**Sapporo Medical Journal**
Volume 58, Issue 12, December, 2024

# DETERMINATION OF APPROPRIATE SITE FOR ORTHODONTIC MINI IMPLANT INSERTION IN MANDIBULAR RAMUS IN TWO DIFFERENT VERTICAL SKELETAL PATTERNS:A CBCT STUDY

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**Abstract— Background:** Several treatment options have been proposed for the management of impacted molars, such as surgical extraction, transplantation, surgical uprighting, or orthodontic uprighting. **Aim:** This study aimed to compare the ramus bone thickness and depth betweentwo different vertical facial types to detect the safety length of mandibular ramus miniscrews. **Methods:** In this study ramus thickness and depth was measured by using Unidentified Cone-beam Computed Tomography scans of 40 subjects they were classified according to vertical facial type into 2 equal groups (norm divergent and hypo divergent).Ramus thickness was measured as the distance from the outer (buccal) to the inner (lingual) aspects of the mandibular ramus. Ramus depth was measured as the distance from the anterior border of the ramus to the inferior alveolar nerve canal.The measurements for ramus thickness and ramus depth were performed at 3 different levels: Occlusal plane (OP), five mm above the (5 OP) and ten mm above the occlusal plane (10 OP). **Results:** Regarding thickness: non-significant difference was found between both groups at the same level while significant difference between two different levels at the same group was recorded. Regarding depth: non significant difference was found between all groups at five mm above the occlusal plane and ten mm above the occlusal plane while significant difference was found between normodivergent group and hypodivergent group. **Conclusion:** The optimal insertion site for placement of miniscrews was considered five mm above the (5 OP) in both groups due to adequate ramus depth and thickness.

**Key words:** Site, orthodontic mini implant insertion, mandibular ramus vertical skeletal patterns

## INTRODUCTION

Orthodontic management of horizontally impacted mandibular molars is challenging because of the anchorage requirements and restricted access. Third and second molars can lead to problems such as; pericoronitis, caries, cyst formation, resorption of neighboring teeth, malocclusion related to the tipping of adjacent teeth, periodontal disease, and pain [(1-5)].

Orthodontic up righting is frequently used for impacted mandibular molars because of its benefits in saving the tooth, obtaining proper occlusion and periodontal conditions, and aiding in future

restorative adjunctive treatment. However, orthodontic uprighting of mandibular molars is challenging. As mandibular molars have wider roots than the adjacent teeth, when uprighting of mandibular molars is performed with conventional dental anchorage, it can lead to the displacement of anchor teeth [6-9].

The common orthodontic tools used for uprighting of impacted mandibular molars such as springs, elastics, push coils, etc. have certain limitations in their implementation and site of installation. Therefore, skeletal anchorage with miniscrews has become a popular option to facilitate the uprighting of mandibular molars and overcome the problems encountered with conventional mechanics. Different locations of miniscrews have been used for up righting impacted mandibular molars, such as retromolarminiscrews, buccal shelf miniscrews, interradicularminiscrews, and ramus miniscrews. Retromolarminiscrews, although found to be effective for closing spaces in the mandibular arch, are inserted in the same horizontal plane as impacted molars and thus, do not provide any biomechanical advantage[10-11].

The use of interradicularminiscrews for up righting horizontally impacted mandibular teeth have limitations related to the interference in the path of movement, damaging adjacent roots, and the high failure rate. The extra-alveolar miniscrews such as buccal shelf miniscrews are inserted lateral to the mandibular first and second molars in the mandibular buccal shelf area and thus, do not interfere with the path of tooth movement[12-14].

However, the biomechanics to correct the horizontally impacted mandibular molars with buccal shelf miniscrews is complex and difficult to control because of its location. To gain a biomechanical advantage, ramus miniscrews were introduced. Ramus miniscrews are inserted into the anterior aspect of the ramus of the mandible and thus, provide occlusal and distal direction of force for the correction of horizontal impacted mandibular molars[15].

However, the current literature lacks information regarding the best location on the anterior aspect of the ramus for the insertion of ramus miniscrews. In addition, a major concern for clinicians regarding ramus miniscrews is the risk of damaging the inferior alveolar nerve. The inferior alveolar nerve traverses through the mandibular ramus from mandibular foramen to the mental foramen. Determining a clinically safe margin for the placement of ramus miniscrews in the anterior aspect of the ramus area in different facial types remains crucial to avoid potential complications related to their placement[16].

This study aimed to compare the ramus bone thickness and depth between two different vertical facial types to detect the safety length of mandibular ramus miniscrews.

## MATERIALS AND METHODS

This retrospective study was conducted on a total 40 unidentified CBCTs scans obtained from the Department of Oral and Maxillofacial Radiology Faculty of Dentistry, Suez Canal University.All CBCTs scans were taken with same machine using SCANORA 3DX device, with setting of acquisition parameters as follows: 120 kV, 5 mA, 4- to 6-second exposure time, 17 cm width and 23 cm height of field of view with 0.3-mm slice.Each CBCT data scan were exported in digital imaging and communications in medicine (DICOM) format then processed using on demand software for examination.

**Sample Grouping and Study Procedures.**

CBCT scans of patients were divided into 2 equal groups based on the vertical skeletal pattern into Group I (Normodivergence), Group II (Hypodivergence) (20 scans in each group)

These groups were determined by the evaluation of the following linear and angular parameters on the 3D volume rendering:Frankfort mandibular plane angle (FMA) & gonial angle.

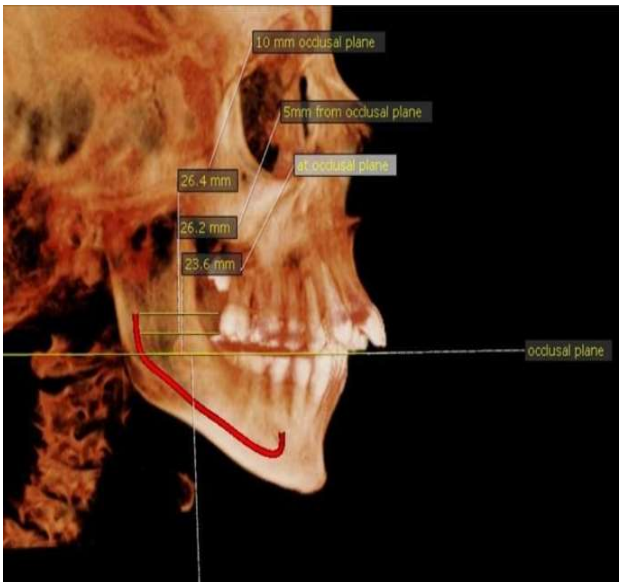
Vertical skeletal pattern was classified according to **Sassouni, 1969**[17] into:

**Group I** (Normodivergence):SN/ Mandibular plane angle (32+/- 4 degree), Y axis to Frankfort plane angle (61+/- 4 degree), Frankfort to Mandibular plane angle (25+/-3 degree), Gonial angle (124 +/-5 degree) and Cranial base angle (132 +/- 5 degree).

**Group II** (Hypodivergence):SN/ Mandibular plane angle is (< 27 degree), Y axis to Frankfort plane angle is (< 57 degree), Frankfort to Mandibular plane angle is (< 19 degree), Gonial angle is (< 119 degree) and cranial base angle is (< 127 degree).

The criteria of selection were: the radiographs should be unidentified; the radiographs should be within the age range (17 to 25 years old). Whilethe criteria of exclusion were: radiographs with craniofacial anomalies,radiographs with previous orthognathic surgery,

Ramus depth was measured as the distance from the anterior border of the ramus to the inferior alveolar nerve canal.




**Figure(1)**:Representmeasurementofframusdepthatthreedifferentlevels.

Ramus thickness was measured as the distance in mm from the outer (buccal) to the inner (lingual) aspects of the mandibular ramus in the axial view.

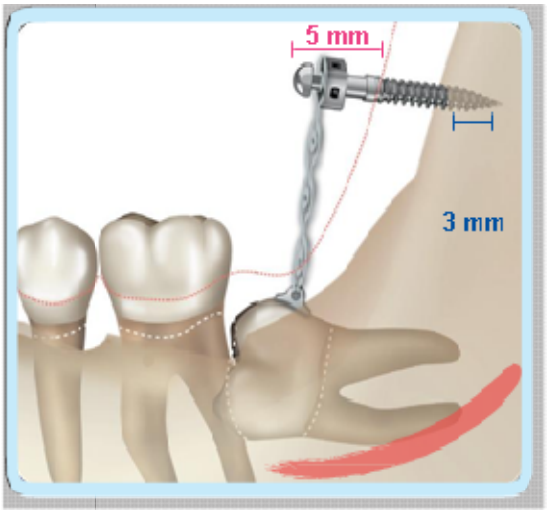
**Figure(2)**:Representmeasurementoframusthicknessatthreedifferentlevels.

The measurements for ramus thickness and ramus depth were performed at 3 different levels:Occlusal plane (OP), five mm above the occlusal plane (5 OP) and ten mm above the occlusal plane (10 OP)

**Safety length of mandibular ramus mini screws:**

According to Chang et al.,(2018), [15], the length of mandibular ramus mini screws was calculated by substracting 3 mm (safety distance away the inferior alveolar nerve ) from ramus depth (measured as the distance from the anterior border of the ramus to inferior alveolar nerve) and by adding 5 mm (soft tissue thickness covering the mandibular ramus)

**Safety length of ramus mini screws = (ramus depth -3 mm) +5 mm**




**Figure(3)**:Representthatthescrewheadisabout5mmabovethsofttissueandtheaverageboneengagementforramus screw about3mm**. Changet al .,(2018),**[15]

**Statistical analysis:**

Data analysis was performed by SPSS software, version 25 (SPSS Inc., PASW statistics for windows version 25. Chicago: SPSS Inc.). Qualitative data were described using number and percent. Quantitative data were described using mean± Standard deviation for normally distributed data after testing normality using Shapiro Wilk test. Significance of the obtained results was judged at the (0.05) level.

**Sample size calculation:**

The calculated sample size of the study was 20 participants for each group (total calculated sample size was 40) at 5% level of significance and 80 % power, using the following formula:

**$N= (Z1-\alpha/2+Z1-\beta)^2 \sigma1^* \sigma2 / \delta^2$**

**$Z1- \alpha/2 =1.96, Z1-\beta= 0.842, \sigma = SD (3.1, 2.3)$**

**$\delta$** = Expected difference to be detected between groups (1.7) based on (Mehta, et al., 2022)

**$\alpha$** = Level of acceptability of a false positive result (level of significance=0.05)

**$\beta$** = Level of acceptability of a false negative result (0.20)

**1- $\beta$** = Power (0.80)

**Ethics consideration:**

The present research will be waived from the approval of the ResearchEthics Committee (REC) of the Faculty of Dentistry, Suez Canal University since it will be conducted on unidentified 40 CBCT scansobtained from archieve of Oral Radiology Department, Faculty of Dentistry,Suez Canal University.Ethical considerations regarding patients or experimental animals are therefore not applied.

**Results:**

**1- Comparison of ramus thickness between different levels:**

Table (1) shows a statistically significant difference between different levels within same group as regard ramus thickness for group I&II ($p<0.001$ each) and within group significance done by Post Hoc Tukey test shows significant difference between each pairs. For group I ; mean (SD) ramus thickness is 12.66 ± 1.6 mm, 10.16 ± 1.26 mm and8.19 ± 1.79 mm for occlusal plane, five mm above the occlusal plane and ten mm above the occlusal plane (10 OP) respectively. For group II; mean (SD) ramus thickness is 12.04 ± 1.57 mm, 9.82 ± 1.92 mm and8.19 ± 2.37 mm for occlusal plane, five mm above the occlusal plane and ten mm above the occlusal plane (10 OP), respectively

**Table (1):** Comparison of ramus thickness between different levels:

| Thickness | Occlusal plane(OP) | Five mm above the occlusal plane (5 OP) | Ten mm above the occlusal plane (10 OP) | Test of significance |
|---|---|---|---|---|
| **Group I** | 12.66±1.60$^{AB}$ | 10.16±1.26$^{AC}$ | 8.19±1.79 $^{BC}$ | F=40.97 P<0.001* |
| **Group II** | 12.04±1.57$^{AB}$ | 9.82±1.92$^{AC}$ | 8.19±2.37$^{BC}$ | F=19.04 |

| | |
|---|---|
| | P<0.001* |

**2- Comparison of ramus thickness between two different groups:**

**Table (2)** demonstrates non statistically significant difference between studied groups as regard ramus thickness for occlusal plane, five mm above the occlusal plane, ten mm above occlusal plane. For occlusal plane; mean (SD) ramus thickness is 12.66 ± 1.6 mm and12.04 ± 1.57 mm for groups I &II respectively. For Five mm above the occlusal plane; mean (SD) ramusthickness is 10.16 ± 1.26 mmand 9.82 ± 1.92 mm for groups I& II respectively. For ten mm above the occlusal plane; mean (SD) ramus thickness is8.19 ± 1.79 mm and 8.19 ± 2.37 mm for groups I& II respectively

**Table (2):** Comparison of ramus thickness between two different groups:

| Thickness (mm) | Group I | Group II | Test of Significance |
|---|---|---|---|
| **Occlusal plane(OP)** | 12.66±1.60 | 12.04±1.57 | F=1.21<br>P=0.306 |
| **Five mm above the occlusal plane (5 OP)** | 10.16±1.26 | 9.82±1.92 | F=0.251<br>P=0.779 |
| **Ten mm above theocclusal plane (10 OP)** | 8.19±1.79 | 8.19±2.37 | F=0.423<br>P=0.657 |

F:One Way ANOVA test, parameters described as mean±SD

**3- Comparison of depth of the ramus between two different groups**

Table (3) Shows statistically significant difference between group I & IIas regard ramus depth for occlusal plane, A non-statistically significant difference is detected between studied groups at five mm above the occlusal plane and ten mm above occlusal plane levels. For occlusal plane;

mean (SD) ramus depth is 12.58 ± 1.42 mm and 14.11 ± 2.27 mm for groups I& II respectively. For Five mm above the occlusal plane; mean (SD) ramus depth is 13.45 ± 2.65 mm and 14.66 ± 2.92 mm for groups I&II respectively. For ten mm above the occlusal plane; mean (SD) ramus depth is 14.36 ± 2.26 mm and 15.42 ± 3.34 mm for groups I&II respectively

**Table (3):** Comparison of depth of the ramus between two different groups

| Depth | Group I | Group II | Test of significance |
|---|---|---|---|
| **Occlusal plane(OP)** | 12.58±1.42 $^{A}$ | 14.11±2.27$^{A}$ | F=3.58<br>P=0.034* |
| **Five mm above the occlusal plane (5 OP)** | 13.45±2.65 | 14.66±2.92 | F=1.15<br>P=0.323 |
| **Ten mm above theocclusal plane (10 OP)** | 14.36±2.29 | 15.42±3.34 | F=0.690<br>P=0.506 |

**4- Comparison of depth of the ramus between different levels**

**Table (4)** demonstrates a statistically significant difference of ramus depth between Occlusal plane and ten mm above the occlusal plane (10 OP) for group I while there is no statistically significant difference between different levels for group II . For group I ; mean (SD) ramus depth is 12.58 ± 1.42 mm, 13.45± 2.65 mm and 14.36 ± 2.29 mm for occlusal plane, five mm above the occlusal plane and ten mm above the occlusal plane (10 OP), respectively. For group II; mean (SD) ramus depth is 14.11 ± 2.27 mm, 14.66 ± 2.92 mm and 15.42 ± 3.34 mm for occlusal plane, five mm above the occlusal plane and ten mm above the occlusal plane (10 OP), respectively

**Table (4):** Comparison of depth of the ramus between different levels:

| Depth | Occlusal plane (OP) | Five mm above the occlusal plane (5 OP) | Ten mm above the occlusal plane (10 OP) | Test of significance |
|---|---|---|---|---|
| **Group I** | 12.58±1.42 [A] | 13.45±2.65 | 14.36±2.29[A] | F=4.16<br>P=0.02* |
| **Group II** | 14.11±2.27 | 14.66±2.92 | 15.42±3.34 | F=1.05<br>P=0.356 |

**Discussion**

The thickness of the bone plays a critical role in the success of miniscrews. The initial success of the miniscrews is attributed to a large extent to the primary stability. Primary stability can be influenced by the diameter of the miniscrew, the anatomic site, and bone quantity. It has been reported that the greater the diameter of the miniscrew, the better primary stability. (18)

The soft-tissue thickness of the tissues overlying the mandibular ramus can exhibit considerable variation, in most cases the soft tissue thickness covering mandibular ramus was 5 mm. (15)

CBCT scans played an essential role in predicting primary stability by detecting the amount of bone density, cortical thickness and bone depth.(19)

In this study, CBCT scans were used to measure cortical bone thickness. Because CBCT scans showed statistically insignificant mean differences with different voxel sizes, confirming that CBCT was an appropriate and reliable tool for linear measurements. (20,21)

In this study ramus thickness and depth was measured by using Unidentified Cone-beam Computed Tomography scans of 40 subjects , they were classified according to vertical facial type into 2 equal groups (norm divergent and hypo divergent).

Ramus thickness was measured as the distance from the outer (buccal) to the inner (lingual) aspects of the mandibular ramus.

Ramus depth was measured as the distance from the anterior border of the ramus to the inferior alveolar nerve canal.

The measurements for ramus thickness and ramus depth will be performed at 3 different levels: at the level of occlusal plane (OP), five mm above the occlusal plane (5 OP) and ten mm above the occlusal plane (10 OP).

Age range was determined from 17 to 25 years old in order to exclude any further growth modification in the mandibular ramus and to ensure growth cessation and full development of lower second molars.

**Analyzing the results:**

Regarding the thickness of mandibular ramus:

At occlusal plane

In this study, the results revealed that thickness in normadivergent group was (12.66±1.60).

When comparing ramus thickness between the two groups at the level of occlusal plane shown that there is no statistically significant difference between both groups.

This result was in agreement with Mehta et al., (2022), who said that there is no significant difference between both normo and hypodivergentgroups.

This result was not in agreement with Mangla et al (2011), who said that the ramus width was found to be significantly smaller in normodivergent group than hypodivergent group, this could be due to number of cbct scans, age of patient and populations type.

- At five mm above the occlusal plane:

In this study, the results revealed that thickness in normadivergent group was (10.16±1.26), while in hypodivergent was (9.82±1.92).

When comparing ramus thickness between the two groups at five mm above the occlusal plane shown that there is no statistically significant difference between both groups.

This result was in agreement with Mehta et al., (2022), who said that there is no significant difference between both groups.

This result was not in agreement with Mangla et al (2011), who said that the ramus width was found to be significantly smaller in normodivergent group than hypodivergent group, this could be due to number of CBCT scans, age of patient and populations type.

• At ten mm above the occlusal plane.

In this study, the results revealed that thickness in normadivergent group was (8.19±1.79 ), while in hypodivergent was (8.19±2.37).

When comparing ramus thickness between the two groups at ten mm above the occlusal plane shown that there is no statistically significant difference between both groups.

This result was in agreement with Mehta et al., (2022), who said that there is no significant difference between both groups.

This result was not in agreement with Mangla et al (2011), who said that the ramus width was found to be significantly smaller in normodivergent group than hypodivergent group, this could be due to number of CBCT scans, age of patient and populations type.

Comparing of ramus thickness of each group at different levels:

- Normodivergent group:

Thickness of mandibular ramus for normodivergent group in this study was measured (12.66 ± 1.60) mm at occlusal plane, (10.16 ±1.26) mm at five mm above the occlusal plane (5 op), (8.19 ± 1.79) mm at ten mm above occlusal plane (10 op).

When comparing between three different levels at same group shown that there is statistically significant difference, observing that the ramus thickness decreased on moving from occlusal plane to five mm above the occlusal plane to ten mm above the occlusal plane.

This result was in agreement with Mehta et al., (2022), regarding to an decrease in ramus thickness was observed on moving from the occlusal plane of mandibular ramus to five mm above the occlusal plane and ten mm above the occlusal plane.

- Hypodivergent group:

Thickness of mandibular ramus for hypodivergent group in this study was found (12.04 ± 1.57) mm at occlusal plane, (9.82 ± 1.92) mm at five mm above the occlusal plane (5 op), (8.19 ± 2.37) mm at ten mm above the occlusal plane (10 op).

When comparing between three different levels at same group shown that there is statistically significant difference, observing that the ramus thickness decreased on moving from occlusal plane to five mm above the occlusal plane to ten mm above the occlusal plane.

This result was in agreement with Mehta et al., (2022), regarding to an decrease in ramus thickness was observed on moving from the occlusal plane of mandibular ramus to five mm above the occlusal plane and ten mm above the occlusal plane.

Regarding the depth of mandibular ramus:

- At occlusal plane:

In this study, the results revealed that depth in normadivergent group was (12.58±1.42), while in hypodivergent was (14.11±2.27).

When comparing ramus depth between the two groups at occlusal plane there is statistically significant difference between normodivergent group and hypodivergent group.

This result was in agreement with Mangla et al., (2011) who said that the ramus height was found to be significantly smaller in normodivergent group than hypodivergent group,

This result wasnot in agreement with Navaneethan & Varghese., (2021), who said that there was no significant difference between class I and class II malocclusion for ramus heightthis could be due to number of CBCT scans, age of patient and population ethnic background.

• At five mm above the occlusal plane:

In this study, the results revealed that depth in normadivergent group was (13.45±2.65), while in hypodivergent was (14.66±2.92 ).

When comparing between the two groups at five mm above the occlusal plane shown that there is no statistically significant difference between them.

This result was in agreement with Navaneethan & Varghese (2021), who said that there was no significant difference between class I and class II malocclusion for ramus height.

This result was not in agreement with Mangla et al., (2011) who said that the ramus height was found to be significantly smaller in normodivergent group than hypodivergent group, this could be due to number of CBCT scans, age of patient and population ethnic background.

- At ten mm above the occlusal plane:

In this study, the results revealed that depth in normadivergent group was (14.36±2.29), while in hypodivergent was (15.42±3.34).

When comparing between the two groups at ten mm above the occlusal plane shown that there is no statistically significant difference between them.

This result was in agreement with Navaneethan & Varghese (2021), who said that There was no significant difference between skeletal class I and class II malocclusion for ramus height.

This result was not in agreement with Mangla et al (2011) Mehta et al. who said that The ramus height was found to be significantly smaller in normodivergentgroup than hypodivergent group, this could be due to number of CBCT scans, age of patient and population ethnic background.

Comparing of ramus depth of each group at different levels:

- Normodivergent group:

In this study depth of mandibular ramus for normodivergent group was found (12.58 ± 1.42) mm at occlusal plane, (13.45 ± 2.65) mm at five mm above occlusal plane (5 op), (14.36 ± 2.29) mm at ten mm above occlusal plane (10 op).

When comparing ramus depth between three different levels at normodivergent group there is a statistically significant difference between occlusal plane and ten mm above the occlusal plane.

This result was in agreement with Mehta et al., (2022), regarding to an increase in ramus depth was observed on moving from the OP of mandibular ramus to 5 OP and 10 OP, this indicates that at higher levels above the occlusal plane, a greater amount of space (ramus depth ) is available to insert ramus miniscrews and thus there is a reduced risk of injuring the inferior alveolar nerve.

- Hypodivergent group:

In this study depth of mandibular ramus for hypodivergent group was found ( 14.11 ±2.27) mm at occlusal plane, (14.66± 2.92) mm at five mm above the occlusal plane (5 OP), (15.42 ±3.34) mm at ten mm above the occlusal plane (10 OP).

When comparing ramus depth between three different levels at hypodivergent group there is no statistically significant difference between three different levels for hypodivergent

This result was not in agreement with Mehta et al., (2022), regarding to an increase in ramus depth was observed on moving from the OP of mandibular ramus to 5 OP and 10 OP, this could be due to number of CBCT scans, age of patient and population ethnic background.

Safety length of mandibular ramus miniscrews:

- At occlusal plane:

The safety length of mandibular ramus miniscrews should be (14.58 mm) in normodivergent group, while in hypodivergent (16.11 mm).

At five mm above the occlusal plane:Safety length of mandibular ramus miniscrews in normodivergent group was (15.45 mm), while in hyperdivergent was (16.24 mm) and in hypodivergent was (16.66 mm).

- At ten mm above the occlusal plane:

Safety length of mandibular ramus miniscrews in normodivergent group was (16.36 mm), while in hypodivergent was (17.42 mm).

This result was in agreement with Chang et al.,(2018), Lin et al., (2015), Roberts et al., (2016), who said that ramus miniscrew of 2 mm diameter and 14 mm length is the best fit for anatomic features of mandibular ramus, as the clinicians need to penetrate the thick mucosa overlying the anterior border of the ramus.

**Conclusions:**

1- The optimal insertion site for placement of miniscrews was considred five mm above the occlusal plane (5 OP) in both groups due to adequate ramus depth and thickness.

2- Ramus thickness decreased while moving from occlusal plane to 5mm above the occlusal plane to 10mm above the occlusal plane for both groups

3- Ramus depth increasedwhile moving from occlusal plane to 5mm above the occlusal plane to 10mm above the occlusal plane for normodivergent group.

4-Safetylength of mandibular ramus miniscrews at occlusal plane innormodivergentgroupshouldbe(14.58mm),whileinhypodivergent(16.11mm).

5- Safety length of mandibular ramus miniscrews at five mm above theocclusal plane in normodivergent group should be (15.45 mm), whileinhypodivergent(16.66mm).

6- While safetylength of mandibular ramus miniscrews at ten mmabove the occlusal plane in normodivergent group should be (16.36mm),whileinhypodivergent(17.42 mm).

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