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# A Computed Tomographic Image Study on Thickness of the Modified Infrazygomatic Crest Site Between Patients with Class I and Class III Skeletal Pattern

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## Abstract

**Objectives:** To compare thickness of modified infrazygomatic crest (IZC) and determine an optimal area for the miniscrew insertion in modified IZCs in skeletal Class I and Class III patients.

**Methods:** Cone-beam computed tomography images of IZCs of 15 of skeletal Class I patients and 15 skeletal Class III patients were oriented using Dolphin Imaging software. Four axial slices were done at vertical levels of 5, 6, 7, and 8 mm apical to the buccal cementoenamel junction of the maxillary first molar (U6). Parameters measured were buccal cortical bone thickness, buccal plate thickness of the distobuccal root of the U6 and mesiobuccal root of the maxillary second molar, and thickness of modified IZC with different angles of insertion, 55°, 60°, 65°, and 70° to the U6 occlusal plane. Independent-sample t-tests were performed ($p<0.05$).

**Results:** Buccal cortical bone thickness in skeletal Class III patients (1.55±0.30 mm to 1.64±0.40 mm) was significantly greater than skeletal Class I patients (1.34±0.36 mm to 1.39±0.35 mm). Thickness of modified IZC in skeletal Class I and Class III patients showed no statistically significant differences. More than 6 mm of thickness of modified IZC were found at vertical levels of 5 and 6 mm in skeletal Class III patients and 5 mm in skeletal Class I patients.

**Conclusions:** Optimal areas for IZC miniscrew insertion were found at vertical levels of 5 and 6 mm in skeletal Class III patients and at vertical levels of 5 mm in skeletal Class I patients with 55°-70° insertion angles.

**Keywords:** buccal cortical bone thickness, Class I skeletal pattern, Class III skeletal pattern, miniscrew implant, modified infrazygomatic crest site

## Introduction

Currently, miniscrews are utilized widely during orthodontic treatment. In the maxilla, the infrazygomatic crest (IZC) is one of the regions selected for miniscrew placement.[1,2] It is a pillar of bony cortex running along the curvature between the alveolar bone and zygomatic process of maxilla.[3] In adults, the IZC is located above the maxillary first molar (U6). However, miniscrew placement at the IZC might injure the U6 root. As such, it is recommended that miniscrew placement be moved to the buccal bone between the distobuccal (DB) root of the U6 and the mesiobuccal (MB) root of the maxillary second molar (U7).[4] This region is called the 'modified IZC site', and is considered a safe zone for miniscrew placement in the maxilla.[4] At present, the modified IZC site has become one of the most common regions for miniscrew placement in the maxilla, due to less chance of injuring dental roots and no hindrance to tooth movement during orthodontic treatment.

In general, modified IZC miniscrews have been used as a skeletal anchorage in patients with all types of skeletal patterns in various circumstances, e.g. entire maxillary arch distalization,[4] posterior-tooth intrusion,[5] and en masse retraction.[6] For skeletal Class III malocclusion cases, miniscrews might play a crucial role in decompensation of maxillary anterior teeth prior to orthognathic surgery, maxillary posterior-tooth distalization for solving dental crowding, and posterior-tooth intrusion in patients with a flat occlusal plane to avoid double-jaw surgery.[7-10]

The stability of miniscrews is a critical factor affecting the success rate of orthodontic treatment,[11] while cortical bone thickness has a significant influence on miniscrew stability.[12,13] Studies have reported that cortical bone thickness of at least 1 mm raised the miniscrew success rate.[13] Miniscrew placement at the IZC 14-16 mm above the maxillary occlusal plane at an angle of 55°-70° to the maxillary occlusal plane has been suggested.[3] Studies have reported that there are cortical bone and buccal bone thickness at the IZC in growing unilateral cleft lip and palate patients.[14,15] Just one study has reported on the thickness of modified IZC in skeletal Class I and Class II patients[16] and another one on IZC thickness in a growing Class III patient for miniplate placement.[17] One study has reported IZC thickness in skeletal Class I, II and III patients.[18] However, buccal cortical bone thickness of IZC in skeletal Class III patients has not been reported on yet.

The aims of this study were thus to compare thickness of modified IZC and determine an optimal area for the miniscrew placement for patients with skeletal Class I and Class III. In addition, we aimed to explain the basis of thickness of modified IZC in patients with skeletal Class III.

## Materials and Methods

### Subjects and image acquisition

This retrospective study was approved by the Human Experimentation Committee, Faculty of Dentistry, Chiang Mai University (NO.76/2020). Samples consisted of 60 Cone-beam computed tomography (CBCT) images of modified IZC regions. The images were taken from Giano (NewTom, Verona, Italy) CBCT unit. Exposure factors were set at 84 kVp, 9 mA, 11×8 cm field of view, 0.15 mm voxel size, and scanning time 18 seconds. The sample was assembled from the CBCT images of 15 skeletal Class I (ANB angle = 2° ± 2°) and 15 with skeletal Class III (ANB angle < 0°) patients who met the inclusion criteria as follows: 1) the image involved the modified IZC region; 2) full eruption of permanent dentition (except for third molar); 3) no history of orthodontic treatment; 4) no severe crowding or spacing of posterior teeth; 5) no evidence of alveolar bone loss; 6) no large metal restoration; and 7) no severe craniofacial anomalies.

### Measurement of thickness of modified infrazygomatic bone

The images were oriented on all three planes before measurement, then analyzed and measured using Dolphin Imaging 11.9 (Patterson Dental Supply, Saint Paul, USA). For coronal slice orientation, the U6 occlusal plane, a plane from the MB cusp to the mesiopalatal cusp of the U6, was oriented parallel to the blue horizontal line that had been drawn automatically as a horizontal reference by the CBCT software and appeared in each coronal image slice (Figure 1A). Sagittal slice orientation, a functional occlusal plane, was oriented parallel to the blue horizontal line and the long axis of the MB root of the U6 parallel to

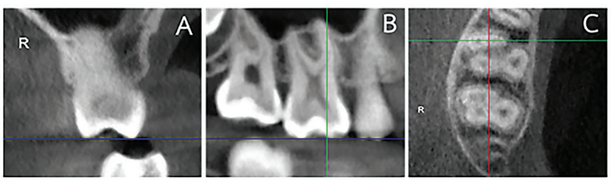


**Figure 1:** The images were orientated in three planes. (A) Coronal slice orientation. MB cusp, and MP cusp of the U6 were oriented parallel to the blue horizontal line. (B) Sagittal slice orientation. The long axis of the MB root of the U6 was oriented parallel to the green vertical line. (C) Axial slice orientation. Images were oriented to ensure that the green horizontal line was superimposed on the MB root of the U6.

a green vertical line that had been drawn automatically as a vertical reference by the CBCT software and appeared in each sagittal image slice (Figure 1B). For axial slice orientation, images were oriented to ensure that the green horizontal line was superimposed on the MB root of the U6 (Figure 1C).

Images were measured on four vertical levels of axial slice planes: 5, 6, 7, and 8 mm apical to the buccal cementoenamel junction (CEJ) of the U6. In the axial slice, the green vertical reference line was moved to bisect the interradicular distance between the DB root of the U6 and the MB root of the U7 (Figure 2A). Afterwards, parameters measured were buccal cortical bone thickness, which intersected with the green vertical line, buccal plate thickness at the DB root of the U6, and buccal plate thickness at the MB root of the U7 (Figure 2B). In the coronal slice, the thickness of modified IZC was measured from the buccal bone to the maxillary sinus wall at 55°, 60°, 65°, and 70°, to the U6 occlusal plane (Figure 2C).

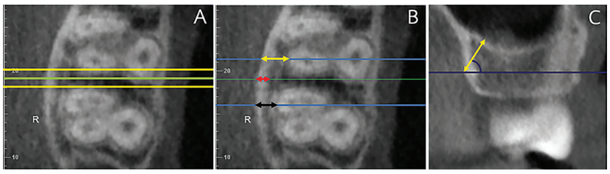


**Figure 2:** (A) The green vertical reference line was moved to bisect the interradicular distance. (B) Buccal cortical bone thickness (red arrow), buccal plate thickness at the DB root of the U6 (yellow arrow), and buccal plate thickness at the MB root of the U7 (black arrow) were measured. (C) Thickness of modified IZC was measured (yellow arrow).

### Statistical analysis

Data herein are given as means and standard deviations, and were processed using SPSS 17.0 (IBM, Armonk, NY, USA). The intraclass correlation coefficient (ICC) were used to assess intrarater reliability, the CBCT images were re-measured by the same examiner after a four-week interval. Shapiro–Wilk test was used to verify the normal distribution of the data, Levene's test to assess equality of variance, and independent-sample t-tests to test differences in means between groups. Significance was set at $p \leq 0.05$.

## Results

The data were normally distributed and showed equality in variance, with the ICC showing high intrarater reliability ($r$=0.95). There was no significant difference between thickness of the left and right modified IZC, so the left and right measurements were pooled.

### Buccal cortical bone thickness

Means and standard deviations of buccal cortical bone thickness in skeletal Class I and Class III patients ranged from 1.34±0.36 mm to 1.39±0.35 mm and 1.55±0.30 mm to 1.64±0.40 mm, respectively (Table 1). At all vertical levels, buccal cortical bone thickness in skeletal Class III patients was significantly greater than skeletal Class I patients.

### Buccal bone thickness

Means and standard deviations of buccal bone thickness of the DB root of the U6 and MB root of the U7 are shown in Table 2. Thickness at the DB root of the U6 at the 5, 6, and 7 mm levels in skeletal Class III patients were significantly greater than skeletal Class I patients, whereas no significant difference was found between groups at 8 mm. At the MB root of the U7, there was no significant difference in buccal bone thickness at any vertical level between skeletal Class I and Class III patients.

### Thickness of modified IZC

Means and standard deviations of thickness of modified IZC are shown in Table 3. Thickness in skeletal Class I and Class III patients ranged from 4.10±1.97 mm to 6.79±2.01 mm and 4.41±2.38 mm to 7.91±2.99 mm, respectively. Rostral vertical cut levels revealed thinner modified IZC. At each combination of different vertical levels and different angles, no significant difference in thickness of modified IZC between skeletal Class I and Class III patients was found.

## Discussion

This study showed that buccal cortical bone thickness at the modified IZC site in skeletal Class III patients were significantly greater than that in skeletal Class I patients, whereas there were no significant differences in thickness of modified IZCs between groups.

Primary stability of the miniscrew is the essential key to providing stationary anchorage during orthodontic

**Table 1:** Means and standard deviations of buccal cortical bone thickness

| Vertical levels (mm) | Buccal cortical bone thickness (mm) | | | | *p* |
|---|---|---|---|---|---|
| | Class I skeletal pattern | | Class III skeletal pattern | | |
| | Mean | SD | Mean | SD | |
| 5 | 1.34 | 0.36 | 1.64 | 0.40 | 0.003** |
| 6 | 1.36 | 0.47 | 1.61 | 0.40 | 0.034* |
| 7 | 1.35 | 0.37 | 1.55 | 0.30 | 0.026* |
| 8 | 1.39 | 0.35 | 1.64 | 0.30 | 0.006** |

**Table 2:** Means and standard deviations of buccal bone thickness of the DB root of the U6 and MB root of the U7

| Vertical levels (mm) | Buccal bone thickness (mm) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | DB root of first molar | | | | | MB root of second molar | | | | |
| | Class I | | Class III | | *p* | Class I | | Class III | | *p* |
| | Mean | SD | Mean | SD | | Mean | SD | Mean | SD | |
| 5 | 2.45 | 0.84 | 3.08 | 0.96 | 0.01* | 2.81 | 0.80 | 2.89 | 0.83 | 0.681 |
| 6 | 2.36 | 0.94 | 3.03 | 1.07 | 0.01* | 3.30 | 0.92 | 3.23 | 0.83 | 0.736 |
| 7 | 2.19 | 0.92 | 3.11 | 1.10 | 0.001** | 3.73 | 1.12 | 3.64 | 0.93 | 0.736 |
| 8 | 2.34 | 1.05 | 3.04 | 1.25 | 0.871 | 4.05 | 1.23 | 4.00 | 0.97 | 0.156 |

**Table 3:** Means and standard deviations of thickness of modified IZC in skeletal Class I and Class III patients

| Angle to U6 occlusal plane (°) | Vertical levels (mm) | Thickness of modified IZC (mm) | | | | |
|---|---|---|---|---|---|---|
| | | Class I | | Class III | | *p* |
| | | Mean | SD | Mean | SD | |
| 55 | 5 | 6.79 | 2.01 | 7.91 | 2.99 | 0.940 |
| | 6 | 5.86 | 2.07 | 6.9 | 2.77 | 0.127 |
| | 7 | 4.99 | 2.04 | 5.93 | 2.64 | 0.161 |
| | 8 | 4.16 | 2.01 | 5.00 | 2.49 | 0.161 |
| 60 | 5 | 6.63 | 2.11 | 7.60 | 2.73 | 0.105 |
| | 6 | 5.79 | 2.06 | 6.64 | 2.64 | 0.170 |
| | 7 | 4.87 | 2.07 | 5.76 | 2.58 | 0.178 |
| | 8 | 4.10 | 1.97 | 4.85 | 2.40 | 0.333 |
| 65 | 5 | 6.54 | 2.16 | 7.43 | 2.69 | 0.126 |
| | 6 | 5.75 | 2.04 | 6.57 | 2.57 | 0.146 |
| | 7 | 4.85 | 2.08 | 5.73 | 2.57 | 0.153 |
| | 8 | 4.26 | 2.15 | 4.60 | 2.33 | 0.644 |
| 70 | 5 | 6.50 | 2.17 | 7.39 | 2.63 | 0.156 |
| | 6 | 5.74 | 2.14 | 6.36 | 2.77 | 0.195 |
| | 7 | 5.03 | 2.16 | 5.32 | 2.7 | 0.555 |
| | 8 | 4.31 | 2.03 | 4.41 | 2.38 | 0.871 |

treatment, and this stability can be obtained from mechanical interlock between the thread of the implant and the surrounding bone.(19) Moreover, the primary stability of miniscrews is also determined by several factors, including cortical bone thickness,(13) bone density,(20) predrilling diameter,(21) and miniscrew design, e.g. miniscrew diameter(22) and length.(23)

Cortical bone thickness has been found to be a crucial factor determining the stability of miniscrews.(1,13,24) It has been generally accepted that cortical bone thickness of at least 1 mm provides greater miniscrew stability than that of <1 mm.(13) In our study, buccal cortical bone thickness in skeletal Class I and Class III patients was 1.34-1.39 mm and 1.55-1.64 mm, respectively—both >1 mm. Furthermore, buccal cortical bone thickness in skeletal Class I patients in our study was consistent with a previous study in Thai samples, which found thickness of 1.18-1.31 mm.(16) Therefore, our findings show that cortical bone thickness at the modified IZC site in Thai skeletal Class I and skeletal Class III patients provide adequate primary miniscrew stability.

It has been suggested that 1 mm of alveolar bone between the miniscrew and dental root is required for periodontal health.(2,25) Furthermore 1-2 mm of buccal bone at the penetration site is required to avoid injury to molar roots.(4,16) This implies that at least 2 mm of buccal bone at the penetration site is mandatory for miniscrew placement. In our study, although buccal bone thickness at the DB root of the U6 and MB root of the U7 at all levels (5, 6, 7, and 8 mm) were >2 mm, modified IZC miniscrews should be inserted with caution to avoid injury to dental roots, particularly at the DB root of the U6 in skeletal Class I patients due to wide range of standard deviation of measurements (2.19±0.92 to 2.45±0.84 mm).

Bone thickness at the miniscrew-placement site also refers to miniscrew biting depth. Several studies have suggested that at least 6 mm of biting depth is required for miniscrew stability.(2,3,26,27) In our study, thickness of modified IZC in skeletal Class I and III patients was 4.10-6.79 mm and 4.41-7.91, respectively. Bone thickness >6 mm was found at 5 mm apical to the CEJ in the U6 in skeletal Class I patients, and at 5 and 6 mm apical to the CEJ of the U6 in skeletal Class III patients.

Practically, miniscrew placement at the modified IZC site at 6 or 7 mm apical to the buccal CEJ of the U6 has been successfully used, although the biting depth at these levels is <6 mm. This could be due to double cortical bone plate penetration in this implant site. The modified IZC site comprises two cortical plates, the buccal cortical bone and sinus floor.(3) Regardless of the high incidence of maxillary sinus penetration after miniscrew placement (78.3%), the IZC miniscrew has been reported to have a success rate of 96.7%.(1) One study reported that <2 mm perforation at the maxillary sinus can resolve itself.(28) Limiting penetration depth to ≤1 mm has been recommended for IZC miniscrew placement. With regard to miniscrew-insertion angle, our study has revealed that a greater angle provides shallower biting depth, similar to other studies reporting that increased miniscrew-insertion angle increased the risk of maxillary sinus penetration.(29,30) More than 6 mm of thickness of modified IZC were found at 5 mm apical to the CEJ of the U6, in skeletal Class I patients and 5 and 6 mm apical to the CEJ of the U6, in skeletal Class III patients. As such, these levels are considered to provide sufficient biting depth for miniscrew placement, while 7 and 8 mm apical to the CEJ of the U6 was questionable for miniscrew placement.

In our study, the vertical skeletal pattern factor was not included in the independent variables due to the limited sample size. One study reported that patients with hyperdivergent patterns had lower cortical bone thickness than those with normodivergent and hypodivergent patterns.(31) It has been reported that a vertical skeletal pattern affects the success rate of miniscrews: a lesser Frankfort mandibular plane angle provided a greater miniscrew success rate than a greater angle.(32) Further research should focus on the effects of both sagittal and vertical skeletal patterns on bone thickness simultaneously.

## Conclusions

Cortical bone thickness in the skeletal Class III group was greater than the skeletal Class I group. Optimal areas for IZC miniscrew insertion at 55°-70° angles were found at vertical levels of 5 and 6 mm in skeletal Class III patients and at vertical levels of 5 mm in skeletal Class I patients.

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## Conflicts of interest

The authors declare no conflicts of interest.

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