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Safe areas for mini-implant placement in orthodontics: Bibliographic review

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Abstract

Orthodontic anchorage using mini-implants has established itself as an effective means of optimizing biomechanical control during orthodontic treatment. However, its success largely depends on the selection of the insertion site, as an inappropriate location can compromise anatomical structures and decrease primary stability. The purpose of this review was to identify the safest areas for mini-implant placement, integrating evidence published between 2010 and 2025. Studies using cone-beam computed tomography (CBCT), anatomical analyses, and systematic reviews that evaluated interradicular spaces, cortical thickness, and variations according to age, sex, and skeletal pattern were included.

The results show that, in the maxilla, the safest interradicular spaces are located between the second premolar and first molar, as well as between the first and second molars on the buccal surface; in the anterior region, the appropriate site is between the central and lateral incisors, 6 mm from the cementoenamel junction. In the mandible, the preferred site is between the first and second molars, 6 mm or more apically, and in the anterior region, between the lateral incisor and canine. The paramedian region of the palate, especially between the first and second premolars, provides the thickest cortex and the greatest stability. Extra-alveolar alternatives include the infrazygomatic crest and the mandibular buccal cortex.

In conclusion, although safe sites exist, mini-implant stability is influenced by individual anatomical factors, so individualized CBCT planning is recommended.

Keywords: Mini-implants; Safe zones; Interradicular; Infrazygomatic ridge

1. Introduction

Temporary anchorage using mini-implants has become an important tool in orthodontics to avoid patient dependency and allow for controlled tooth movement. However, the stability and safety of these devices depend largely on the insertion site. Improper placement can cause contact with tooth roots, perforation of the maxillary sinus, or damage to the inferior alveolar nerve. Therefore, the literature has identified "safe zones" based on the availability of interradicular space, the quantity and quality of cortical bone, soft tissue anatomy, and the distance to critical anatomical structures.

This review integrates clinical and tomographic evidence published between 2010 and 2025 on the recommended sites for mini-implant placement in the alveolar and palatal regions, and in extra-alveolar areas such as the infrazygomatic ridge and the mandibular buccal cortex. Studies involving computed tomography (CT and CBCT), anatomical measurements on cadavers, and systematic reviews are included.

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2. Review Methodology

A search was conducted in PubMed, PMC, and open-access databases using terms such as mini-implants, safe zones, interradicular, and infrazygomatic crest. Articles in English and Spanish published between 2010 and 2025 that evaluated mesiodistal interroot distance, buccal and palatal/lingual cortical thickness, and bone density at different heights from the cementoenamel junction were selected. Articles comparing variations by age, sex, and skeletal pattern were also reviewed.

Studies using cone beam computed tomography (CBCT) were specifically consulted for its accuracy in measuring interradicular distances and cortical thickness, as well as reviews establishing clinical guidelines. Data were synthesized by anatomical region (maxilla, mandibular, palatal, extraalveolar areas).

In the maxilla, there are buccal interradicular spaces, which are divided into:

- **Anterior region.** Fayed et al. [1] evaluated 100 patients using CBCT and determined that, in the anterior region of the maxilla, the optimal site for microimplants is located between the central incisor and the lateral incisor, 6 mm apical to the cementoenamel junction. This space offers greater mesiodistal distance without compromising the roots and a relatively thick palatal cortex [1].
- **Posterior region.** The same study noted that, on the buccal surface, the most secure insertion sites are between the second premolar and first molar, as well as between the first and second molars[1]. A 2025 CBCT study (Gupta et al.)[2] measured the dimensions at 6 mm from the CEJ in 100 subjects and found that the largest mesiodistal space (approximately 3.5 mm) and the largest bucco-palatal distance (approximately 14 mm) are recorded between the first molar and second premolar. Furthermore, the largest buccal cortex (approximately 1.9 mm at 4 mm apical) is located between the first and second molars[2]. These findings support that the posterior area between premolars and molars is preferable for mini-implants of 1.2–1.6 mm diameter.Cortical palatina
- **Anterior paramedian zone.** The literature highlights the paramedian part of the palate (3–5 mm from the midline and 6–8 mm posterior to the incisors) as one of the best areas for mini-implants due to its thick cortical bone and keratinized mucosa. The study by Fayed et al. [1], indicated that the largest palatal cortex (approximately 1.77 mm at 6 mm apical) was located between the first and second premolars [2], so the slightly more apical palatal insertion between premolars offers stability and avoids the incisor palatal canal.

On the other hand, in the mandible, the oral interradicular spaces are divided into:

- **Anterior region.** According to Fayed et al. [2], the recommended site in the anterior mandible is located between the lateral incisor and the canine, 6 mm from the cementoenamel junction [1]. The interradicular distance is moderate, and the insertion should be slightly angled to avoid convergent roots.
- **Posterior region.** Both the study by Fayed et al. [2] and Gupta et al. agree that the widest and thickest cortical space (approximately 4.7 mm mesiodistal distance and approximately 13.6 mm bucco-lingual thickness at 6 mm from the cementoenamel junction) is located between the first and second mandibular molars [2]. Furthermore, the largest buccal (3 mm) and lingual (2.6 mm) cortex are located at this site [2]. Therefore, insertion in the molar region, preferably 6 mm or more apical to the cementoenamel junction, reduces the risk of root contact.

3. Factors Influencing Cortical Thickness

Data from Cassetta et al. [3] demonstrated that cortical thickness and density increase from the alveolar crest to the base; they are greater in adults than in adolescents and in men than in women. Furthermore, the mandibular cortex is thicker and denser than the maxilla, and the posterior region presents higher values than the anterior region [4]. These interindividual differences justify selecting longer mini-implants or increasing the attachment level (6–8 mm from the crest) to achieve stability in patients with thin cortices [4].

4. Extraalveolar Zones

4.1. Infrazygomatic Crest (IZC)

The infrazygomatic ridge, located above the mesiobuccal root of the maxillary first molar, provides thick cortical bone and an extraalveolar attachment that avoids roots and sinuses. Several studies indicate that the safe zone is 11–14 mm above the alveolar crest

between the first and second molars, where the bone is more than 3 mm thick. Mini-implants are placed at a 30–70° inclination to maximize bone trajectory length and minimize penetration into the maxillary sinus. This zone is especially useful for distalizing the maxilla or correcting Class II deformities [5].

4.2. Mandibular Buccal Shelf

The outer cortex of the mandible, above the external oblique line and behind the second molars, constitutes a useful extraalveolar area for distalizing mandibular teeth. CBCT studies report that the thickest bone is located between the mandibular first and second molars, 4–5 mm above the mucogingival junction, with a cortical thickness of 3–4 mm. The insertion is angled 20–30° to the occlusal plane to maximize bone surface area and avoid the inferior alveolar nerve [6].

Other considerations

- **Angle and depth of insertion.** A 60–70° angle is recommended in the buccal interradicular region to increase the cortical contact length and move the tips away from the roots. In the palatal region and extraalveolar areas, the angle may be smaller (30–45°) due to greater bone thickness [3].
- **Minimum distance between roots**. For screws with a diameter of 1.2–1.6 mm, a minimum interradicular space of 3 mm is required to preserve 1 mm of bone around the implant. The study by Gupta et al. [2] showed that the spaces between the first molar and second premolar in the maxilla and between the first and second molars in the mandible exceed this measurement at 6 mm from the cementoenamel junction [7].
- **Anatomical variations and age.** The cortex thickens with age and in men[3]; in adolescents or patients with thin cortex, it is recommended to use longer screws or to select the palatal region. People with craniofacial syndromes such as Down syndrome may have limited safe zones, so specific tomographic maps help with planning [8].
- **Postoperative care.** Rigorous hygiene, light immediate loading, and the absence of micromovements favor the survival of mini-implants. Soft tissue inflammation is considered one of the main factors for failure.

5. Discussion

The evidence reviewed demonstrates that the regions with the greatest cortical thickness and interradicular distance are concentrated in the posterior sites of the maxilla and mandible. The space between the maxillary second premolar and first molar offers, 6 mm from the cementoenamel junction, a mesiodistal space of approximately 3.5 mm and a buccopalatal thickness of 14 mm [2]. In the mandible, the space between the first and second molars presents an even greater distance and thickness, with a buccal cortex of approximately 3 mm [2]. These measurements allow the insertion of standard-diameter mini-implants without risk of root contact.

The paramedian palatine region is also a privileged area due to the combination of keratinized mucosa and thick cortical bone; however, the operator should avoid the incisive canal and the greater palatine foramen. Data from Fayed et al. and Gupta et al. indicate that the palatal cortex reaches values greater than 1.7 mm between the first and second premolars [2].

Variations in cortical thickness by age, sex, and skeletal pattern suggest that “safe zone” guidelines are not absolute. Cassetta et al. demonstrated that adults and men have thicker cortices than adolescents and women[3]; furthermore, the cortical bone is thicker lingually than buccally[4]. These observations underscore the importance of individual assessment using 3D imaging before insertion.

Extraalveolar areas such as the infrazygomatic crest and the mandibular buccal surface expand the anchorage possibilities for block movements. Their main advantage is that they avoid the interradicular space and provide thick cortical bone. However, care must be taken with structures such as the maxillary sinus and inferior alveolar nerve, and the insertion angle must be adjusted to maximize the length of the bone tract.

6. Conclusions

Selecting the appropriate site for mini-implant placement in orthodontics is a determining factor in ensuring their stability and clinical success. In the maxilla, the safest interradicular spaces are located between the second premolar and the first molar, as well as between the first and second molars on the buccal surface. In the anterior region, the area between the central and lateral incisors, approximately 6 mm from the cementoenamel junction, is also considered suitable for the insertion of these devices.

In the mandible, the preferred interradicular site is located between the first and second molars, provided that insertion is 6 mm or more apical to the cementoenamel junction, and that there is sufficient mesiodistal space and a buccal cortex of approximately 3 mm. In the anterior region, the space between the lateral incisor and the canine has been identified as a recommended area.

Regarding the palatal cortex, the paramedian region of the palate represents the most favorable site, particularly between the first and second premolars, because it offers a greater amount of cortical bone and, consequently, a more stable support for mini-implants.

Additionally, there are extra-alveolar areas that constitute safe alternatives in specific cases. These include the infrazygomatic crest, located between 11 and 14 mm above the alveolar crest, and the mandibular buccal surface posterior to the molars. Placement in these areas requires careful planning and the use of radiographic studies to avoid compromising adjacent anatomical structures.

Finally, it is important to consider that the stability of the mini-implant depends not only on the anatomical location but also on individual factors such as bone quality, age, sex, and skeletal structure of the patient. In this regard, although there are generally safe areas, an individual assessment using cone beam computed tomography (CBCT) is always recommended to determine the most appropriate insertion site in each case [3]. This review highlights the importance of integrating anatomical evidence with individual clinical assessment to select the optimal location of mini-implants and minimize complications.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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