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Original Research Article

Cross sectional analysis of mandibular anthropometric points using CBCT to derive biometric measurements for a safer approach to mandible osteotomies

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Abstract – Purpose: This study aims to derive a series of biometric measurements using cone-beam computed tomography (CBCT) from a cross sectional group of population to help the surgeon accurately locate the mandibular foramen and the mental foramen during mandibular osteotomies. **Methods:** CBCT images of 800 subjects were evaluated. Various measurements were noted and compared between the two sides of the mandible in and between the sexes. **Result:** Statistically significant values were noted between the right and left sides of Line X to Point A in female subjects, Line Z & Line B only in male subjects and Line X′ in both male and female subjects . However, Line Y was found to be significant when comparing both sides in both males and females and also on correlation between the genders. **Conclusion:** Although the identification of the mandibular lingula and anatomical landmarks is an important step during mandibular osteotomies, the position of one side, however, cannot be blindly extrapolated to the contra lateral side. Also, pre operative CBCT is a useful tool to derive measurements which when transferred clinically during the surgery gives an accurate and safe approach for localisation of lingula, thus reducing the incidence of post operative neurologic morbidities.

Introduction

The bilateral sagittal split ramus osteotomy (BSSRO) and genioplasty are versatile orthognathic procedures for treating mandibular deformities. BSSRO was first introduced in 1942 [1] and osseous genioplasty was introduced in 1957 by Richard Trauner and Hugo Obwegeser through an intraoral approach [2]. Over the years they have been refined and modified to give predictable results. Despite its versatility and numerous advantages, postsurgical neurosensory disturbances are common [3–6], because it is performed in close proximity to the inferior alveolar nerve (IAN) and its branches. IAN injury during surgery largely results from manipulation of the nerve or structures surrounding the nerve or from direct injury to the nerve during the procedure. Reports have suggested neurosensory deficits in the lower lip and mental region in 30–40% of patients after surgery [7,8]. This can potentially affect patient's quality of life due to adverse effects on speech, eating and drinking, leading to psychological and social issues.

Therefore a comprehensive understanding of anthropometric landmarks on the mandible and its clinical application is essential to minimize IAN damage. Computer assisted surgery technology has been employed in several surgical fields such as neurosurgery, endoscopy, arthroscopy and bone surgery [9–11]. Reducing the risk of damage to anatomical structures such as nerves, vessels and neighbouring structures is one of the desired outcomes of preoperative computer aided planning [9–12]. Computed Tomography (CT) or Cone Beam CT (CBCT) have been used as tools for surgical guidance by transferring preoperative planning based on volumetric patient data to the intraoperative site [9–12]. Accurate intraoperative verification of the position of the lingula with subsequent location of the mandibular foramen anatomical landmarks is an important step to not only determine the first osteotomy cut but if done accurately will lead to reduced incidences of neurosensory deficits post operatively.

This study aims to determine a safe approach for mandibular osteotomies by locating the approximate position of the mandibular foramen and mental foreman in a group of population after correlating a series of anthropometric measurements using CBCT. It also does a comparative evaluation of these measurements and position between the two sides of the mandible and the genders.

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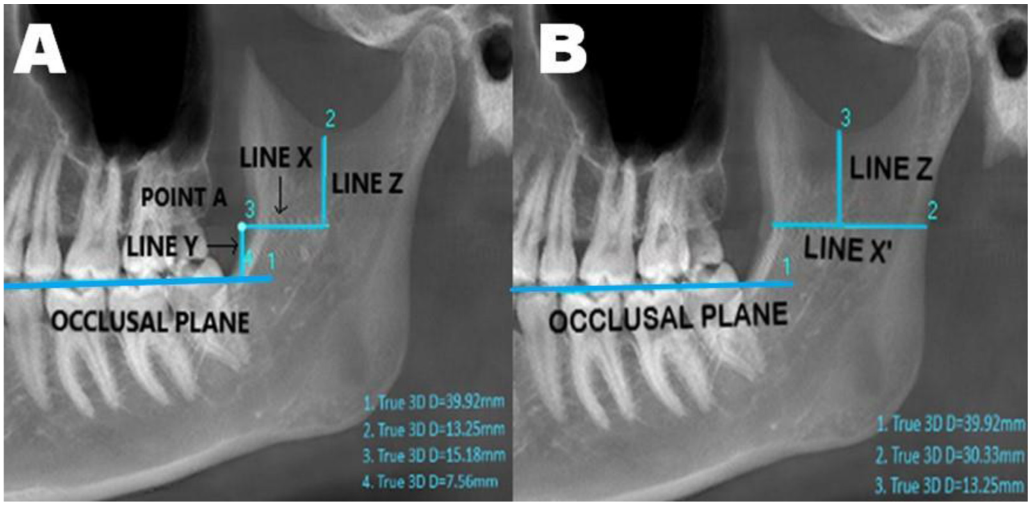

Fig. 1. Diagrammatic representation of measurements on ramal surface of mandible (A) Showing Line X, Y, Z and Point A, (B) Showing Line X′ and Line Z.

Materials and methods

A random selection of routine cone beam computed tomography (CBCT) made on 800 patients in whom 440 (55%) were males and 360 (45%) females in the age group of 13 years to 42 years from a group of urban population belonging to the same ethnicity were considered in this study. The study protocol was reviewed by the institutional review board (IRB) and given ethical clearance certificate (NO. DDYPDCH/SS-PG-Oral Surg.-Ethical/491-A/of 2014), in compliance with the Helsinki Declaration and a detailed informed consent from each subject was also obtained.

The inclusion criteria were absence of pathology, trauma and the presence of a clinically acceptable occlusion with stable mandibular position and temporomandibular joint.

All the CBCTs were taken by the same trained personnel during 2016–2019 from the same CT machine (Carestream Health Inc. Rochester, New York 5100) & DICOM software was used to analyse the images with constant settings. Manufacturer's instructions regarding the positioning and placement were followed. Calibration of the linear measurements had been performed using known dimensions in millimetres. Panoramic CBCT images and cross sectional images of mandible were reconstructed & evaluated by three blinded observers to reduce the bias.

Using the axial, coronal and sagittal sections, various designated points were identified and linear measurements were made in cross sections. Using 200 microns thick sections, the various distances were measured.

The following variables were marked and measured for every subject by three blinded observers and mean values were taken (Figs. 1a, 1b, 2, 3):
(1) Line Z – Distance from superior most point on mandibular lingula to the deepest point on sigmoid notch. (2) Line X – Distance of a perpendicular dropped from the mid-point of mandibular foramen roof along with line Z to the anterior border of ramus (Point A – landmark at anterior border of ramus designated by line X perpendicular from line Z). (3) Line X– Width of the ramus of the mandible at the level of mandibular foramen roof. (4) Line Y – Distance from point A to mandibular occlusal plane. (5) Line A – Distance from the roof of the mandibular canal to the buccal cortex in the First molar region. (6) Line A′ – Cross-sectional thickness of the mandible at this level. (7) Line B – Distance from foramen roof to root apices of first & second premolars.

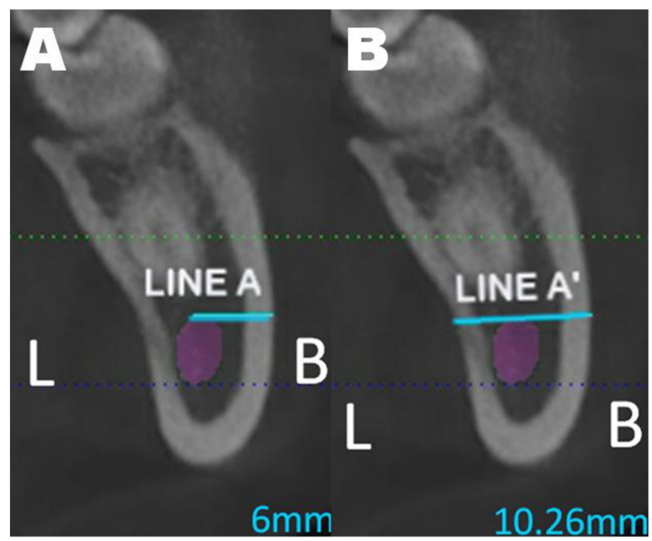

Fig. 2. Diagrammatic representation of measurements on cross-section of mandible at first mandibular molar region (Coronal section). (A) Showing Line A, (B) Line A′.

All the data was entered and analysed using package SPSS, version 16.0. Descriptive statistics of the variables and measurements were procured.

Fig. 3. Diagrammatic representation of measurements on cross-section of mandible (Sagittal section in median plane).

Table I. Descriptive statistics.

	N	Minimum	Maximum	Mean	Std. Deviation
Sex	800	1	2	1.45	0.498
Line X Right	800	11.6	24.0	17.987	2.8205
Line X′ Right	800	24.6	38.0	30.609	3.0191
Line Y Right	800	1.1	16.0	6.276	3.9254
Line Z Right	800	6.8	20.4	12.467	3.0652
Line A Right	800	2.6	8.8	6.309	1.2442
Line A′ Right	800	7.5	16.0	11.492	2.3853
Line B Right	800	1.0	5.5	2.924	1.3810
Line X Left	800	11.3	23.8	17.942	2.7490
Line X′ Left	800	24.4	39.0	30.794	3.1835
Left Y Left	800	1.2	16.3	6.489	3.9270
Line Z Left	800	0.5	20.1	12.139	3.3828
Line A Left	800	2.2	8.7	6.313	1.2240
Line A′ Left	800	7.7	16.2	11.532	2.4085
Line B Left	800	1.0	5.9	2.978	1.4285
Valid N (list wise)	800				

Results

A total of 800 subjects were considered for this study. 440 (55%) were males and 360 (45%) were females with the mean age of the subjects being 21 years. CBCT of these subjects were systematically evaluated using anthropometric measurements. These measurements were analysed to reach a clinical conclusion. The results are as follows:

The mean and standard deviation of each of the seven variables of both left and right side was calculated (Tabs. I and II).

In order to find co-relation between the variables, Pearson's co-relation test was used to analyse the different parameters. *P*-value of less than 0.05 was considered significant. There was no statistically significant difference noted in the right and the left side measurements. There was a positive co-relation between the right and left side, significant at 99% confidence interval (*P*-value 0.01).

The co-relation of gender with the variables was also done.

In order to find co-relation between the variables, Pearson's co-relation test was used to analyse the different parameters. *P*-value of less than 0.05 is considered significant.

Table II. Genderwise distribution of mean, standard deviation and *P* value.

	Male		Female		
	Mean	Std. Deviation	Mean	Std. Deviation	*P* value
Line X Right	17.66512	2.874592	18.34054	2.749592	0.286778
Line X′ Right	30.48372	2.934842	30.72432	3.151226	0.726249
Line Y Right	5.37907	3.715127	7.42973	3.976449	0.020354
Line Z Right	12.99302	3.083087	11.92973	3.013752	0.123653
Line A Right	6.462791	1.327192	5.071429	1.145519	0.189388
Line A′ Right	11.49767	2.476604	11.31351	2.533022	0.853655
Line B Right	3.055814	1.403618	2.913514	1.622783	0.372274
Line X Left	17.65349	2.759602	17.87838	3.689334	0.335135
Line X′ Left	30.70465	3.099843	30.52432	4.025157	0.825026
Left Y Left	5.569767	3.755538	8.181081	5.313078	0.017692
Line Z Left	12.82791	3.088406	11.28919	3.56883	0.070777
Line A Left	6.453488	1.262716	6.4	1.946221	0.228238
Line A′ Left	11.52326	2.504076	11.37297	2.539865	0.903509
Line B Left	3.155814	1.46276	2.918919	1.65862	0.231948

**P*-value of less than 0.05 was considered significant.

Table III. Sidewise and gender wise comparasion showing *P* value.

P value		Female	Male
Line X Right	Line X Left	0.049985	0.793662
Line X′ Right	Line X′ Left	0.025007	0.000556
Line Y Right	Left Y Left	0.007258	0.007422
Line Z Right	Line Z Left	0.094761	0.010276
Line A Right	Line A Left	0.583024	0.810228
Line A′ Right	Line A′ Left	0.227878	0.558737
Line B Right	Line B Left	0.891932	0.015899

* *P*-value of less than 0.05 was considered significant.

Line Y was found to be significant when comparing both sides in both males and females and also on correlation between the genders (Tabs. II and III).

Statistically significant value was noted for Line X only for right & left side of female subjects and Line X′ only for right & left side of both male and female subjects . Line Z & Line B were statistically significant only for right and left side of male subjects (Tabs. II and III).

Discussion

An attempt was made to derive a series of biometric measurements using the CBCT from a cross sectional group of population to help the surgeon accurately locate the position of various anatomical landmarks for osteotomies like the mandibular foramen from the anterior border of ramus intraoperatively during the BSSRO procedure and mental foreman during genioplasty, thus minimizing the risk of iatrogenic injury to the inferior alveolar nerve and vessels during the medial ramus osteotomy. These measurements will also help the surgeon to plan the osteotomy cuts in a manner which will ensure least post operative morbidities.

Many anthropometric studies have been done previously but very few of them derived the landmarks point A and line Y which we hope gives a safer and accurate measurement for the localisation of lingula during medial ramal osteotomy in BSSRO.

Cross-sectional images provided by the CBCT are three dimensionally more accurate. Although, CBCT studies have drawbacks with the amount of radiation exposure and high expenses [13], accurate measurements can be taken from such modalities with precise three dimensional details [14].

Many studies have stated that antilingula also can be used as reference point for ramus osteotomies; however, it is controversial as the antilingula has no scientific basis for medial ramus osteotomies [15,16]. The accurate identification of the lingula, is a reliable & useful anatomical landmark for medial horizontal ramus osteotomy & results in fewer complications [17].

Medial horizontal ramus osteotomy is always performed above the mandibular foramen. A lower osteotomy results in high risk of injury to inferior alveolar nerve whereas higher osteotomy may result in unfavourable split and cause complications [18].

To reduce such complications, accurate identification of the lingula is considered the main anatomic landmark for medial horizontal ramus osteotomy as its relationship to inferior alveolar nerve favours less complications [19,20].

It is important to however note; that, the level of lingula varies in individuals & it even varies in the same subject from side to side. Thus, although identification of lingula is important, the surgeon cannot collate the position to the contra-lateral side without causing an injury to inferior alveolar nerve [19,21].

Mean of our findings (in mm) with clinical significance included Line X – 17.9 mm (±2.82), Line X′ – 30.6 mm (±3.01), Line Y – 6.2 mm (±3.92) for the lingula, line Z – 12.2 mm (±3.06) for the sigmoid notch and Line A – 6.3 mm (±1.24), Line A′ – 11.5 mm (±2.38), Line B – 2.9 mm (±1.38) for the mental foramen.

Gender and sidewise means of Line Y and Line X, can be clinically applied during the osteotomy as an aid for positioning the lingula during BSSRO. Line X′ determines width of mandible at level of lingula and Line Z determines vertical dimension from sigmoid notch to lingula. Both these biometric measurements can be helpful in Vertical Ramus Oteotomies. Biometric means of Lines A, A′ and B can be helpful in BSSRO during the anterior osteotomy and fixation devices and in genioplasties to plan the osteotomy cut.

Monnazzi *et al.* [17] did a cadaveric study in which forty-four (88 sides) dry mandibles were evaluated and they concluded mean values for Line X-16.50 mm (±2.32), Line Y-14.63 mm (±2.13) and Line Z-16.38 mm (±2.59) which is similar to our findings of Line X & Line X′ (Line X + Line Y). However, Line Z of our study shows a mean of 12.2 mm (±3.06) which is significantly less.

Chenna *et al.* [22] also did a cadaveric study on 50 (100 sides) dry human mandibles and they concluded; mean values for Line X-16.37 mm (±2.32), Line Z-15.00 mm (±2.78) and LineY-15.36 mm (±2.18) which are similar to our mean findings of Line X, Line Z, Line X′ (Line X + Line Z). However, the Line Z mean of our study is significantly less.

Lima *et al.* [23] did a study on 30 dry human mandibles and they concluded mean values for ML-SM-16.47 mm (±1.98) and ML-AM-19.32 mm (±3.75), which is similar in context and measurement to our Line Z and Line X respectively. However our Line X′ with mean value of 30.6 mm (±3.01) which corresponds to their ML-AM (19.32 mm ± 3.75) + ML-PM (15.79 mm ± 2.08) with a total mean value of (35.11 mm ± 2.91) was significantly lower.

Akcay *et al.* [24] did a study on 60 subjects divided into 2 groups of skeletal Class1 and Class3 with 30 subjects in each group and 120 sites evaluated with measurements done using CBCT and all values measured from mandibular lingual (ML). They found mean values of ML-AR –11.63 mm (±1.67), ML-MN-18.21 mm (±2.81), ML-OP-9.01 mm (±3.17) similar to our Line X, Line Z, Line Y respectively. Also, our Line X′-30.6 mm (±3.01) corresponds to their ML-PR-16.18 mm (±1.76) + ML-AR-11.63 mm (±1.67) with similar values.

Zhao *et al.* [25] did a study using CBCT on 407 patients and found mean values for, LA –17.02 mm, *h* –5.52 mm which were similar in context and measurement to our Line X and Line Y respectively. However, our Line X′-30.6 mm (±3.01) which corresponded to their LA+LP (17.04 mm) which yielded a mean value of 34.06 mm which was much lower. Also, Line Z of our study shows a mean of 12.2 mm (±3.06), which was significantly less when compared to their LN-16.8 mm.

The differences in the mean in various studies may be partly attributed to the sample size variation, which was lesser when compared to our study, the different methodology used and to the different demography of population used in studies.

Balaji *et al.* [26] did a CBCT study with a sample of 20 patients and found mean value for Line F-10.16 mm (±0.89) (outer cortex to outer cortex width along the centre of mandibular canal in first molar region) which is similar to line A′-11.5 mm (±2.38) (Cross-sectional of the mandible at roof of the mandibular canal in first molar region) of our study. Also, Line A-6.3 mm (±1.24) (distance of the roof of the mandibular canal from the buccal cortex in the First molar region) of our study is similar in measurement to the line C+D –5.4 mm (±0.57) (line C- inner cortex to outer IAN on buccal side, line D – distance between outer and inner buccal cortex) of their study.

Ozturk A *et al.* [27] did a CBCT study on 52 adult skulls and found a mean horizontal thickness of mandible at first molar region as 10.91 mm to 11.08 mm from mesial to distal and mean horizontal thickness of mandible from mandibular canal to buccal surface at first molar region as 4.47 mm to 5.35 mm from mesial to distal. This corresponds to Line A′ and Line A respectively, of our study, which showed similar mean values.

Lee *et al.* [28] evaluated 58 facial CT scans and found the mean value of the horizontal length between the inferior alveolar canal and the buccal cortical bone as 5.9–6.8 mm and mandibular thickness at the same level with a mean value of 10.7 mm to 12 mm. Line A′ and Line A respectively of our study have also shown similar mean values.

H A-M *et al.* [29] evaluated 302 CBCT scans of patients and calculated the distance of mental foramen from adjacent root apex (2nd Premolar). They concluded that it was $<$1 mm in 17.05%, 1–3 mm in 38.74%, 3.1–5 mm in 29.8%, $>$5 mm in 14.4% of the population. He found mental foreman located 1–3 mm below premolar apex in maximum population. Whereas our mean of Line B – 2.9 mm (±1.38) similar to his study.

Zhang *et al.* [30] did study on 172 patients using CBCT and found vertical relationship of both the premolar apices with mental foremen, with first premolar the distance was 2.79 mm (±1.77) and with second premolar, it was 2.48 mm (±1.80). The mean of Line B- 2.9 mm (±1.38) similar to his study.

Our study shows significant variation in Line Y when co-relation of genders was done whereas all other lines were insignificant. Thus, Line Y measurement in one gender cannot be blindly extrapolated to the other gender.

Mean of Line Y, which has been rarely described in literature previously, can be a useful measurement intraoperatively to derive the Point A which lies in the same horizontal plane as the mandibular foramen. Thus, point A can be used as reference to accurately determine position of medial horizontal ramus osteotomy.

Conclusion

To conclude, although the identification of the mandibular lingula is an important step during mandibular ramus surgeries, the position of one side, however, cannot be blindly extrapolated to the contra lateral side. Preoperative CBCT evaluation using the landmarks and measurements described in this study and their subsequent application intraoperatively along with the biometric mean measurements derived from this study will undeniably aid the surgeon in performing an uneventful procedure with least postoperative morbidity.

Authors contribution

Y. Kini: Conceptualization, Methodology. C. Girotra: Conceptualization, Methodology. M. Padhye: Conceptualization, Methodology. G. Tomar: Writing original draft, Investigation. M. Kankaria: Visualization, Investigation. S. Nebhnani: Visualization, Investigation. A. Maini: Writing- Reviewing and Editing. S. Meswani: Writing- Reviewing and Editing.

Conflict of interests

The authors declare that there is no conflict of interest.

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Ethical approval

Ethical clearance given by Dr. D.Y. Patil Dental College & Hospital – NO.DDYPDCH/SS-PG-Oral Surg.-Ethical/491-A/of 2014.

Patient consent

Patient's consents were obtained.

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