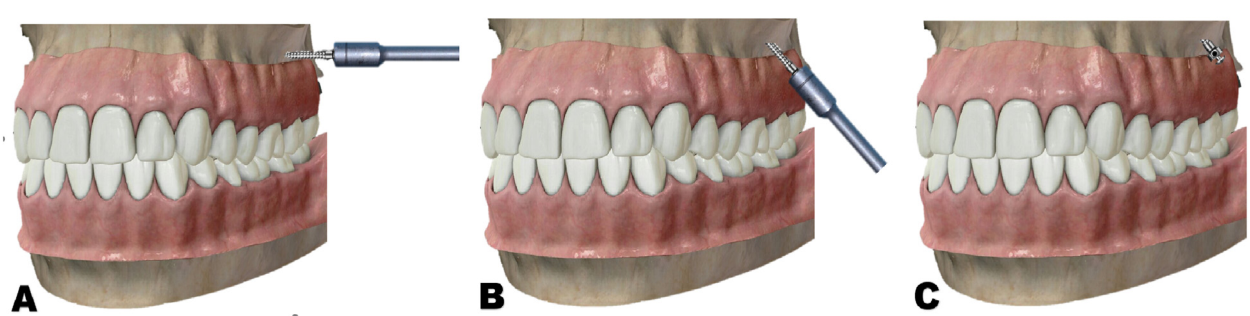

Fig. 2. A) IZC TAD positioning at the starting of the insertion "90° to the buccal cortical plate". B) Change the direction by 55−70° after penetration buccal cortical plate by approximately 1 mm. C) final position of IZC TAD after insertion.

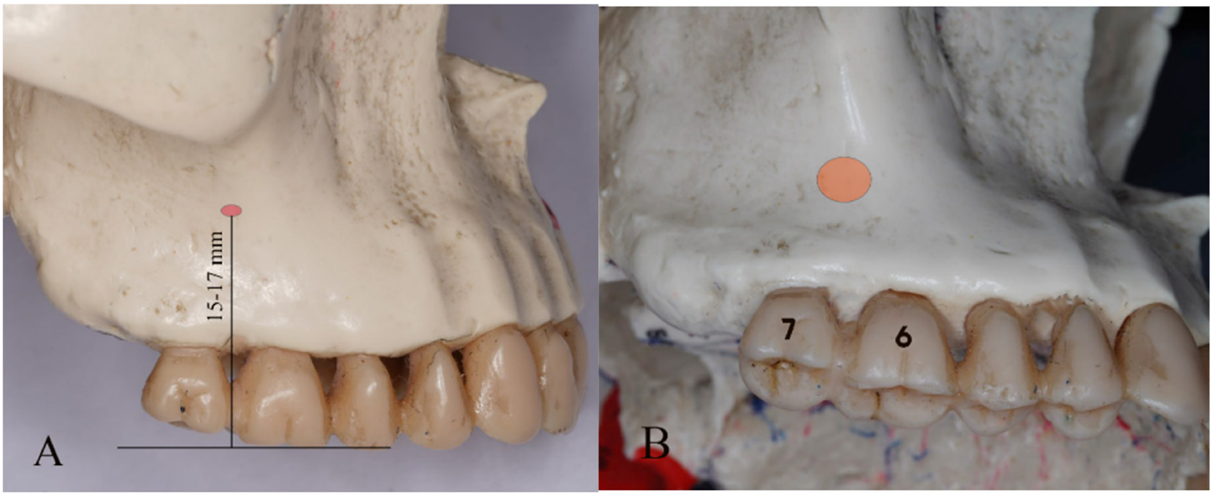

Fig. 3. Vertical distance for IZC TAD from occlusal surface of upper 1st molar (A), insertion site (orange) for IZC TAD (B).

for achieving good primary stability, particularly in partially edentulous patients. This region boasts the best bone quality in the maxilla, offering advantages for bi-cortical fixation and good primary stability when utilizing orthodontic anchorage mini-implants. The IZC comprises two cortical plates (buccal cortical plate and sinus floor) enhancing its suitability for bi-cortical fixation [8].

This anatomical advantage makes the IZC a favourable site for addressing issues in the vertical dimension. Studies have indicated that there is adequate cortical bone thickness for mini-implants when inserted at specific direction to the upper arch occlusal plane. Measurements taken at 40°−75° to the upper occlusal plane and 15−17 mm above the occlusal plane with thickness of bone range from 5 to 9 mm in the IZC, further supporting its suitability for orthodontic applications [9].

9.2. IZC TADs failure rate

Mini-implants can be considered successful if they are maintained inside the bone until the treatment goals are achieved or their planned removal. Mini-implants are considered to have failed if they have severe clinical mobility and cannot act as a stable anchor, necessitating their replacement or removal [24]. Their loss within less than six months after placement, the minimal interval for anchorage to retract the maxilla, is also considered a failure [25,26]. Many factors can lead to mini-implant failure, such as their loosening due to inflamed tissue around the insertion site, higher force overloading, cortical bone thickness and lower mineral density, mini-implant design, and root damage [27,28].

Studies have reported differing success and failure rates for mini-implants placed into IZC. Xueting et al. stated an overall success rate for 96.7% for mini-implants inserted into the IZC area [29]. Similarly, Chang et al. reported an overall success rate of 93.7% for mini-implants [30], which is considered clinically high and very optimistic. However, Gauri et al. reported a failure rate of 28.1% [31]. Similarly, Uribe et al. showed a 21.8% failure rate for IZC mini-implants insertion [24], which seems lower than those in the other studies.

Factors such as sex, age, mini-implant length (12/14 mm), occlusogingival position, force application method, and insertion angle may not be significantly related to lower or higher odds of mini-implant failure [31,32].

10. Conclusion

Inserting at the IZC does pose a higher probability of maxillary sinus perforation and may encounter challenges associated with poor soft tissue. However, if the benefit-risk ratio is favourable or individual imaging shows above-average bone depth, there is no integral reason to avoid utilizing this biomechanically advantageous insertion site. The decision to use this site should be made based on a careful assessment of individual patient factors, weighing the potential risks against the benefits associated with the biomechanical advantages offered by the IZC.

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Conflict of interest

The authors declare no conflicts of interest.

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