Original Article

Morphometric analysis of prognathic and non-prognathic mandibles in relation to BSSO sites using CBCT

Tengku Aszraf Tengku Shaeran^{a,*}, Ramizu Shaari^a, Shafulizan Abdul Rahman^a,
 Mohammad Khursheed Alam^b, Alauddin Muhamad Husin^c

^a Department of Oral & Maxillofacial Surgery, Hospital University Sains Malaysia, Malaysia

^b Department of Orthodontic, Hospital University Sains Malaysia, Malaysia

^c Department of Oral & Maxillofacial Surgery, Hospital Raja Perempuan Zainab II, Malaysia

ARTICLE INFO

Article history:

Received 12 August 2016

Accepted 12 October 2016

Available online 19 October 2016

Keywords:

Inferior alveolar nerve canal (IAN)

BSSO

CBCT

Prognathic mandibles

ABSTRACT

Background: Bilateral sagittal split osteotomy (BSSO) is the most versatile procedure and adopted by many surgeons to relocate the mandible in patients having mandibular prognathism (MP). Injury to the inferior alveolar nerve (IAN) and unfavorable splits are two surgical complications of BSSO which are associated with mandibular morphology. Uses of cone beam computed tomography (CBCT) in providing 3-D images has gained a wider acceptance in surgical field nowadays. Its advantages are including reduced cost, lesser radiation dose and smaller physical footprint comparing to the conventional computed tomography.

Purpose: This study aims to identify the differences in morphology of prognathic and non-prognathic mandible at BSSO sites using cone beam computed tomography images.

Methods: This retrospective study involved 51 CBCT images of patients having mandibular prognathism and without mandibular prognathism. The latter group made up from patients with Class I skeletal pattern. Samples were taken using purposive sampling method from two clinical centers.

Result: Prognathic mandible has higher lingula level, superiorly and buccally placed inferior alveolar nerve canal at distal second molar, thinner mediolateral width of ramus at anterior and posterior part and thinner anteroposterior width of the ramus.

Conclusion: Morphology of mandible in patients with mandibular prognathism (MP) was significantly different from patients without mandibular prognathism (WMP) for most of the parameters. The high risk parameters may be highlighted to the patients using cone beam computed tomography images.

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1. Introduction

Surgical repositioning of jaw in patients with prognathic mandible has two main aims; to place the upper and lower jaws in a relationship with good occlusal function as well as to bring about a more harmonious skeletal profile.

Bilateral sagittal split osteotomy (BSSO) is a commonly used method in correcting lower third facial deformities. There are three osteotomy sites in BSSO. The first cut is made through the lingual cortex superior to the mandibular foramen parallel to the occlusion. The second corticotomy is made through the buccal cortex in a vertical direction at the level of the first or second molar.

The third corticotomy is made along the external oblique ridge, connecting the first two osteotomy lines. The prepared bone is then split into proximal and distal segments before it is fixed into the desired position.

Injury to the inferior alveolar nerve (IAN) and unfavorable splits are two surgical complications of BSSO which are associated with mandibular morphology. As the name of the procedure implies, sagittal splitting of the mandible involves intrusion into the nerve locality. Amount of cancellous bone and mediolateral width of the surgical sites are factors contributing to these circumstances.

Patients with mandibular prognathism have thinner mediolateral mandible compared to retrognathics.^{1,2} Since a narrow width between mandibular canal and buccal cortex was found to cause the greatest risk of nerve damage,³ the risk is thus, higher in patients with mandibular prognathism. Besides, mandibles which are too narrow and have small mandibular height were also

* Corresponding author. Present address: Oral & Maxillofacial Surgery Department, Hospital Kuala Lumpur, Jalan Pahang, 50586 Kuala Lumpur, Malaysia.

E-mail address: farza_sha@yahoo.com (T.A. Tengku Shaeran).

identified as two factors contributed to the impediment of the sagittal split osteotomy.⁴

Routinely, orthopantomogram (OPG) is taken as part of the pre-operative evaluation of the mandibular structures. It is however, proven to be problematic when measuring anatomy of the bone due to the image being in two-dimensional view. In addition, there is presence of magnifications obviating precise measurements. Conventional computed tomography (CT) might be used in certain orthognathic cases such as when overall assessment of the facial skeleton is required or when the surgeons need a three dimensional images of the bone which is going to be osteotomized. However, CT imaging is not convenient enough to be used routinely due to its higher cost and higher radiation exposure.

We need to evaluate morphological differences between patients with mandibular prognathism (MP) and patients without prognathic mandible (WMP) in regards to all osteotomy sites in bilateral sagittal split osteotomy using CBCT. It has never been explored in detail using CBCT in any study before. Previous morphological studies carried out using either cadaveric mandibles or utilizing CT imaging on real patients. We need to highlight the differences, if any and perhaps we can advocate the CBCT usage in managing patients for orthognathic surgery.

2. Methods

2.1. Population sample

This retrospective study involved 51 patients from Oral and Maxillofacial Surgery Department Hospital Universiti Sains Malaysia and Hospital Raja Perempuan Zainab II. We used purposive sampling method with 17 of them having Class III skeletal pattern and 34 patients having Class I skeletal pattern. For the study group, their CBCT images had been requested prior to their orthognathic surgery, whereas, for the control group, images were taken as part of investigations for variety other reasons such as midfacial fractures and third molar surgery. Inclusion criteria were; the CBCT images must include at least condylar neck until middle of mandibular body, presence of mandibular second molar and patients in the age range of 18–35 years old at the time of radiographic investigation. Images with any pathology or traumatic injury at the area of interest were excluded from the study. CBCT images of patients with syndromes and cleft palate were also excluded.

2.2. Data collection procedure

Methods for CBCT measurements were outlined in Figs. 1–3. Mandibular morphology between patients with mandibular prognathism and without mandibular prognathism were measured and compared in the following:

- 1) The distance from buccal aspect of inferior alveolar nerve canal (IANC) to the outer buccal cortical plates at distal of second mandibular molar.
- 2) The distance from superior part of the inferior alveolar nerve canal (IANC) to the alveolar crest at distal of second mandibular molar.
- 3) The height of lingula measured from alveolar crest at distal of second mandibular molar.
- 4) The distance from lingula to the anterior border of ramus.
- 5) The distance from anterior border of ramus to posterior border of ramus at 4 mm above the lingula level.
- 6) Thickness of anterior third, middle third and posterior third of mandibular ramus at 4 mm above the lingula level.
- 7) Thickness of anterior and posterior cortical plate at 4 mm above the lingula level.
- 8) Marrow width of ramus at 4 mm above the lingula level.

Fig. 1. Measurement for study objectives no. 1 and 2. The coronal view was adjusted to be at distal 2nd mandibular molar. The distance from buccal of IANC to outer buccal cortical plates and the distance from superior part of IANC to the superior alveolar crest at distal of 2nd mandibular molar were then measured. We took measurements for both right and left side and its mean was calculated. The units were taken as millimeter as what has been set by the manufacturer of the machine.

Fig. 2. Measurement for study objectives no. 3, 4 and 5. The yellow line indicating lingula site to alveolar crest first marked at the coronal slice. The blue line is the axial line which can be moved freely. This blue line is then placed at the tip of the yellow line. At distal of 2nd mandibular molar, lingula height from the alveolar crest was measured up to the blue line. From lingula, the distance to the anterior border of ramus is made, and distance from anterior to posterior border of ramus 4 mm above the lingula level were measured. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

2.3. Statistical analysis

The analyses carried out using IBM SPSS Statistic Version 20. Confidence interval was set at 95% with probability level of 0.05 to be statistically significant. We used the Mann Whitney test to determine significant differences between mandibular prognathism (MP) and without mandibular prognathism (WMP). This test was used as the two independent variables are not normally distributed and the sample size of the study is small. Descriptive analysis was also done to obtain overall characteristics of the variables for both study groups.

2.4. Ethics

The study was approved by the Human Ethics Committee USM [Reference no: USM/JEPeM/274.4 (1.8)] and Malaysian Medical Research and Ethics Committee (NMRR-14-180-19532).

Fig. 3. Measurement for study objective no. 6, 7. Note that the blue line is not moved from the previous measurement. The yellow dot indicates the most protuberant site of lingula. All measurements were taken at 4 mm above lingula level for mediolateral width, lingual and buccal cortical thickness. (a) At anterior part of ramus. (b) Middle part of ramus. (c) Posterior part of ramus. Marrow widths at anterior and posterior part of ramus were obtained by subtracting the sum of cortical thickness from the ramus width. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

3. Results

A total of 51 patients evaluated, with 30 of them are females and more than half were from Malay ethnicity. Most of the measurements taken had shown that there are significant differences between mandibular prognathism and without mandibular prognathism. Two of them had p -values < 0.001 . These highly statistically significant differences are from measurements of the distances from superior part of IANC to the alveolar crest at distal of 2nd mandibular molar and also from lingula to the anterior border of ramus. There are only three measurements which had p -values > 0.05 . These were; mediolateral width of ramus at the middle part, thickness of the ramus cortex at posterior buccal plate and marrow width of ramus at anterior ramus region. Figs. 4 and 5 highlighted the differences between the two study groups. Tables 1 and 2 provide the details.

4. Discussion

The patients involved in the study were between 18 to 35 years old, with mean age of 24.8 (SD 4.8) years. It is very important for study to have similarity between studied age and the age at which patients commonly undergo surgical correction of dentofacial deformities as the results of the study will be inferred precisely to the target population.² These young adults usually become more concern about their facial esthetics including occlusal and jaw function. Because jaw growth had ceased or about to be completed, most surgeries will be undertaken within these age range.

Regarding gender, females made up the majority of prognathic cases who had seek treatment for jaw repositioning surgery at our center. It should be emphasize that, as a matter of fact; both males and females are concerned about facial esthetics. Nevertheless, they perceived it differently. Males judged negatively if they had a

Fig. 4. Coronal view at distal second mandibular molar. The inferior alveolar nerve canals (IANC) were more buccally and superiorly placed in patients with mandibular prognathism (a) comparing to the control group (b).

Fig. 5. Sagittal view of half mandible in patients from both groups. Patients with mandibular prognathism (a) showed a higher lingula level measured from alveolar crest at distal 2nd mandibular molar while the anteroposterior distance of mandibular ramus from lingula and the distance from lingula to anterior border of ramus were shorter in contrast to those in control group (b).

Table 1

Distribution of patients in both study groups according to their ethnicity. Majority of patients in the subject group as well as those in the control group were of Malay ethnicity and only 7 patients were of Chinese descent. There was no other ethnicity involved.

Skeletal pattern		Mandibular prognathism (MP)	Without mandibular prognathism (WMP)	Total
Race	Malay	13	31	44
	Chinese	4	3	7
Total		17	34	51

Table 2

CBCT evaluation of mandibular morphology. There are significant differences between patients with mandibular prognathism and without mandibular prognathism in most of the measurements.

Median (IQR)				
Variables		Mandibular prognathism (MP)	Without mandibular prognathism (WMP)	p value
1.	Distance from buccal of IANC to outer buccal cortical plates at distal of 2nd mandibular molar (mm).	5.12 (2.88)	6.74 (1.90)	0.008**
2.	Distance from superior part of IANC to the alveolar crest at distal of 2nd mandibular molar (mm).	11.36 (2.72)	13.88 (2.44)	<0.001***
3.	Heights of lingula from the alveolar crest at distal of 2nd mandibular molar (mm).	18.87 (4.7)	15.62 (4.33)	0.011*
4.	Distance from lingula to the anterior border of ramus (mm).	12.48 (2.16)	15.00 (2.61)	<0.001***
5.	Distance from anterior border of ramus to the posterior border of ramus 4 mm above the lingula level (mm).	29.28 (4.48)	30.90 (4.85)	0.007**
6.	Mediolateral width of ramus (4 mm above the lingula level)			
	- Anterior	6.40 (2.48)	8.00 (1.90)	0.004*
	- Middle	6.88 (1.52)	7.50 (2.08)	0.298
	- Posterior	5.28 (1.30)	6.58 (1.21)	0.001**
7.	Thickness of ramus cortex (4 mm above the lingula level)			
	- Anterior buccal plate	2.40 (0.76)	2.80 (1.05)	0.003*
	- Anterior lingual plate	2.56 (0.66)	3.00 (0.80)	0.006*
	- Posterior buccal plate	2.24 (0.44)	2.20 (0.72)	0.795
	- Posterior lingual plate	1.76 (0.60)	2.20 (0.77)	0.017*
8.	Marrow width of ramus (4 mm above the lingula level)			
	- Anterior	1.60 (2.34)	1.42 (1.03)	0.749
	- Posterior	0.96 (1.68)	1.80 (1.60)	0.048*

Mann-Whitney test.

* $p < 0.05$.

** $p < 0.01$.

*** $p < 0.001$.

class II skeletal pattern, in contrast to females who judged class III skeletal pattern as non-esthetically pleasing.^{5,6} Males with class III skeletal pattern considered their prominent lower jaw as strong-looking facial character and manly. Hence, they do not frequently seek for surgical correction, comparing to the females who have similar facial profile. This difference in perception might contribute to the larger number of females than males in our study of prognathic mandibles.

4.1. MP has more buccally and superiorly placed inferior alveolar nerve canal than WMP

In bilateral sagittal split osteotomy (BSSO), it is recommended that surgeons should perform the lateral vertical osteotomy in the first and second molar regions⁷ or in the retromolar region because at these places, the nerve bundles are lingually located and the length of nerve exposure

during splitting can be reduced, minimizing the risk of nerve injury.^{8,9}

Prognathic mandibles in our study showed, these distances were 5.12 mm (2.88) and 11.36 mm (2.72), respectively, both of which are statistically significant. MP patients had a more buccally and superiorly placed IAN compared with the WMP patients at the area of the distal second mandibular molar. Surgeons must recognize the relevance of these measurements while performing the vertical osteotomy and splitting at this site.

Relevance:

- The second corticotomy or vertical osteotomy should go no deeper than 4 mm into the medullary bone and for splitting, osteotome cannot be tapped straight downward deeper than 10 mm. Rather, the osteotome must be kept just inside the buccal cortex and moves downward to the buccal side.
- As for fixation, if bicortical plate is chosen, the safe area considered for its placement is within 10 mm from the alveolar crest.

4.2. MP has higher lingula level and shorter distance from anterior border of ramus than WMP

Lingula is a tongue-shaped projection on the medial aspect of the ramus which was said to be a reliable and useful landmark in performing the medial ramus osteotomy because of its close association with the mandibular foramen.¹⁰ This foramen is situated inferiorly and posteriorly to the greatest prominence of the lingula. Patients with mandibular prognathism in our study had a higher average lingula level, 18.87 mm (SD 4.7), than patients without mandibular prognathism, 15.62 mm (SD 4.33) ($p < 0.05$). They are also differed from the control group in terms of the distance from lingula to the anterior border of the ramus, in which their distances was shorter; 12.48 mm (SD 2.16).

Relevance:

- Some surgeons prefer to perform the medial horizontal osteotomy when they have positively identified the lingula by reducing the convexity of the internal oblique ridge using a large trimming bur. For some other surgeons, the medial cortex is exposed inferiorly using periosteal elevator until it reached a resistance of soft tissue, preventing them to strip further inferiorly. In this latter technique, our result suggests that we can potentially risk inferior alveolar nerve if we stripped the medial tissue too inferiorly, beyond the range of 14–22 mm from alveolar crest.
- Inferior alveolar nerve blocking may not work if anesthesia is given at a lower level, as is done in patients with a normal mandible. At the same time, great care must be given when delivering the injection because the distance from anterior border of the ramus is shorter. If the needle is inserted too far inside the tissue, there is a risk of injuring the nerve.

4.3. MP has smaller and thinner ramus than WMP

Our measurement of anteroposterior width was significantly smaller in patients with MP than patients without prognathism. They were 30.90 mm (4.85) for WMP and 29.28 mm (4.48) for MP. Mediolateral width of ramus had revealed that both group of patients had thinner ramus when moving anterior to posterior part. Similarly to our results, the thinner mandibular ramus in the prognathic group had also been observed by several other authors.^{1,2,11,12}

Relevance:

- Thin mandibular ramus had been associated with higher risk of unfavorable splits and IAN damage.^{12–14} Surgeons need to highlight this point in their pre-operative discussion with patients.

4.4. Marrow width

The existence of adequate cancellous bone will favor a good fracture. Marrow width between mandibular canal and inner buccal cortical bone of 0.8 mm or less were said to likely develop neurosensory disturbance post-operatively.¹⁵ A study done by Ma and Lu¹⁶ had found out that the percentage of prognathic mandible having marrow space of less than or equal to 0.8 mm is higher than the percentage of mandible without prognathism; 30% versus 7.5%. Considering these findings, patients with MP are at higher risk of getting unfavorable splits and also IAN injury.

Relevance:

- Medial osteotomy has been advocated to be done at most 4.0 mm above the lingula and extend posteriorly 6.0–8.0 mm because the presence of considerably thick cancellous bone.^{13,17–20} Patients of both MP and WMP in our study had more than 0.8 mm marrow width, with measurements taken at 4.0 mm above the lingula level.

5. Study limitations

This study had been carried out in a pool of both male and female patients. Unequal distribution in regards to gender and ethnicity are perhaps due to the nature of surgery which preferably chosen by female gender comparing to males and the locality of the study which comprised more of the Malay population.

6. Conclusion

Morphology of mandible in patients with mandibular prognathism (MP) was significantly different from patients without mandibular prognathism (WMP) for most of the parameters. The high risk parameters may be highlighted to the patients using cone beam computed tomography images.

Conflict of interest

The authors have none to declare.

Acknowledgements

Thanks to Mr. Johari Yap Abdullah, Dr. Enny Esdayanty Abdul Manab and Dr. Azlan Jaafar for assisting in acquisition and interpreting of data, Mr. Firdaus Daud who has provided the radiological images and technical input, staffs at Digital Laboratory and Dental Clinic of both study centers. Also to Ministry of Health of Malaysia who had given permission for this study to be carried out in their facilities.

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