

Assessment of accurate landmark for the horizontal cut in Sagittal split ramus Osteotomy: A Tomographic study

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Abstract:

Purpose of the study : This study aimed to determine the height at which both the lateral and medial cortical bone layers of mandibular ramus merge, using a reference point on the anterior margin of the mandibular ramus and comparing with lingula as another reference point, using cone beam computed tomography, thus establishing an effective method of determining the level of the horizontal cut of sagittal split osteotomy.

Material and Methods: The mandibular ramus of 15 patients were analysed on a three dimensional (3D) model constructed using Cone Beam Computed Tomography. Starting at reference point (A), a line was marked from the anterior border of the ramus of mandible till the posterior border on lateral surface. On three vertical section of the ramus (1/3rd

and 2/3rd and lingula), the level at which both lingual and buccal cortices meet were determined- A1 and A2 and L respectively.

The results of the study showed that mean height of fusion of medial and lateral cortices at 1/3rd and 2/3rd and lingula were 8.96mm, 4.62mm and 11.00mm respectively.

Conclusion: The point A is a safe and easy to locate anatomic reference point to establish the level of horizontal cut in sagittal split ramus osteotomy (SSRO).

Keywords: Orthognathic surgery, Lingula, Coronoid notch, CBCT, presurgical assessment, Inferior alveolar nerve paresthesia, Unfavourable fracture.

Introduction :

Sagittal split ramus osteotomy of the ramus (SSRO) is a widely used surgical procedure for the correction of mandibular deformities¹. The advantage of SSRO is that the surgical access to the mandible is intraoral, which doesn't produce scars on the face and lowers the risk of injury to the facial nerve. The sagittal split ramus osteotomy of the mandible has been used for over 30 years and has undergone numerous modifications and improvements. Despite of these improvements, number of complications still occurs such as paraesthesia and unfavourable fracture².

The inferior alveolar nerve is vulnerable to injury at and superior to lingula during exposure of the medial aspect of the ramus, during retraction, while performing the osteotomy and fixation.^{3,4} According to the studies published, the horizontal cut must be performed above the mandibular foramen and below the level at which medial and lateral cortices merge. They also mentioned that the lower the horizontal cut, the higher the risk of injury to inferior alveolar nerve. However, the higher the horizontal cut, higher the risk of unfavorable fracture⁵

Surgical procedures should be performed with better understanding of anatomic landmarks to minimize these complications. The knowledge of the position of fusion between the buccal and lingual cortical plates will guide the placement of horizontal medial osteotomy in sagittal split osteotomy.

The aim of this study was to determine the superior extent of trabecular bone from an anatomical landmark on the anterior border of mandibular ramus. The objectives was to determine the height at which both the lateral and medial Cortices of mandibular ramus merge, measured from lingula and coronoid notch (point 'A') so as to establish safe limits for performing the horizontal cut for sagittal split osteotomy.

Materials and method:

This Prospective descriptive study was conducted on 15 patients who had visited to the Oxford Dental College and Hospital. Patients were selected based on inclusion and exclusion criteria. Patients of both gender between 18 to 40 years were included in the study. Patients with facial Asymmetry, TMJ ankylosis, condylar fracture, cysts and tumours in the jaw were excluded in the study. The study was conducted after obtaining clearance from institutional

ethical committee. The written informed consent was obtained from all patients. Evaluation of the mandibular ramus was done using Cone beam computed tomography with Kodak 9300 3D imaging system operating at 70-80 kVp, 5-10 Ma AND 70 V.

The image data was saved in DICOM file format and reconstructed into reformatted 3D images using the CS 3D imaging software (version 4.1.2) (Figure 1). The digital imaging tools were used to determine the most posterior point on the anterior margin of mandibular ramus. It was designated as point 'A'. The horizontal plane was adjusted at the level of point A on the CBCT. A line was drawn from point A reaching the posterior margin of ramus of mandible (Figure 1). The total length of the line 'A' was measured. Two points on the line 'A' were marked at one-third and two-third of the antero-posterior ramus width as points 'A1' and 'A2' respectively (Figure 3). By moving vertical plane from point A along the horizontal plane the ramus was sectioned lengthwise at the line A1 and A2. On the cross section obtained, where the lateral and medial cortical bone layers merge on lines A1 & A2 was regarded as points M1 and M2 respectively. (Figure 4, 5)

A positive value was assigned when the merging point occurred above line 'A'. A null value was given when merging point was on the line 'A'. A negative value was assigned when merging point was below line 'A'. The distance between points A1 and M1 and distance between points A2 and M2 were measured. Another line was drawn passing through the tip of the lingula (L) from sigmoid notch to the lower border of mandible. On vertical section at this line distance from lingula (L) to fusion of buccal and lingual plates (F) were measured. (Figure 6).

Statistical analysis:

All these values were recorded, tabulated and Statistical analysis was done. The results were analysed by using SPSS version 23. Results on continuous measurements were presented in Mean \pm SD (Min-Max) and results on categorical measurements were presented in percentage (%). Significance was assessed at 5 % level of significance. Student t-test, was used to find the significance of study parameters.

Results:

The mean distance of A1 and A2 from point A were found to be 9.33 ± 0.70 and 18.74 ± 1.41 respectively. The mean height of the fusion of buccal and lateral cortical plate at cross section H1, H2 and at L were found 8.96 ± 0.79 , 4.62 ± 0.52 and 11.00 ± 1.10 respectively

The Mean \pm SD height of fusion of buccal and lateral cortical plate at cross section F and H1 was found to be 11.00 ± 1.10 and 8.96 ± 0.79 respectively. The difference between groups was found to be statically significant p value < 0.001 The Mean \pm SD height of fusion of buccal and lateral cortical plate at cross section F and H2 was found to be 4.62 ± 0.52 and 11.00 ± 1.10 respectively. The difference between groups was found to be statically significant p value < 0.001

Discussion:

SSRO is a versatile surgical procedure for the correction of mandibular deformities. This procedure offers the advantage of greater area of bone contact, which promotes good bony healing. However, surgical complications including injury to the inferior alveolar neurovascular bundle and unfavourable fracture of the ramus can occur⁸.

Schuchardt¹ modified the previously highly problematic horizontal mandibular osteotomy by introducing a technique in which a horizontal cut was made above the lingula just through the medial cortical plate and extended to the posterior border of the ramus. Obwegeser expanded on Schuchardt's technique by increasing the separation between the horizontal cuts to 25 mm. Neither Obwegeser nor Schuchardt advocated stripping of the masseter or medial pterygoid muscles. Obwegeser's procedure was the real beginning of the sagittal split osteotomy. Dal Pont's technique the lingual horizontal cut was stopped just past the lingula. Hunsuck (1968) found that it wasn't necessary to make an actual cut through to the lingual as Dal Pont had done in his connecting cut. Hunsuck's technique, like Dal Pont's, required only minimal muscle and periosteal stripping. The subsequent modifications have, generally, focused on attempts to manage or minimize intra-surgical or post-surgical problems. These problems started to be reported in the literature in the late 1960s and early 1970s. Hinds and Kent* published their book 'Surgical Treatment of Developmental Jaw Deformities' in 1972. This reference source widely distributed which served to broaden the base of interest in orthognathic surgical procedures¹.

According to the studies published, the horizontal cut must be performed above the mandibular foramen and below the level at which medial and lateral cortices merge. A Fernandes et al* stated that the horizontal cut for the sagittal split osteotomy must be performed above the mandibular foramen and below the level at which medial and lateral cortices. They also mentioned that the lower the horizontal cut, the higher the risk of injury to inferior alveolar nerve. However, the higher the horizontal cut, higher the risk of unfavorable fracture⁵.

Lingula is the main anatomical landmark for the basis of horizontal cut in SSRO because of its relationship to the IAN. It is important to note that the level at which lingula is found varies among individual and even can vary from side to side in the same person. Neurosensory disturbances have been reported to develop with the various degrees of numbness in the lower lip and mental area of 30% to 40% patients after SSRO⁷.

In 1954, Caldwell and Letterman first proposed to use 'antilingula' as the reference for the entrance of the IAN, which was defined as 'a very slight rounded prominence on the lateral surface of the ramus that can be used to identify the mandibular foramen on the mesial side. In 1976 Yates, Olson and Guralnik, in anatomical study examined 70 dried mandibles and found that only 44% of mandibles showed presence of antilingula or ramal prominences on the lateral surface. In rest of 56% of cases it was either absent or variable in relation to mandibular foramen. When performing lateral ramus surgery, the antilingula is typically used as an anatomic landmark corresponding to the location of the mandibular foramen⁸.

Tominaga et al suggested that the initial osteotomy point should be determined by their technique, using an individual point identified based on each patient's radiograph, and not based on statistical data such as the relationship of the point to the foramen. Therefore, the location of the mandibular foramen should be confirmed preoperatively by panoramic radiograph and axial CT images. Further modifications of ramus surgical technique and instrument development should make mandibular ramus osteotomy easier and safer. The authors suggest that the posterior and superior thirds of the mandibular ramus are a "safe area" to make the medial cut of the SSRO or the vertical cut of a mandibular ramus osteotomy with a low incidence of inferior alveolar nerve injury⁹.

In our study we used CBCT which has advantage over the drawbacks of conventional radiography. The main advantage is that the image produced has minimal unequal magnification and distortion and produces more reliable and accurate data. The images in this study were reconstructed 3-dimensionally using 3D CS software so that they could be sectioned at any plane and position. Several anatomic landmarks have been proposed in the literature to guide surgeons in locating and avoiding IAN during ramus osteotomy. Although, techniques such as conventional radiographs, topography and the use of human dry skull have been used to locate the IAN recent evidence suggests that CT scanning, especially the 3D variant provides the best technique for assessing the location of IAN and different important anatomical landmarks¹⁰.

The point of fusion of cortical plates in relation to different landmarks is critical in planning the medial osteotomy.

In our study we found that the mean height of fusion of lateral and medial cortices in the mandibular ramus on 1/3rd and 2/3rd on line 'A' using point A as a reference point was found to be 8.96 mm and 4.62 mm respectively whereas mean height of fusion of lateral and medial cortices taking lingula as a reference point was 11.00mm. This result coincides with the result of Smith et al. that determined the point of fusion of lateral and medial cortices relative to lingula in 49 adult Asian mandibles of unknown gender¹¹. They found the point of fusion to occur between 7.5 mm and 13.3 mm superior to the lingula. Tom et al⁵. found that the fusion of medial and lateral cortices differ between genders while using the same cross section which smith et al used in his study. Yamamoto et al.¹² reported that neurosensory disturbance occurred in all cases where there was no evident bone marrow space. According to Jones et al., 1990, the vascular supply may also be compromised if the nerve is exposed during surgical procedures. Graham et al.¹³ uses nerve hook that enables the medial cut to be made as close as possible to the lingula, maximizing the amount of medullary bone between the cortices. The nerve is also protected posterior to the nerve hook, thus minimizing potential neurological complications associated with the medial bone cut. Graham et al stated in his study that the amount of medullary bone decreases from the lingula superiorly and there is a significant chance of fused cortices as the sigmoid notch area is reached.

A condylar split is the most serious complication, which can happen when the sagittal cut is too high. Mercier⁵ found that the ramus became progressively more cortical and less medullary as one proceeded posteriorly. He felt that the medial osteotomy should be carried

to the posterior border of the mandible to take advantage of neutral zone of cancellous bone that was found frequently.

In our study, we used point A as a reference anatomical landmark for the horizontal cut in SSRO. This point is present on the anterior border of mandibular rami, so requiring minimal soft tissue dissection, thus minimizing IAN injury. Rajchel et al.⁷ stated in his article on the location of the mandibular canal and its relationship to the sagittal ramus osteotomy was the first to report specifically on the medio-lateral position of the mandibular nerve.

The incidence of severance of the inferior dental neurovascular bundle has previously been reported as about 3.5%. The mandibular surgical procedure most frequently associated with sensory alterations of the inferior alveolar nerve is sagittal osteotomy, whereas the only alterations associated with vertical osteotomy are due to excessive medial twisting of the proximal osteotomy segment (Wang and Waite, 1975).⁸ Westermark⁷ surveyed 496 SSROs and evaluated possible correlations between neurosensory dysfunction and several variables that had been implicated. They suggested that dissection of the soft tissue on the medial aspect of the mandibular ramus might be partly responsible for nerve dysfunction of the lower lip and chin. Nerve fibers can be injured by surgical manipulation, such as stretching or crushing during the operation, or by compression of the nerve bundle within the mandibular canal; nerve damage can also result from the hypoxia and edema caused by these manipulations. The type of nerve injury that results is most likely a combination of neurapraxia (bruising that damages the myelin sheath) and partial axonotmesis (nerve fibre damage caused by sectioning of the axon). Jaaskelainen et al.¹⁴ monitored the IAN during SSRO intraoperatively and noticed that the most obvious changes in sensory nerve conduction occurred during preparation of the medial side of the ramus for horizontal bone cuts when the nerve was compressed and stretched at the same time by retractors. Ylikontiola et al.¹⁵ reported that exposing the medial surface of ramus with the retractor and manipulating the IAN seemed to be one of the main factors causing neurosensory disturbance (NSD) in the IAN.

Surgeons have been encouraged to avoid the use of a single criterion and to obtain as many anatomic guide points as possible when performing mandible ramus osteotomy. The identification of the anatomic positions of the lingula, the antilingula, and the mandibular foramen, as well as a preoperative radiographic assessment, will assist the surgeon in determining safe anatomic guidelines for mandibular surgery.⁷ So, point A which is used in our study can be used as an additional landmark for the horizontal cut in SSRO.

Smith et al.¹¹ suggested that, based on consideration of fusion of lateral and medial cortices, there is no rationale to extend the medial osteotomy to the posterior border because the incidence of fusion of the cortices increases posterior to lingula, increasing the potential for an unfavourable fracture. Instead the study result supported the work of Dal Pont, Hunsuck, Epker and Jonsson, who all suggested extending the medial osteotomy only as far posteriorly as the lingual fossa.

Several reports suggested that the medial horizontal osteotomy should be 'just above the mandibular lingula', and should be extended as far back as possible from the tips of the mandibular lingula. The average length of the line was 18 mm⁵.

In this survey of a young Taiwanese population, the mean horizontal distance from mandibular foramen to anterior border of ramus was 18.6mm, which was greater than the suggested 18 mm¹.

In attempt to find safer approach for the horizontal cut in SSRO which requires minimal lingual soft tissue dissection and reflection comparing to lingula, we found a anatomic landmark 'point A', the most posterior point on the anterior border of mandible.

Sectioning the mandibular ramus lengthwise vertically at 1/3rd and 2/3rd in the CBCT on the line "A" using "point A" as a landmark as , we found that the mean heights at which medial and lingual cortices merge was 10.33mm and 4.3mm. whereas as lingula as a reference point, the height of cortical merge was found 11.0mm. We found that the result found in our study were similar to those reported in the previous study.

We also found that the lingula (L) was always below the line A which makes point A, a safe landmark for the horizontal cut in SSRO and regarding injuries to the neurovascular bundle entering the mandibular foramen which requires minimal lingual soft tissue dissection/reflection.

Conclusion:

To conclude the study, we believe that the point "A" should be used as a reference anatomical landmark for the horizontal cut in SSRO. This landmark is easy to find, considering the exposure of anterior border of mandibular ramus which requires minimal lingual soft tissue dissection for horizontal cut in SSRO, thus minimizing IAN injuries. Point 'A' can also be used as a reference for finding the mandibular foramen and determining the height of horizontal cut in SSRO. Point 'A' appears to be convenient anatomic landmark that makes surgical access safer with less risk of IAN injury. SSRO horizontal cut should not be performed more than 4mm above point A.

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Table 1: Mean ± SD distance from point A to 1/3rd (A1) and 2/3rd (A2)

	N	Mean	Std. Deviation	Minimum	Maximum
A1	15	9.3733	.70758	8.00	10.30
A2	15	18.7467	1.41516	16.00	20.60

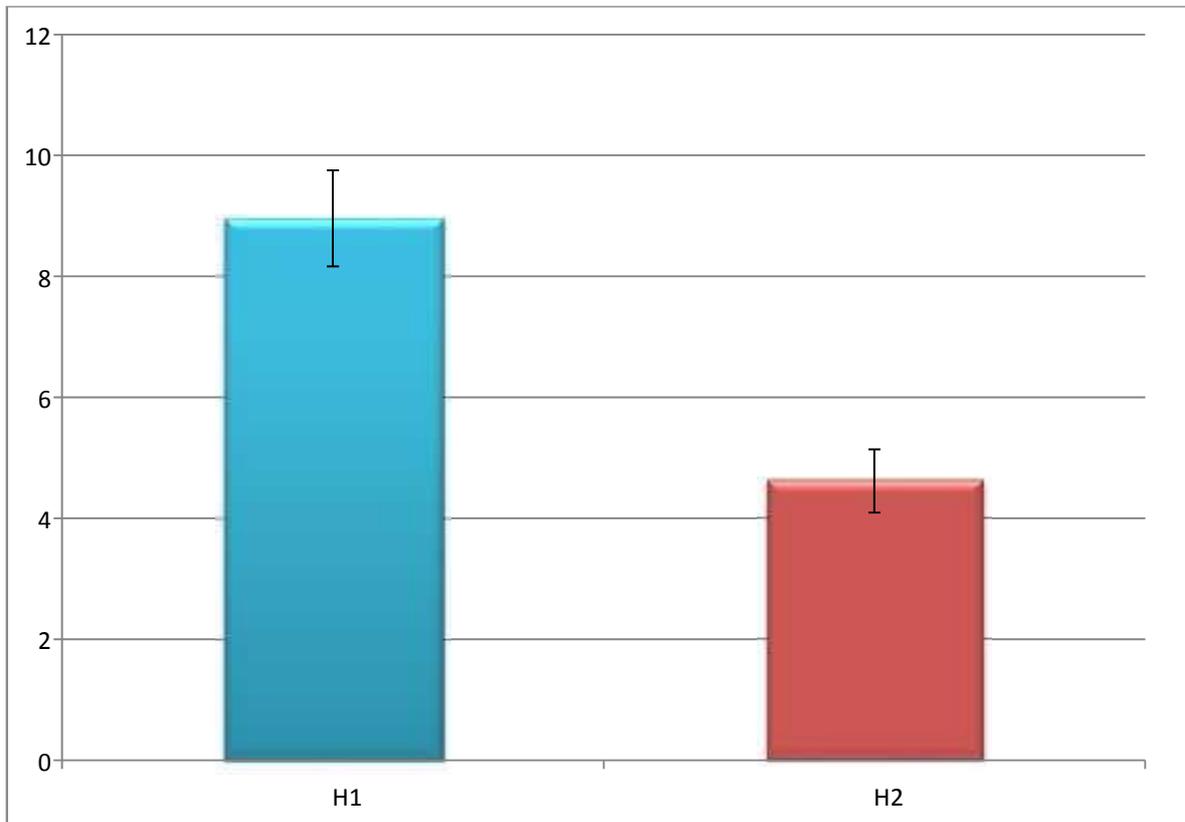
According to table.1, the mean distance of A1 and A2 from point A were found to be 9.33 ± 0.70 and 18.74 ± 1.41 respectively.

Table 2: Mean \pm SD height at which buccal and lateral cortical plates merge

	N	Mean	Std. Deviation	Minimum	Maximum
H1	15	8.9600	.79355	7.50	10.10
H2	15	4.6200	.52400	3.60	5.50
F	15	11.0067	1.10354	9.50	12.90

According to table.2, The mean height of the fusion of buccal and lateral cortical plate at cross section H1, H2 and at L were found 8.96 ± 0.79 , 4.62 ± 0.52 and 11.00 ± 1.10 respectively.

Graph 1: Mean height at which buccal and lateral cortical plates merge at H1&H2



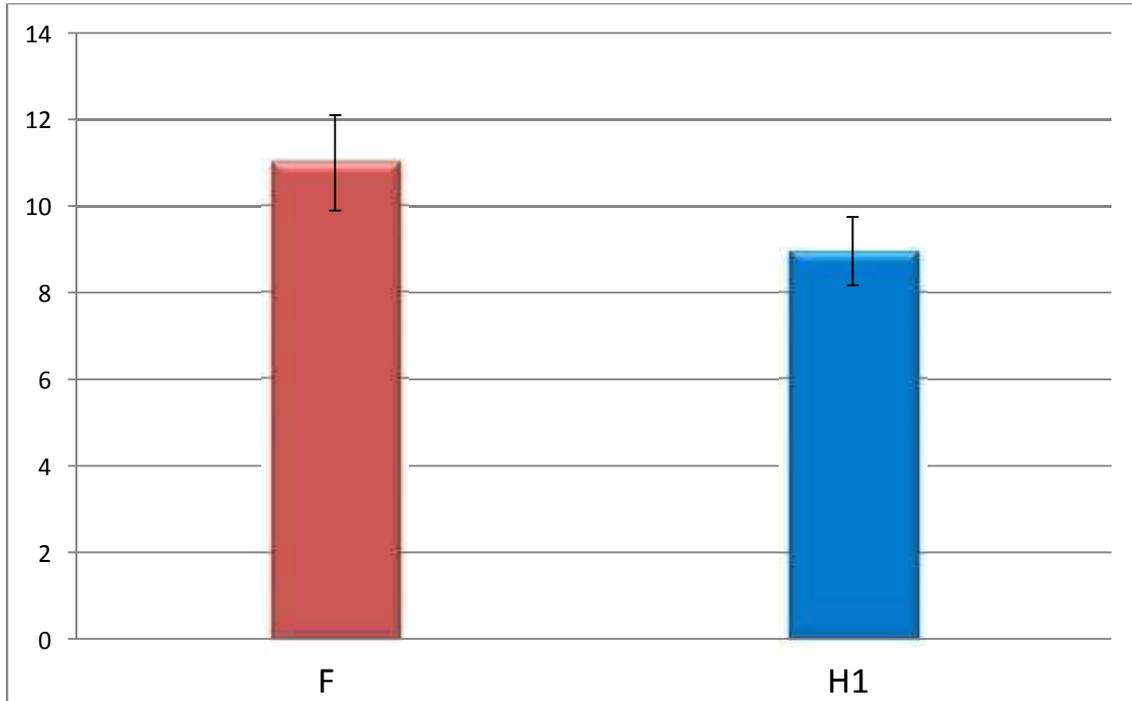
STUDENT T-Test

Table 3: Mean \pm SD height of fusion of buccal and lateral cortical plate at cross section F and H1.

	NUMBER	MEAN	STD. DEVIATION
F	15	11	1.10

H1	15	8.96	.79
t = 5.83 p value < 0.001			

Graph 2: Mean ± SD height of fusion of buccal and lateral cortical plate at cross section F and H1.

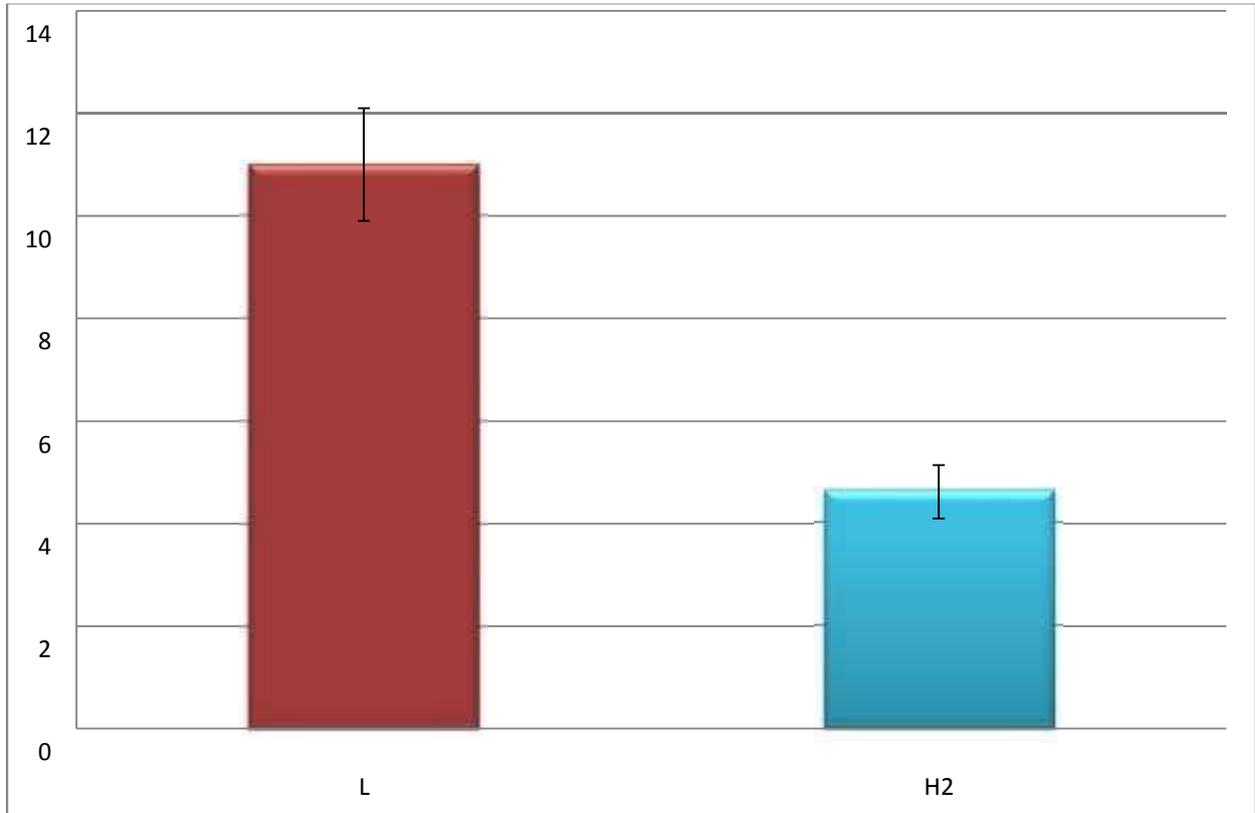


According to table 3 and graph 2, The Mean ± SD height of fusion of buccal and lateral cortical plate at cross section F and H1 was found to be 11.00 ± 1.10 and 8.96 ± 0.79 respectively. The difference between groups was found to be statistically significant i.e p value < 0.001

Table 4: Mean ± SD height of fusion of buccal and lateral cortical plate at cross section F and H2.

	NUMBER	MEAN	STD. DEVIATION
F	15	11	1.1
H2	15	4.62	.52
t = 20.24 p value < 0.001			

Graph 3: Mean \pm SD height of fusion of buccal and lateral cortical plate at cross section F and H2.



According to table 4 and graph 3, The Mean \pm SD height of fusion of buccal and lateral cortical plate at cross section F and H1 was found to be 4.62 ± 0.52 and 11.00 ± 1.10 respectively

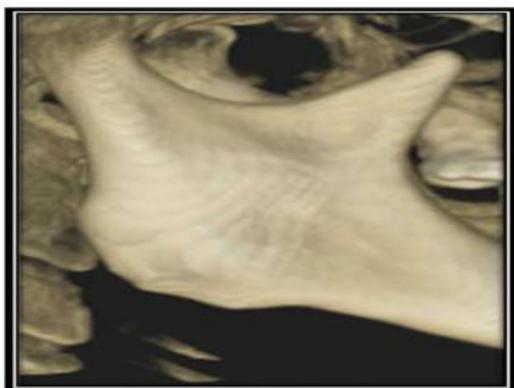


Figure1. CBCT of mandible.

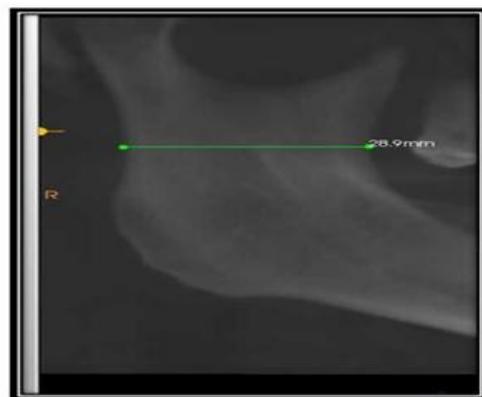


Figure 2. Point A and line A marking

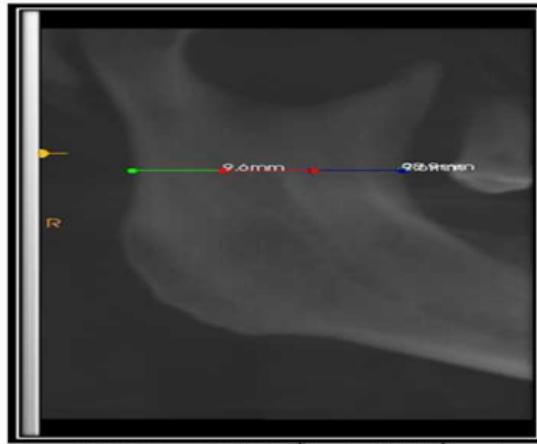


Figure 3. Marking of A1(1/3rd) and A2(2/3rd) on line A

