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Original Article

Assessing Best Locations for Mini-Implants in the Mandibular Symphysis Based on Different Mandibular Growth Patterns: A CBCT Study

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Main Points

- The mandibular symphysis is a reliable site for orthodontic mini-implant placement.
- Low-angle growth patterns exhibit greater complete and cortical bone width.
- Bone thickness increases with greater insertion depth and angulation.

ABSTRACT

Objective: The aim was to evaluate optimum site for insertion of orthodontic mini-implants at mandibular symphysis in patient with different mandibular growth patterns using cone-beam computed tomography (CBCT). The objectives were to evaluate and measure complete bone width (CBW) and cortical bone width (CtBW) in the symphysis area at various heights [2 mm, 4 mm, 6 mm, 8 mm, 10 mm, and 12 mm from cementoenamel junction (CEJ)] and at various angles (0º, 10º, 20º, 30º, 40º, 50º, and 60º to the occlusal plane), and to assess the effect of mandibular growth patterns (low, average, and high angle) on these measurements.

Methods: The study sample included 45 patients aged 16-30 years. Patients were categorized into three groups (n=15) corresponding to the mandibular growth pattern for the assessment of CBW and CtBW. Individual data for each patient were entered into a master table in Microsoft Excel and subjected to statistical analysis using SPSS version 22.0. Analysis of variance was applied to investigate the influence of insertion location, facial type, insertion height and insertion angle on overall bone thickness and CtBW. A p-value <0.05 was considered statistically significant. Intra-observer reliability was assessed using the intraclass correlation coefficient.

Results: CBW was notably greater in patients with a low-angle mandibular growth pattern than in patients with other mandibular growth patterns at insertion heights of 8, 10, and 12 mm. CtBW was greater in cases with a low-angle mandibular growth pattern than in cases with other mandibular growth patterns. Similar results were observed for CtBW.

Conclusion: The mandibular symphysis in patients with a low-angle growth pattern provides more favorable anatomical conditions for mini-implant placement. The ideal insertion site lies between 6 and 10 mm below the CEJ of the central incisors, with angulation ranging from 0° to 60° relative to the occlusal plane. CBCT assessment should be considered essential in treatment planning to customize implant positioning based on individual growth patterns, thereby enhancing implant stability and success.

Keywords: Orthodontic mini-implants, CBCT, mandibular symphysis, cortical bone, occlusal plane

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INTRODUCTION

Orthodontic mini-implants, also known as temporary anchorage devices have become indispensable tools in modern orthodontics due to their ability to provide absolute anchorage and support for complex tooth movements without relying on patient compliance.[1] These devices have revolutionized biomechanical planning, allowing greater control and precision in tooth movements such as molar distalization, anterior retraction, intrusion of overerupted teeth, midline correction, and en masse retraction.[2]

The mandibular symphysis region, offers a strategic site for mini-implant placement, especially in cases where traditional inter-radicular spaces are inadequate or at high risk for root damage.

Clinical applications include intrusion of lower anterior teeth, correction of incisor proclination, management of anterior open bite cases, torque control during camouflage treatment, and en masse anterior retraction.

Despite the biomechanical benefits, mini-implant placement in the anterior mandible is often limited by narrow interradicular spaces and close proximity to dental roots.[3] Historically, most research has focused on interradicular areas, which are commonly considered contraindicated for implant placement in the anterior mandible because of spatial limitations.[4]

Recent studies suggest that the mandibular symphysis possesses a thick layer of cortical bone and favorable bone morphology that can support mini-implants without compromising dental or periodontal structures.[1] However, bone morphology in the symphysis is not uniform across individuals. Growth pattern variations-particularly vertical skeletal discrepancies-can significantly influence both cortical and medullary bone characteristics.

According to Handelman et al.,[5] patients with a low plane (MP) angle typically exhibit greater cortical bone thickness, particularly on the lingual side, while high-angle individuals tend to have thinner alveolar bone on the labial aspect of the symphysis. These variations are clinically relevant, as bone thickness directly affects primary stability, a key determinant of mini-implant success.

Although cone-beam computed tomography (CBCT) has become the gold standard for assessing alveolar bone dimensions and quality,[6] there is limited literature evaluating the mandibular symphysis region as a site for mini-implant placement across different mandibular growth patterns.

The focus of the study is to evaluate the optimal site for insertion of an orthodontic mini-implant at the mandibular symphysis in patients with different mandibular growth patterns using CBCT, with the objective of evaluating and measuring complete bone width (CBW) and cortical bone width (CtBW) in the mandibular symphysis at different heights [2 mm, 4 mm, 6 mm, 8 mm, 10 mm, and 12 mm from cementoenamel junction (CEJ)] and angles (0º, 10º, 20º, 30º, 40º, 50º and 60º to the occlusal plane).

METHODS

This research obtained approval from the Rungta College of Dental Sciences and Research Institute Institutional Ethical Committee (approval no: RCDSR/IEC/MDS/2022/D-11, date: 29.05.2023). The study involved 45 patients aged between 16-30 years attending the outpatient Rungta College of Dental Sciences and Research, Department of Orthodontics and Dentofacial Orthopaedics, Bhilai, India. Consent was secured from the patients themselves or from their guardians; for those under 18 years old, additional consent was obtained from parents.

Each patient underwent a lateral cephalogram and a CBCT scan using the cephalostat machine (NewTom GiANO HR 3D CEPH-CBCT Machine from Imola, Italy). The settings of the scanner were as follows: 85 kV, 5.0 mA, exposure time of 17.5 s, and a field of view of 8×8 cm or 10×10 cm, resulting in voxel sizes of 0.165 mm and 0.25 mm, respectively. Inclusion criteria included fully erupted mandibular incisors and the absence of hereditary or developmental craniofacial abnormalities. Exclusion criteria included dental implants and missing incisors and canines in the mandibular anterior arch, indeterminate CBCT and lateral cephalogram images, a history of bone metabolism-related conditions, and previous orthodontic treatment.

Data Collection

This was a descriptive cross-sectional study employing purposive sampling. Patients were categorized into three groups based on their mandibular growth pattern as observed on lateral cephalograms: Group A [low-angle mandibular growth pattern; frankfort horizontal-MP (FH-MP) angle <22°], Group B (average-angle mandibular growth pattern; FH-MP angle 22°-28°), and Group C (high-angle mandibular growth pattern; FH-MP angle >28°).

The sample size was calculated using G*Power software (version 3.1.9.2) based on data from Hoang et al.[7] An a priori power analysis was performed using a two-tailed test with an alpha level of 0.05, a beta level of 0.20 (power=80%), and an effect size of 1.11. The analysis indicated that at least 14 subjects per group were required to detect statistically significant differences. To ensure equal representation across the three mandibular growth pattern groups and to strengthen statistical reliability, the total sample size was rounded up to 45 participants, with 15 individuals allocated to each group.

Method of Measurement

CBW is the measurement between the labial and lingual edges of the bone, or between the lamina dura and the labial edge of the bone where it meets the tooth root. CtBW was measured between the outer and inner sides of the labial cortical plate (Figure 1). Complete and CtBWs were evaluated using CBCT with a slice thickness of 1 mm. Measurements were taken at seven anatomical locations using the Federation Dentaire

Internationale tooth numbering system: 42 (along the long axis of the right lateral incisor), 41-42 (between the right central and lateral incisors), 41 (along the long axis of the right central incisor), 41-31 (between the right and left central incisors), 31 (along the long axis of the left central incisor), 31-32 (between the left central and lateral incisors), and 32 (along the long axis of the left lateral incisor). These locations correspond to D, C, B, A, B′, C′, and D′ respectively (Figure 2). Each location was measured at six heights (2 mm, 4 mm, 6 mm, 8 mm, 10 mm, and 12 mm from the CEJ) and seven angles (0°, 10°, 20°, 30°, 40°, 50°, and 60° to the occlusal plane) (Figure 3).

For assessment of the mandibular symphysis, a longitudinal slice was positioned along the mandibular midline (Figure 4). Symphysis height was recorded from the midpoint of the anterior alveolus (Idm) to menton (Me), while symphysis width was recorded from the buccal pogonion (Pog) to the lingual Pogl (Figure 5). Subsequently, the height-to-width ratio of the symphysis was computed (Figure 6).

Statistical Analysis

Statistical was performed using SPSS version 22 (IBM, Corporation, Armonk, New york, USA). Analysis of variance (ANOVA) was applied to investigate the influence of insertion location, facial type, insertion height, and insertion angle on overall bone thickness and CtBW. A p-value less than 0.05 was considered statistically significant. Also symphysis height and width ratio was significant. After a two-week interval, twenty percent of the sample were randomly selected for repeated measurements by the same investigator to assess intra-observer reliability using the intraclass correlation coefficient.

RESULTS

No statistically significant differences were found between the right and left sides for CBW and CtBW at any of the seven locations (A, B, C, D, B′, C′, and D′). Therefore, data from both sides were combined, and the analysis focused on four locations (A, B, C, and D).



Figure 1. OBT and CtBW between the incisors.
OBT, overall bone thickness; CtBW, cortical bone width.

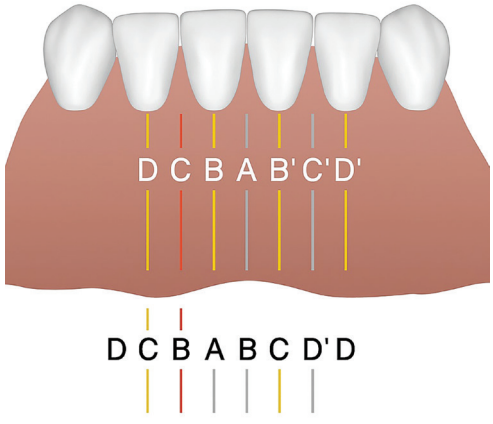


Figure 2. Different locations for placement of orthodontic mini-implants.

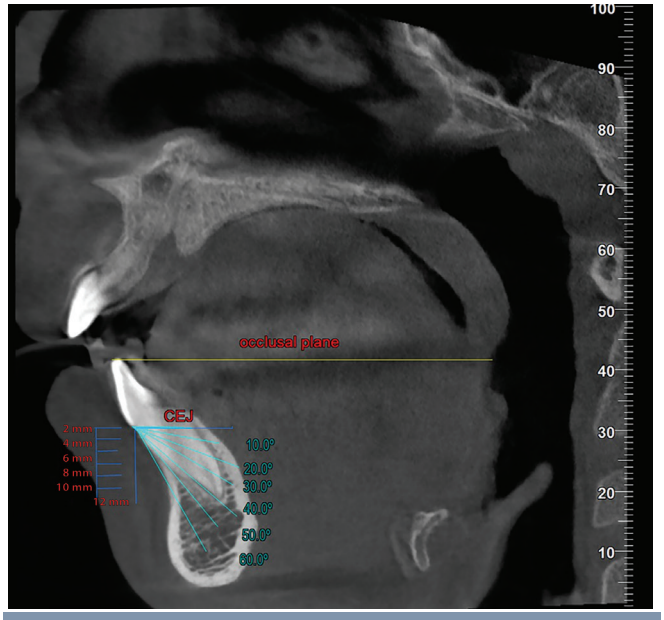


Figure 3. Different heights and angulations for placement of orthodontic mini-implant.
CEJ, cementoenamel junction.

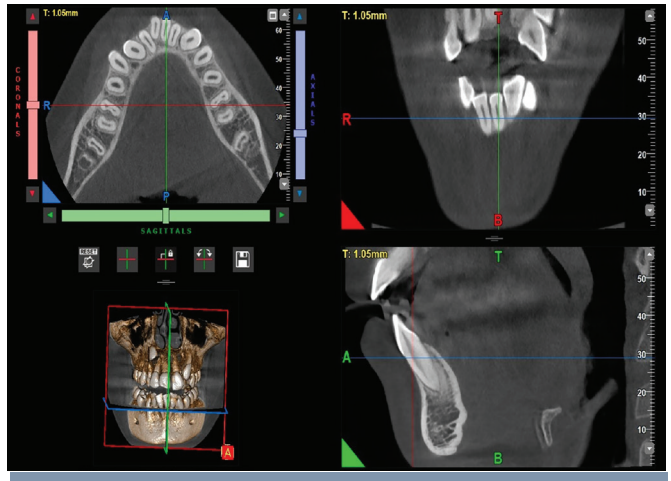


Figure 4. Symphysis dimension measurements, a sagittal slice was placed along the mandibular plane.

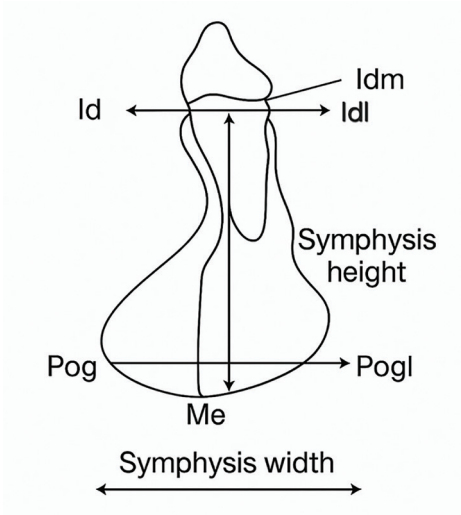


Figure 5. Sagittal cross section of the mandibular symphysis displaying symphysis region landmarks and variables.

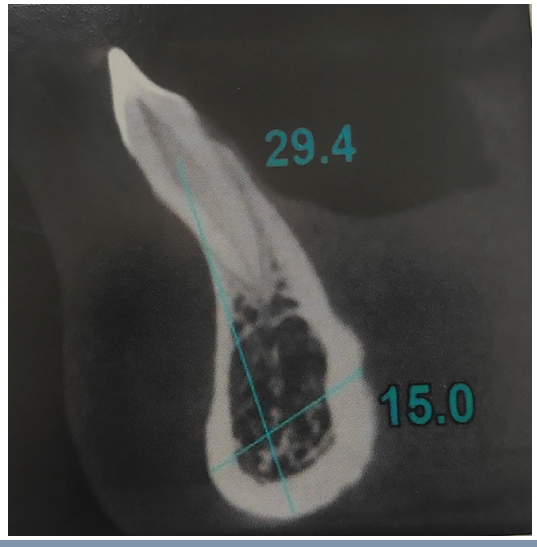


Figure 6. Symphysis height and width ratio.

- **Comparisons of CBW and CtBW among different mandibular growth patterns**

CBW was greater in cases with a low-angle mandibular growth pattern than in those with average- and high-angle mandibular growth patterns. This difference was observed at location A for insertion heights of 6, 8, 10, and 12 mm, and at location C for insertion heights of 4, 8, 10, and 12 mm. Almost identical results were observed for CtBW at locations B (10 and 12 mm) and D (6, 10, and 12 mm), as detailed in Graph 1.

- **Comparison of CBW and CtBW at different insertion locations and insertion angles**

Tukey's post hoc test revealed differences in CBW among the four insertion locations. It was highest at location A, with width measurements in descending order: A > C > B > D, as shown in Graph 1. Similar findings were observed for CtBW, except that no such variation was observed between locations A and C. The thickness order was A > C > B > D, as shown in Graph 1. Specifically, CBW was uniform across the four insertion locations at a height of 12 mm, but varied at heights below 12 mm. CBW increased with higher insertion angles at all locations except at the 2 mm insertion height, as illustrated in Graph 2. Similar trends were observed for CtBW, as depicted in Graph 3.

- **Comparison of symphysis dimensions among different mandibular growth patterns**

One-way ANOVA indicated a significant difference in the symphysis height-width ratio among mandibular growth patterns. The ratio in cases with a low-angle mandibular growth pattern was lower than that of cases with average- and highangle mandibular growth patterns, as shown in Graph 4.

DISCUSSION

Mini-implants are commonly used in the anterior mandible (mandibular symphysis) to intrude incisors.[1] However, their clinical application is often limited in cases of anterior crowding due to a interradicular space.[3]

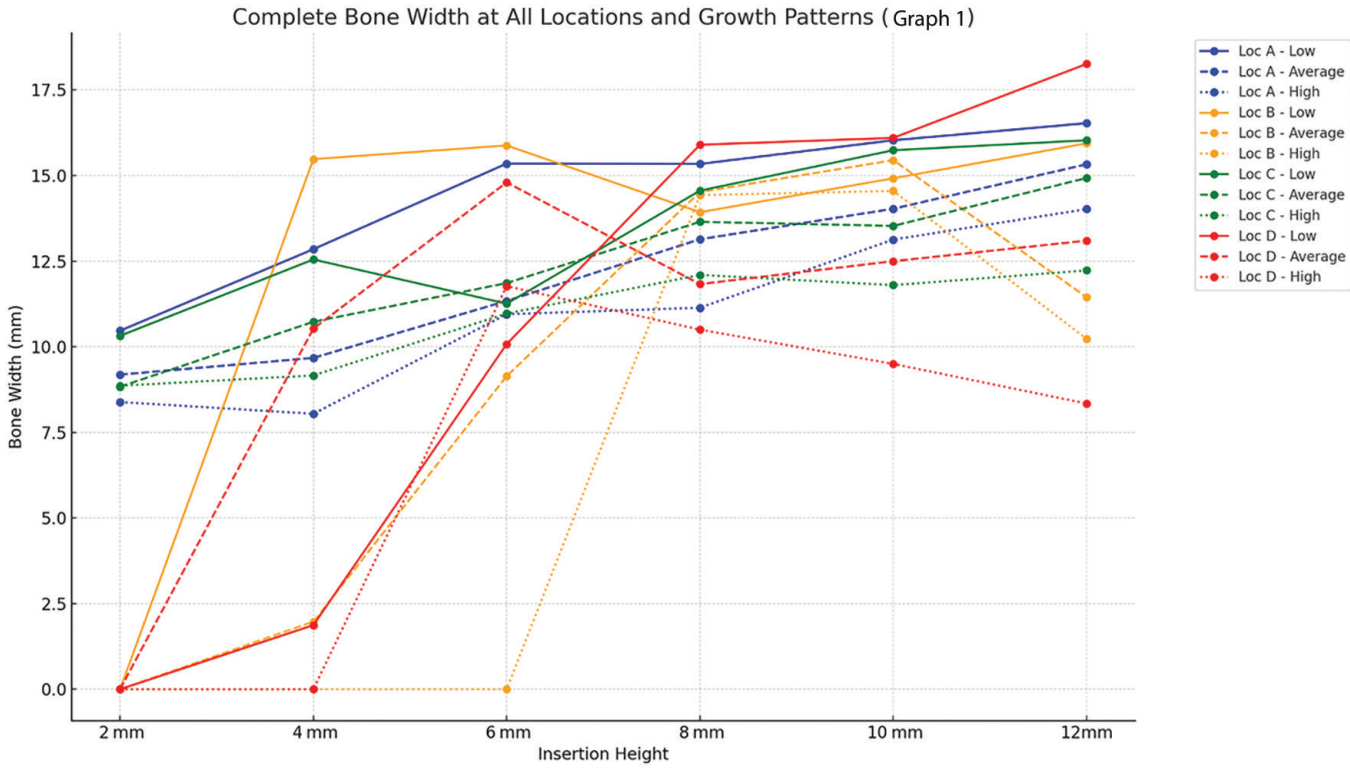
This study found no significant differences in CBW or CtBW (CtBW) between the right and left sides across seven evaluated locations (A, B, C, D, B′, C′, and D′). These findings are consistent with those of Zhang et al.,[1] supporting the anatomical symmetry of the anterior mandibular region and confirming its suitability for bilateral implant placement.

Alveolar bone width is known to vary with mandibular growth patterns. Our results revealed that both CBW and CtBW were significantly greater in patients with low-angle mandibular growth patterns than in those with average- or high-angle patterns. This observation supports the findings of Hoang et al.,[7] but contrasts with those of Sadek et al.,[8] potentially due to differences in insertion depth or landmark selection between the studies.

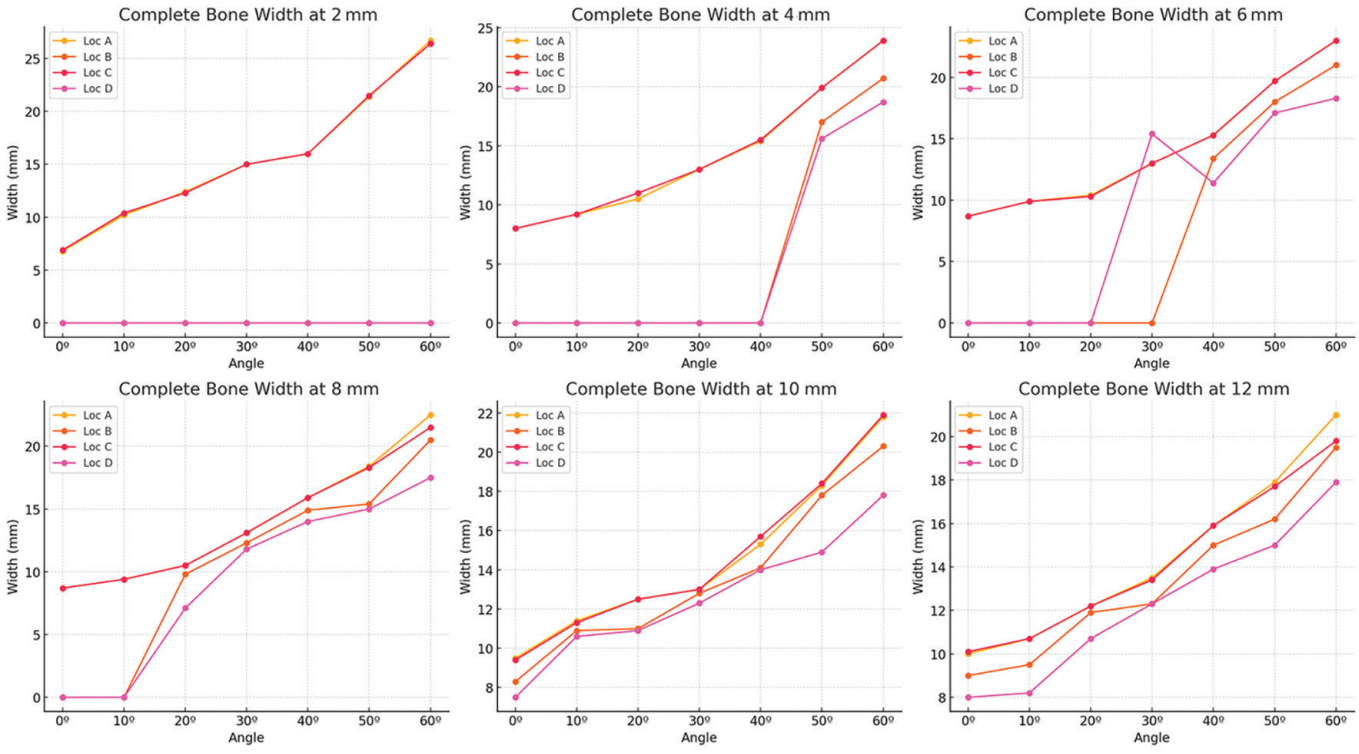
Across all locations, CBW and CtBW were lowest at point D and highest at point A. This pattern reflects the natural fusion and lateral growth of the mandibular symphysis, where bone tends to be thickest at the midline and thins toward the lateral regions. Specifically, CBW followed the order A > C > B > D up to a depth of 10 mm. Beyond 12 mm, bone width was more uniform, likely due to reduced influence of dental roots.

Interdental regions (locations A and C) consistently exhibited higher CBW than root-adjacent locations (B and D), in which the presence of roots limited bone volume. At depths beyond 12 mm, root interference decreased, resulting in more consistent bone width across all locations. A similar trend was noted for CtBW, which was thinner at root-adjacent sites and thicker in interdental areas.[1]

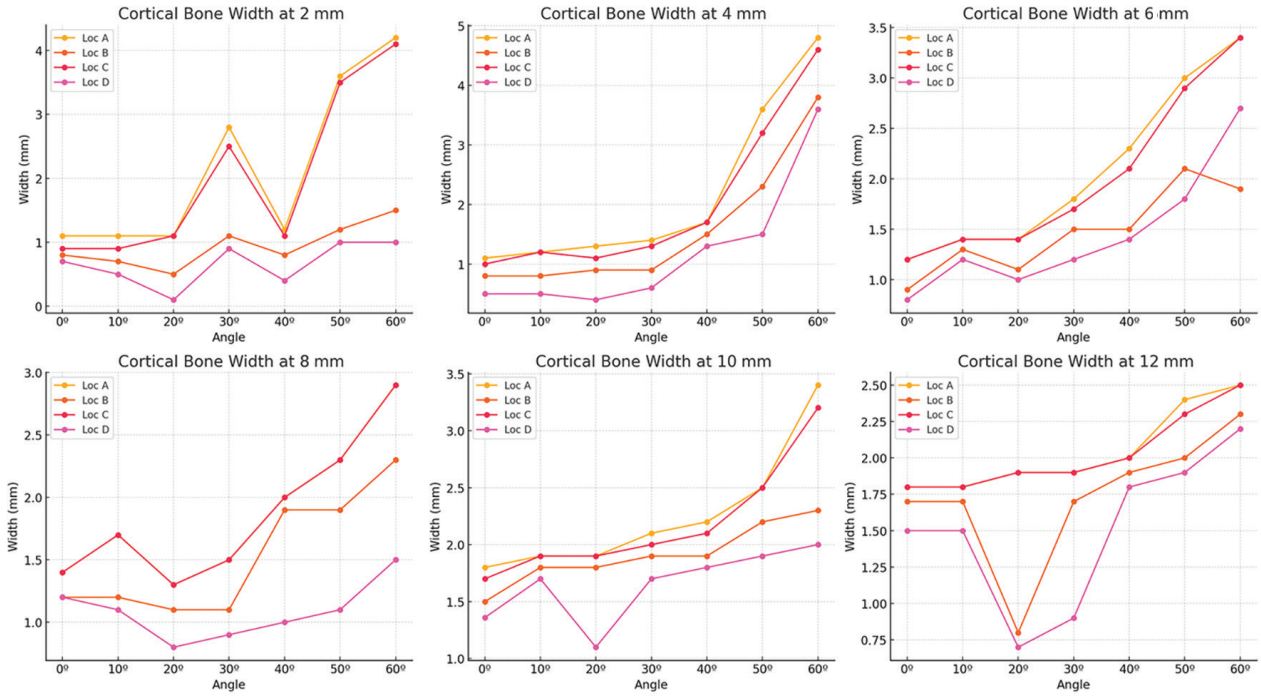
In clinical situations where bone quality or quantity is inadequate, mini-implants should be placed deeper and angled strategically to avoid root contact. This recommendation is supported by anatomical observations showing that root size decreases and inter-radicular space increases with depth.



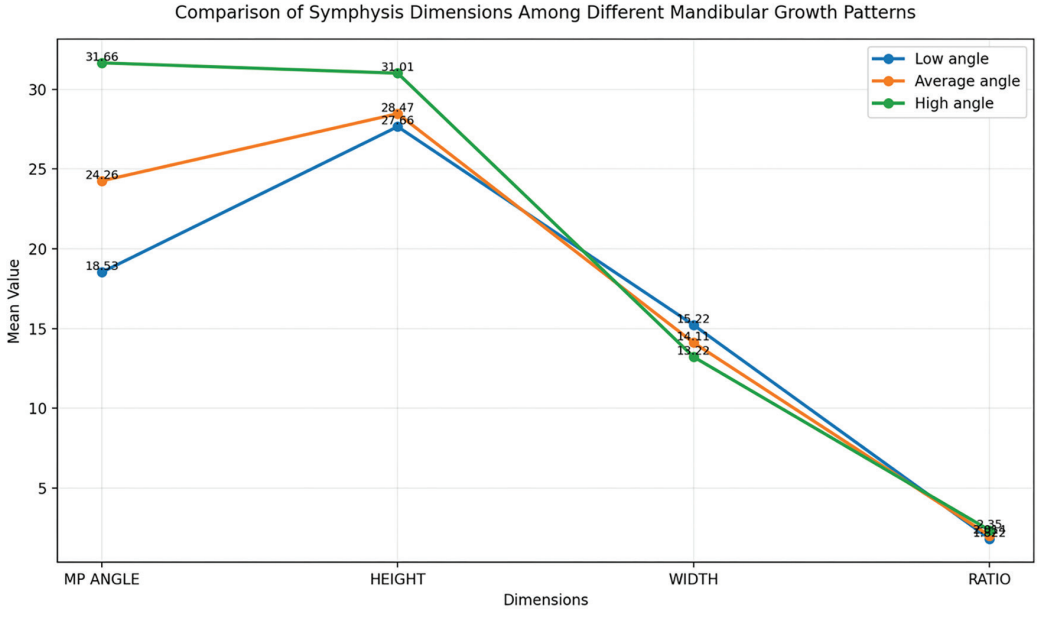
Graph 1. CtBW, cortical bone width. Comparison of complete bone width and CtBW among different mandibular growth pattern at each location.



Graph 2. Comparison of the complete bone width among four insertion locations at each insertion height & insertion angles.



Graph 3. CtBW, cortical bone width. Comparison of the CtBW among four insertion locations at each insertion height & angles.



Graph 4. Comparison of symphysis dimensions among different mandibular growth pattern

Additionally, buccal cortical bone thickens with increasing insertion angle.[9,10] Our findings confirmed that both CBW and CtBW increased with greater insertion depth and insertion angle, contributing to enhanced implant stability.

Implant reliability is influenced by several factors, with insertion depth and cortical bone thickness being particularly important.[11] Studies have shown that mini-implants are more stable when inserted to a depth greater than 5 mm.[12] However, an increased risk of cortical fracture has been reported when cortical thickness exceeds 2 mm.[13] Therefore, a cortical thickness of 1-2 mm is generally considered ideal for safe and stable mini-implant placement. Our results support the clinical recommendation of using steeper insertion angles at shallower depths, as proposed by Zhang et al.,[1] to maximize stability while minimizing soft tissue irritation and implant slippage.

The anatomical structure of the mandibular symphysis, especially the bony projection formed during fusion of the mandibular halves, makes location A particularly favorable

for mini-implant placement. Based on our measurements, the optimal insertion site is located between the central incisors, at a depth of 6-10 mm apical to the CEJ, and at an angle of 0º-60º.[1]

Finally, we observed that the height-to-width ratio of the symphysis was lowest in individuals with a low-angle mandibular growth pattern. A wider symphysis was associated with denser apical alveolar bone on the lingual side. Conversely, a tall and narrow symphysis suggested reduced bone support, aligning with the findings of Wehrbein et al.,[14] who noted compromised bone stability in elongated symphyses.

Although only intraobserver reliability was assessed, the methodology aligns with several prior studies in which single calibrated observers yielded consistent and reproducible measurements in CBCT-based evaluations. Zhang et al.[1] and Sadek et al.[8] have validated this approach. Nonetheless, future studies would benefit from including multiple observers to enhance the reproducibility of findings.

Study Limitations

A limitation of this study was the lack of consideration of sagittal discrepancy, as the thickness of the mandibular symphysis might vary among individuals with different mandibular growth patterns. Further research is necessary to explore this concept fully. Another limitation was the relatively small sample size. However, future studies with larger sample sizes and more diverse ethnicities are warranted to enhance generalizability. Interobserver reliability assessment was not conducted, which may limit the generalizability of the findings. However, previous CBCT-based studies have reported high intraobserver consistency when conducted by a calibrated examiner Zhang et al.[1], Sadek et al.[8], supporting the reliability of single-observer measurement in similar research contexts.

CONCLUSION

The mandibular symphysis is an appropriate site for placement of orthodontic mini-implants, particularly between the central incisors. Complete Bone Thickness and CtBW is more between two central incisors. The ideal site for implant placement is located 6-10 mm below the CEJ of the two central incisors, with an insertion angle of 0°-60°. The symphysis height-to-width ratio is lower in individuals with low-angle mandibular growth patterns than in those with average- and high-angle patterns.

Ethics

Ethics Committee Approval: This research obtained approval from the Rungta College of Dental Sciences and Research Institute Institutional Ethical Committee (approval no: RCDSR/IEC/MDS/2022/D-11, date: 29.05.2023).

Informed Consent: Consent was secured from the patients themselves or from their guardians; for those under 18 years old, additional consent was obtained from parents.

Footnotes

Author Contributions: Concept – G.A.; Design - G.A.; Data Collection and/or Processing – A.H., S.J.; Analysis and/or Interpretation – S.G., S.H.; Literature Search – H.M., P.P.; Writing – A.H., S.J.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Zhang S, Wei X, Wang L, et al. Evaluation of optimal sites for the insertion of orthodontic mini implants at mandibular symphysis region through cone-beam computed tomography. *Diagnostics (Basel)*. 2022;12(2):285. [CrossRef]
2. Arqub SA, Gandhi V, Mehta S, Palo L, Upadhyay M, Yadav S. Survival estimates and risk factors for failure of palatal and buccal mini-implants. *Angle Orthod.* 2021;91(6):756-763. [CrossRef]
3. Monnerat C, Restle L, Mucha JN. Tomographic mapping of mandibular interradicular spaces for placement of orthodontic mini-implants. *Am J Orthod Dentofacial Orthop.* 2009;135(4):428.e1-e9; discussion 428-429. [CrossRef]
4. Foosiri P, Mahatumarat K, Panmekiate S. Relationship between mandibular symphysis dimensions and mandibular anterior alveolar bone thickness as assessed with cone-beam computed tomography. *Dental Press J Orthod.* 2018;23(1):54-62. [CrossRef]
5. Handelman CS. The anterior alveolus: its importance in limiting orthodontic treatment and its influence on the occurrence of iatrogenic sequelae. *Angle Orthod.* 1996;66(2):95-109; discussion 109-110. [CrossRef]
6. Wang Y, Shi Q, Wang F. Optimal implantation site of orthodontic micro-screws in the mandibular anterior region based on CBCT. *Front Physiol.* 2021;12:630859. [CrossRef]
7. Hoang N, Nelson G, Hatcher D, Oberoi S. Evaluation of mandibular anterior alveolus in different skeletal patterns. *Prog Orthod.* 2016;17(1):22. [CrossRef]
8. Sadek MM, Sabet NE, Hassan IT. Three-dimensional mapping of cortical bone thickness in subjects with different vertical facial dimensions. *Prog Orthod.* 2016;17(1):32. [CrossRef]
9. Fayed MM, Pazera P, Katsaros C. Optimal sites for orthodontic mini-implant placement assessed by cone beam computed tomography. *Angle Orthod.* 2010;80(5):939-951. [CrossRef]
10. Villela HM, Vedovello Filho M, Valdrighi HC, Santamaria-Jr M, Menezes CC, Vedovello SAS. Evaluation of miniscrew angulation in the posterior maxilla using cone-beam computed tomographic image. *Dental Press J Orthod.* 2018;23(1):46-55. [CrossRef]
11. Vilani GN, Ruellas AC, Mattos CT, Fernandes DJ, Elias CN. Influence of cortical thickness on the stability of mini-implants with microthreads. *Braz Oral Res.* 2015;29:S1806-83242015000100220. [CrossRef]
12. Bourassa C, Hosein YK, Pollmann SI, et al. In-vitro comparison of different palatal sites for orthodontic miniscrew insertion: effect of bone quality and quantity on primary stability. *Am J Orthod Dentofacial Orthop.* 2018;154(6):809-819. [CrossRef]
13. Pan CY, Liu PH, Tseng YC, Chou ST, Wu CY, Chang HP. Effects of cortical bone thickness and trabecular bone density on primary stability of orthodontic mini-implants. *J Dent Sci.* 2019;14(4):383-388. [CrossRef]
14. Wehrbein H, Bauer W, Diedrich P. Mandibular incisors, alveolar bone, and symphysis after orthodontic treatment. A retrospective study. *Am J Orthod Dentofacial Orthop.* 1996;110(3):239-246. [CrossRef]