Evaluation of the correlation between tooth size-arch length and bone dimension for the correct position of orthodontic miniscrew: a literature review

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Abstract

Objective: To define a map of secure spaces where miniscrew can be likely placed at a level covered by attached gingiva, and to assess if a correlation between crowding and availability of space exists. For this reason, orthopantograms and CBCT images are been evaluated to search safe zones. Methods: A manual and electronic research was carried out in the main journals to select studies that analysed the correlation between anatomical parameters and dental malocclusion, during the planning phase and position of miniscrews. Results: In the mandible, the most convenient sites for miniscrew insertion were in the spaces comprised between second molars and first premolars; in the maxilla, between first molars and second premolars as well as between canines and lateral incisors and between the two central incisors. The interradicular spaces between the maxillary canines and lateral incisors, and between mandibular first and second premolars revealed to be influenced by the presence of dental crowding. Conclusions: The average sites map hereby proposed can be used as a general guide for miniscrew insertion at the very beginning of orthodontic treatment planning. Then, the clinician should consider the amount of crowding: if this is large, the actual interradicular space in some areas might be significantly different from what reported on average. Individualized radiographs for every patient are still recommended.

Introduction

Orthodontic miniscrews are devices specifically designed to be temporarily inserted in the maxillofacial bones to provide anchorage for an orthodontic appliance1. They are commonly used when it is necessary to obtain a real maximum anchorage for the orthodontic appliance, for realising orthopedic therapies in adult patients, as when compliance is an issue, of if there are insufficient teeth to assure an appropriate biomechanics2. Their success rate is reported to be between 61% and 100%,3-5 and is affected by many factors: miniscrews dimensions, geometry, surface characteristics, surgical technique and clinicianâ€™s experience, bone quantity and quality, loading force, primary stability and oral hygiene3,6-9. Another important anatomical parameter seems to be the root proximity, influencing the risk of surgical and orthodontic complications after the intervention10. Many authors have tried to define a map of â€œsafe zonesâ€• for miniscrews insertion: Schnelle et al11 assessed on panoramic radiographs the presence of at least 3 or 4 mm of bone between two adjacent roots, in order to define a map of the interradicular sites where most likely a miniscrew can be safely placed. The authors decided to use the reference of 3 and 4 mm of space considering a miniscrew diameter between 1.2 and 2 mm, and the need of at least 1 mm of bone around the miniscrew. Other authors measured the space between roots at different levels on panoramic radiographs12 or Cone Beam Computed Tomography (CBCT)13-17. Nevertheless, in order to have a convenient primary stability of the miniscrew, the quality of the cortical bone seems to be crucial; thus, many authors have investigated the variation of thickness of the buccal cortical plate of maxillary and mandibular bone between different sites14,15,18,19. One study used micro-CTs on autopsy material to evaluate the cortical thickness in the posterior region of maxillary and mandibular bones and the possible interference with the maxillary sinus20. From a systematic literature review emerges that the ideal sites for the placement of orthodontic miniscrew in both the maxilla and the mandible, taking into consideration quantity and quality of bone, are the buccal and lingual interradicular spaces between the second premolar and the second molar21. Moreover, another important aspect for the success of miniscrews insertion is their placement in the attached gingiva:22,23 indeed, this is not affected by tissue movements, hygiene manoeuvres are simpler and the risk of tissue irritation is lower. Some authors11,16 measured the interradicular spaces together with the height of attached gingiva.Obviously, the availability of bone between the roots is influenced by the position of the teeth, for example, when a malocclusion or dental crowding is present. In this way, in different malocclusions there are differences in bone availability between the roots;24 the authors related this finding to changes in teeth axial inclination depending on dentoalveolar compensation, which is a consequence of the presence of a skeletal malocclusion. Also, Schnelle et al11 found that in orthodontic patients, after tooth alignment, there were more available spaces for miniscrews positioning than before treatment.The objectives of this study were to find in international literature references to an average map of the interradicular spaces where is possible to find at least 3 mm of bone available for miniscrew insertion; as to investigate the influences of the crowding of the arches, in order to put orthodontic miniscrew in a more safe condition. The null hypothesis was that no correlation exists between dental crowding and amount of interradicular space.

Materials and Methods

During the more recent years, several dentistry works have been published on international literature about the use of orthodontic miniscrew and about their application. Many studies have been published on the description of their planning. So, a detached research of international literature on the use of these orthodontic devices and on all the differences between them has been performed using the principal medical databases: PubMed (Medline), Lilacs and Scopus. The keywords used were: Miniscrew, Mini-implant, Skeletal Anchorage and bone-bone anchorage; to identify all articles reporting on the topic till May 2019. No restrictions of time and languages have been fixed. The results have been filtered and valued following our eligibility criteria and then organized following the PRISMA method. The search identified 5,532 abstracts, which were reviewed manually and each article of interest was marked for further review. The full text of the marked studies was retrieved and studies that satisfied our eligibility criteria were included in this review. At the end only 9 full articles have been selected.

Results

A great variability in patientâ€™s age was revealed in literature. So several studies have been excluded for including only that on adolescent group (average age of 16Â±5,2 years). In the maxilla, all data concerning interradicular space were not normally distributed, except for the measurements of the interradicular space between canine and lateral incisor of both sides, as well as between the maxillary central incisors, which were normally distributed. In the mandible, all the data were normally distributed except for those concerning the spaces between all the four mandibular incisors. In the maxilla, for all the interradicular spaces, 3 mm of available bone on average were present far beyond halfway the length of the roots. The lowest values were found between first molar and second premolar, between canine and lateral incisor and between the two central incisors. In the mandible 3 mm of interradicular space were found at the coronal half of the root length between first and second molars, between first molar and second premolar, and between first and second premolars; the worst values were found between the four mandibular incisors. The measurements of interradicular spaces were used to depict the average interradicular sites map.Concerning crowding, the most crowded segment were the mandibular anterior segment, followed by the maxillary anterior segment.

Discussion

The aim of this review was to assess the amount of mesiodistal interradicular space between adjacent roots for miniscrew insertion and evaluate if the presence of malocclusion as the dental crowding could influence the availability of interradicular space for miniscrew positioning. The measurements of tooth size-arch length discrepancy also showed a small measurement error, confirming that digital models are a reliable method for assessing the presence of crowding and/or spacing in the arch. The horizontal magnification of the panoramic radiographs was overcome using a calibration method that involved digital models. Magnification assessed on panoramic radiographs was greatest in the lower molar region, whilst the smallest values were found in the upper incisors region. These values are smaller (from a minimum of 19% for the maxillary central incisors to a maximum of 55% for the mandibular second molars), but higher than the magnification values reported by Schnelle et al (from 2-6% in the anterior region to 22% in the posterior mandible). In non-calibrated panoramic radiographs, a general overestimation of the available bone was found of about 1 mm in excess for the mandibular molar region. The literature analysed a sample with dental crowding ranging from mild (less than 4 mm) to moderate (from 5 to 9 mm), with only a few cases showing severe (more than 10 mm) crowding. The differences regarding interradicular space can therefore, indeed, be attributed to the different radiographic techniques.Â

In another study about â€œsafe zonesâ€• for miniscrew placement based on panoramic radiographs, the areas between premolars both in the mandible and maxilla were discarded due to a high distortion risk. In the same study, it was found that sites with more than 3 mm of interradicular space in the maxilla were evident between the first molar and second premolar, the canine and lateral incisor, and the central incisors. In the mandible, these sites were between the second and first molar, the first molar and second premolar, and the canine and lateral incisor. These results are in accordance with some other studies on panoramic radiographs, except for the space between the maxillary first molar and the second premolar, as well as between the mandibular canine and lateral incisors, where smaller spaces were detected.

Poggio et al evaluated interradicular spaces at different levels of the alveolar crest on CBCTs. The greatest amount of space in the maxilla was found between the second and first premolars, between the first premolar and canine, and to a lesser extent between the first molar and second premolar; in the mandible, with the exception of the space between the first premolar and canine, there was generally good amount of space.

Despite the heterogeneity of the considered publications, a systematic review reported general agreement regarding the best sites for miniscrew placement: the areas between the first and second molars, the first molar and second premolar both in the maxilla and in the mandible were indicated as the best locations. In other studies, however, the posterior region of the maxilla, and the space between the second and first molars in particular, showed a small amount of available bone, thus contradicting what was found in the literature. Overall, panoramic radiographs underestimated the available interradicular spaces compared with CBCT, which is considered the gold standard for linear measurements. Two exceptions were the space at the coronal third between the first and second molars in the mandible, and the space at the apical third between the maxillary canine and lateral incisor. The latter can probably be explained because at that point the arch displays an increased curvature and panoramic radiographs images therefore present greater distortion.

In general, tooth size-arch length discrepancy measured at the crown level seems to be related to the amount of interradicular space. Schnelle et al repeated interradicular space measurements on post-orthodontic treatment panoramic radiographs of patients assessed before treatment: in this way, they assessed whether having roots that are parallel and aligned following orthodontic treatment generally ensures a greater number of available interradicular spaces. In particular, they observed that the availability of â‰¥ 3 mm of bone increased at the space between the maxillary canine and lateral incisor, and between the mandibular canine and lateral incisor. In the present study, a statistically significant correlation between tooth size-arch length discrepancy and interradicular spaces measured on panoramic radiograph was found for the space between the canine and lateral incisor in the maxilla. The presence of this correlation is particularly important for interradicular areas where a suitable amount of space for miniscrew insertion is usually found; however, for a patient who has crowding, it should be expected that the interradicular space would be less than usual. In their review, AlSamak et al proposed the use of â€œsafe zoneâ€• maps provided by the literature to define guidelines for miniscrew insertion, arguing that they would thereby avoid radiographs, at least for those sites that have proven to be favorable. Indeed, sometimes clinical examination alone is appropriate for evaluating miniscrew insertion sites. Considering also the results of Landin et al, this task can be reasonably achieved. In the present study, the value of â€œsafe zoneâ€• maps was improved by additional data from tooth size-arch length discrepancy; maps of average interradicular space are important, but the presence of crowding or spacing may substantially change the actual space available. The last map provided, derived from CBCT interradicular spaces measurements and correlations with tooth size-arch length discrepancy, can be used during the initial stage of orthodontic treatment planning in combination with the measurement of the tooth size-arch length discrepancy. This map can be used to evaluate the probability of sufficient space when increased crowding is present: the space can indeed be different from what is commonly found in the literature. Therefore, the map can be used in combination with tooth size-arch length discrepancy assessment in light of the ALARA principle, whereby redundant radiographic investigation of the patient may be avoided. The map may also be used to unveil different biomechanics to bypass those inconvenient spaces, or even to choose from the outset to use 3D radiographic examination that allows more comprehensive evaluation of the desired insertion sites. To help clinicians in this process, a decision tree based on the maps of safe zones and the map of correlations has been proposed. Nevertheless, further studies are needed to validate the suggested method in a clinical environment. To illustrate how the decision tree could help in clinical scenarios, two examples are provided. Fewer correlations between tooth size-arch length discrepancy and interradicular spaces were found on panoramic radiographs with respect to CBCTs. When crowding increases, interradicular space decreases, since a positive (interradicular space) and a negative value (dental crowding) were correlated. Surprisingly, when correlating interradicular spaces measured on CBCTs and tooth size-arch length discrepancy, a negative correlation was found at the apical level of the interradicular space between the lateral and central incisors in both the maxilla and the mandible, which means that for these regions, more crowding results in more interradicular space. The reason for this finding may relate to the divergence of the roots where crowding is present. It is important to underline that single interradicular spaces were correlated with the tooth size-arch length discrepancy of the entire relative segment (anterior or posterior) and not with a value of tooth size-arch length discrepancy between the two adjacent teeth relative to that interradicular space. This procedure was chosen to reflect what is usually applied in clinical practice, where tooth-by-tooth assessment of crowding is meaningless. â€œSafe zoneâ€• maps should be used in combination with the map showing which interradicular spaces are correlated with dental crowding. This combination facilitates the preliminary planning of miniscrew insertion before choosing which radiographs to prescribe, thereby making it possible to avoid unnecessary ionizing radiation.

Conclusion(s)

The use of digital models to calibrate panoramic images constitutes a valuable tool, while direct horizontal measurements on non-calibrated panoramic radiographs lack precision. Panoramic radiographs underestimate the actual interradicular space, hindering the use of miniscrews when in reality insertion would be possible, if the amount of crowding is the same. The findings of this study result in a new â€œsafe zoneâ€• map. The best areas for miniscrew insertion are between the upper central incisors and the interradicular spaces from the mandibular second molar to the mandibular first premolar. The map correlating interradicular spaces to tooth size â€“ arch length discrepancy may surpass previously published â€œsafe zonesâ€• when crowding is present.

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