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ORIGINAL ARTICLE

Imaging study on relationship between the location of lingula and the Gonial angle in a Chinese population

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Abstract

Purpose The purpose of this study was to investigate the Gonial angle in relation to the position of the lingula using computerized image analysis to guide the oral surgeons to prevent injury to the inferior alveolar nerve and peripheral blood vessels during surgery.

Methods We measured Gonial angle sizes of bilateral rami and the distances from the lingula tip to the mandibular notch (LN), the anterior (LA) and posterior (LP) margin of the mandibular ramus, the mandibular base (LB) and the occlusive plane (*h*) in 407 Chinese adults with CBCT.

Results In males, the mean distance of LN was 17.64 mm in the low Gonial angle group while 16.76 mm in the high Gonial angle group, which was significantly different between two groups ($P < 0.001$). The distance of LA in LGA group was obviously longer than that in HGA group ($P < 0.001$). The mean distance LP of men was 17.94 mm in LGA group while 16.9 mm in HGA group ($P < 0.001$). In females, the mean distance of LB in LGA group was 33.32 mm and 32.37 mm in HGA group ($P < 0.01$).

Conclusion We discovered that the segment of the mandibular branch, between the mandibular lingula and the mandibular angle, was obviously smaller in the HGA group than that in the LGA group.

Keywords Lingula · Gonial angle · Cone-beam computed tomography · Mandibular ramus · Mandibular plane angle

Introduction

The lingula of mandible is a sharp tongue-shaped bony projection on the medial side of mandibular ramus [5]. The attached sphenomandibular ligament plays an important role in protecting the nerve and blood vessels during mandibular movements and preventing overstretching of the mandible during rapid open mouth movements. Many anatomical studies on mandibular branches presented that the localization of the lingula were highly variable [12, 15].

The lingula, located in the anterior superior part of the mandibular foramen (MF) where the buccal, lingual and inferior alveolar nerve (IAN) pass through, is a surgical landmark to search MF [22]. Due to its close approximation to MF and IAN, researches on the location of lingula can provide some reference for clinicians' operations, such as sagittal split ramus osteotomy (SSRO), intraoral vertical ramus osteotomy (IVRO) [16], IAN block anesthesia [20] and so on. Damage to IAN may result in numbness or altered sensation of the chin and lower lip area, which can potentially affect patients' speech, eating, and drinking [2]. The local IAN block anesthetic failure is partly due to the wrong location of the lingula [10]. Evaluation of the lingula position distribution among different patients is of great significance for effective IAN anesthesia in clinical practices [22].

In this study, we divided the Gonial angle (GA) into high Gonial angle (HGA) and low Gonial angle (LGA) according to the size of the mandibular plane angle [3]. Then, we measured the distance from the lingula to surrounding landmarks of the mandibular ramus using cone-beam computed tomography (CBCT). Based on these observations, we could

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identify if there was any significant variation in the location of the lingula among patients with different Gonial angle sizes and genders. In this way, we can estimate the correct location of the lingula before surgery according to patient's gender and his mandibular angle size to protect the IAN and peripheral blood vessels during surgery.

Methods

We studied 407 patients' mandibular CBCT images including 201 males and 206 females from January 2015 to January 2017 for oral clinical diagnosis. IRB of Affiliated Stomatological Hospital of Nanjing Medical University approved this study and all participants had been informed that their CBCT would be used in this study. All study samples were collected according to the following inclusion criteria: absence of any pathologic lesions in the posterior mandible; without obvious facial asymmetric deformity; good quality of the CBCT mandibular images; absence of severe atrophy of the lower jaw; the occlusive plane could be obtained easily; patients with known sex and their age ranging from 25 to 35 years old. All CBCT examinations were carried out by a professional dental technologist following a standardized protocol, using the same machine (New-Tom VG 10048S; QR srl Inc., Verona, Italy), with uniform parameter settings (110 kVp). All the mandibular CBCT images were analyzed with NNT 4.6.0.0 software in the Department of Radiology, Affiliated Stomatological Hospital of Nanjing Medical University.

We measured the distances from the tip of the lingula to different mandibular ramus landmarks (Fig. 1). LN represented the distance from the lingula to the lowest point of the sigmoid notch. The shortest distance from the lingula to

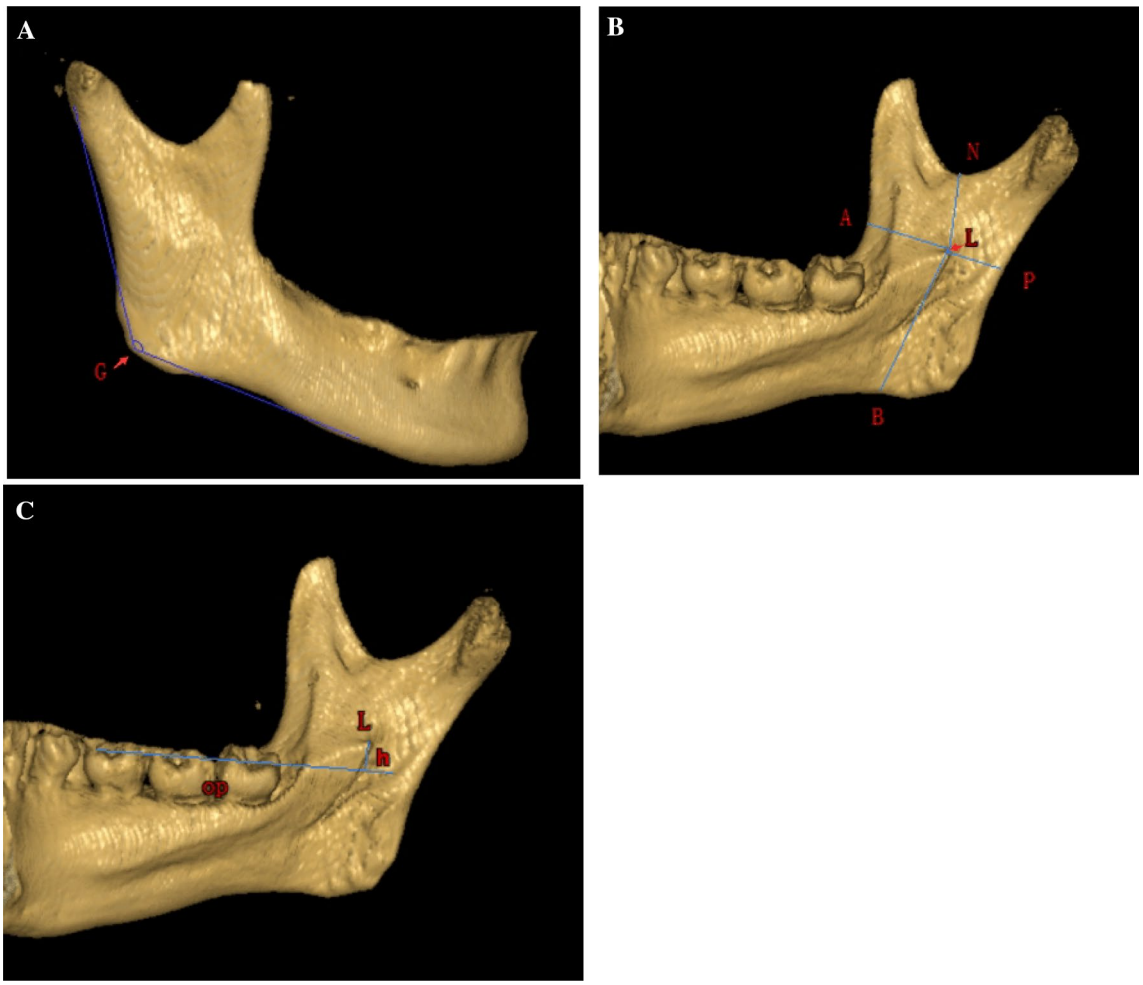

Fig. 1 Three-dimensional CBCT images of the internal and external surface of the mandible for positioning the lingula spot from different landmarks. **a** Location of the Gonion (G) and outline of the Gonial angle. **b** Location of the highest spot of lingula (L) and outline the distance from the lingula tip to various mandibular ramus landmarks: the lowest spot of the sigmoid notch (N); spots which makes the shortest distance from the anterior and posterior border of mandibular ramus to the lingula tip (A, P); spot makes the shortest distance from the mandibular base to the lingula spot (**b**). **c** The vertical distance from the lingula tip to the occlusal plane of mandibular molars (op)

the anterior and posterior border of the mandibular ramus was designated as LA and LP. The shortest distance from the mandibular base to the lingula was designated as LB. The vertical distance from the lingula to the occlusive plane of mandibular molars was defined as "h" which indicated the height of the lingula [16]. Therefore, measurements were denoted as LN, LA, LP and LB that represented the superior, anterior, posterior, and inferior distances. In addition, GA indicated the Gonial angle and GA were divided into HGA and LGA group with 125° as the demarcation standard. HGA indicated that the angle size was bigger than 125°, adversely, LGA represented that the angle size was smaller than 125° [3, 13].

We used the average of two repeated measurements from two different operators in accordance to a standardized protocol to analysis the values. If two repeated values showed difference over 1-mm then a third operator measured again for a lower difference between two values. We also did the concordance analysis between two operators. All obtained data were tabulated and analyzed using the Statistical Package for Social Science, version 16.0 (SPSS Inc, Chicago, Ill, USA). The statistical significance was considered as $P<0.05$.

Results

The study showed difference in size of the GA between men and women that the average mandibular plane angle of males and females were 125.17° and 127.22° ($P<0.01$).

Distances from the lingula to various mandibular ramus landmarks and the occlusal plane are revealed in Tables 1 and 2. Men had larger LN in LGA group than that in HGA group with the mean distances of 17.64 mm and 16.76 mm ($P<0.001$). LA of males differed significantly between LGA group (17.63 mm) and HGA group (16.53 mm) ($P<0.001$). However, LN and LA in females reported no statistical mean difference between two groups.

LP and LB in LGA group presented larger than those in HGA group. The mean value of LB in LGA group of men was 36.86 mm and 34.74 mm in HGA group that presented a statistically significant difference ($P<0.001$). In females, the difference also showed that the mean value of LP was 17.05 mm in LGA group and 16.42 mm in HGA group ($P<0.01$). However, the distance "*h*" did not present an obvious difference between two GA groups.

In Table 2, LN, LP and LB in males were larger than those in females. In addition, the mean distance "*h*" of

Table 1 Distance of lingula from various mandibular ramus landmarks of 407 patients and their comparison between HGA group and LGA group (*$P<0.05$, **$P<0.01$, ***$P<0.001$)

Gender	Gonial angle	Number	Minimum	Maximum	Mean	*P* value
LN (mm)						
Male	HGA	218	10.6	22.17	16.76	<0.001***
	LGA	184	12.05	31.61	17.64	
Female	HGA	270	8.4	36.71	16.22	0.182
	LGA	142	10.47	24.28	16.6	
LA (mm)						
Male	HGA	218	11.31	22.93	16.53	<0.001***
	LGA	184	11.38	23.71	17.63	
Female	HGA	270	9.52	22.21	16.77	0.055
	LGA	142	12.2	22.28	17.18	
LP (mm)						
Male	HGA	218	11.03	22.14	16.9	<0.001***
	LGA	184	10.82	23.83	17.94	
Female	HGA	270	10.73	22.22	16.42	0.006**
	LGA	142	11.13	27.9	17.05	
LB (mm)						
Male	HGA	218	25.86	48.46	34.74	<0.001***
	LGA	184	27.95	46.56	36.86	
Female	HGA	270	21.07	43.04	32.37	0.005**
	LGA	142	25.59	41.58	33.32	
h (mm)						
Male	HGA	218	−5.88	13.46	5.97	0.793
	LGA	184	−4.46	15.69	5.88	
Female	HGA	270	−5.55	15.58	5.03	0.583
	LGA	142	−5.88	15.6	5.21	

Table 2 Distance of lingula from various mandibular ramus landmarks of 407 patients and their comparison between males and females (*$P<0.05$, **$P<0.01$, ***$P<0.001$)

Gonial angle	Gender	Number	Mean	*P* value
LN (mm)				
HGA	Male	218	16.76	0.014*
	Female	270	16.22	
LGA	Male	184	17.64	0.001***
	Female	142	16.6	
LA (mm)				
HGA	Male	218	16.53	0.236
	Female	270	16.77	
LGA	Male	184	17.63	0.074
	Female	142	17.18	
LP (mm)				
HGA	Male	218	16.9	0.006**
	Female	270	16.42	
LGA	Male	184	17.94	< 0.001***
	Female	142	17.05	
LB (mm)				
HGA	Male	218	34.74	< 0.001***
	Female	270	32.37	
LGA	Male	184	36.86	< 0.001***
	Female	142	33.32	
h (mm)				
HGA	Male	218	5.97	0.001***
	Female	270	5.03	
LGA	Male	184	5.88	0.049*
	Female	142	5.21	

males also was larger than that in females. In HGA group, the mean value of "*h*" was 5.97 mm in males and 5.03 mm in females ($P<0.001$). In LGA group, the mean value of "*h*" was 5.88 mm in males and 5.21 mm in females ($P<0.05$).

Discussion

In previous studies, there have been numerous studies on the size of the GA in different ethnic groups. After measuring 60 panoramic radiographs, Pirgousis et al. [14] reported that the mean GA of German was 123.6° in females and 123.43° in males with no significant difference between genders. However, our study showed that the mean GA of Chinese men was 125.17°and that of women was 127.22° ($P<0.001$), which presented that Chinese females' GA size was statistically larger than that of males. In other studies, Bhardwaj et al. [4] obtained higher values in Indian females (122.10° ± 6.04°) than in males (117.66° ± 6.54°). Huumonen et al. [6] also found higher GA values in Finnish females (127.3° ± 6.4°) than in males (123.3° ± 7.4°). Abu Alhaija et al. [1] revealed higher GA values in Caucasian females (125.10° ± 7.06°) than in males (123.43° ± 7.85°). The above gender differences were also significant. Zhou et al. [22] found in young Koreans, GA was 125.1° in females and 124.1° in males. We considered that the difference in the size of the GA between male and female, combining the values of LN, LA, LP, LB, and h could help the forensic doctor determine the sex of the mandible.

The size of LA is important for IAN block anesthesia. Whether it can avoid the blockage of the lingula and make the anesthetic enter the mandibular canal through the mandibular nerve groove is the key to successful anesthesia [22]. Our results showed that LA of males was lower in HGA group (16.53 mm) than in LGA group (17.63 mm). When the clinician performs IAN anesthesia in HGA male patients' mouth, the needle insertion depth should be treated about 1 mm shallowly than in the LGA male patients.

In recent years, SSRO has become a routine surgical technique for the correction of malocclusion [17]. The position and height of the lingula are important references in SSRO for properly protecting the IAN and accompanying blood vessels [18]. This study shows that the distance between the lingula and the surrounding landmarks is highly variable. The distance LN is an important surgical distance for horizontal osteotomy in SSRO because the horizontal osteotomy is positioned close to the lingula [11]. In our study, the distance LN helps surgeons to locate the lingula. The mean values that we found for females (16.22 mm in HGA group; 16.6 mm in LGA Group) were lower than those that we found for males (16.76 in HGA group; 17.64 in LGA Group). When performing osteotomy, clinicians must keep away from the sigmoid. According to Sekerci et al. [16], the horizontal osteotomy line should be 15.3 ± 2.4 mm away from the sigmoid; according to Jansisyanont et al. [7], it should be 16.6 ± 2.9 mm. The differences among the average values for the LN distance are associated with ethnicity and gender [7].

Zhou et al. [22] found that the distance from the lower border of the mandible and mandibular second molar to the lingula was statistically larger in Korean males than that in females. They concluded that the segment of the mandibular ramus below the lingula could be larger in males than in females, which was consistent with our study. Our results showed that men's LP, LB and *h* were larger than women's, so we can concluded that the segment of the mandibular ramus below the lingula could be larger in males than in females in Chinese.

In previous studies, the relationships between the Gonial angle and the mandibular lingula have received little attention [9, 19]. In this study, we find that the surrounding anatomic landmarks distribute statistically differently between HGA group and LGA group. Particularly, the distances from the lingula to the posterior margin of

the mandible and the mandibular base were larger in LGA group than those in HGA group. This result showed that the segment of the mandibular branch, between the mandibular lingula and the mandibular angle, was obviously smaller in the HGA group than in the LGA population. This finding was consistent with the reported assumption [22]. Because our research shows that the men's mandibular angle is significantly smaller than the size of the women's and men's LB and LP are larger than women's, we believe that these two results are mutually supportive and meaningful. The segment is important for arc osteotomy of mandible to correct prominent severe mandibular angle [8] and intraoral approach operation in the treatment for large cyst near the mandibular angle [21], In HGA female patients, the operation of the mandibular angle bone resection should be paid more attention to protection of the IAN and peripheral blood vessels, because the LB and LP of the HGA patients are about 1–2 mm lower than those of LGA group. However, the values of LB and LP varied widely in our study. Clinicians must realize that the distances should be estimated by measurements on CBCT before surgery to reduce nerve damage.

Conclusion

We concluded that the segment of the mandibular branch, between the mandibular lingula and the mandibular angle, was obviously smaller in the HGA group than that in the LGA group, and women with HGA should be paid more attention to protecting the IAN and its surrounding vessels during such operations. This research provides some data with great clinical value on the height of the lingula and analysis for its location related to patients' Gonial angle sizes and gender. We believe that these conclusions described here will play an important role in reducing nerve injuries during oral surgery and promoting more effective anesthesia for clinicians.

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Author contributions KZ and YH carried out the experiments and drafted the manuscript; LM and BZ collected data, analyzed and interpreted the results; BZ and RW were involved in the statistical analysis; RW and HY critically reviewed the manuscript; HY managed the experimental design, reviewed the manuscript and provided funding support. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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