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Topographic Relationship between the Zygomatic Arch and Coronoid Process of the Mandible

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Abstract : Illustrations in almost all textbooks and atlases of anatomy normally show that the zygomatic arch (ZA) and coronoid process (CP) of the mandible overlap vertically. Their topographic relationship is important for plastic surgeons in various situations, such as restorations of ZA fractures. The present study investigated the topographic relationship between the ZA and CP of the mandible in three-dimensional models of Korean human cadavers. The topographic relationship was classified into three types: overlapped, tangential, and separate. The overlapped type was the most common, but the three types showed similar incidences in three-dimensional models. There were no lateral or sex differences according to the three types. The incidence of both sides showing the same type was 70.1%. In conclusion, the predominance of illustrations in almost all textbooks and atlases showing the overlapped type is misleading, since the other two types - where the CP of the mandible does not overlap the ZA - are almost as common.

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Key words : Zygomatic arch, Coronoid process, Mandible, Anatomy, Topography

Introduction

The long zygomatic arch (ZA) is the most laterally protruding structure in the facial skeleton. The coronoid process (CP) of the mandible represents the insertion site of masticatory muscles such as the temporalis muscle. Illustrations in almost all anatomy textbooks and atlases normally show the ZA and CP as overlapping vertically in the lateral view (Romanes 1995, Snell 1995, Clement 1997, Köpf-Maier 2001, Agur and Dally 2005, Drake et al. 2005, Saladin 2005, Putz and Pabst 2005, Ross et al. 2006), with this pattern also predominating in photographs of skulls (White and Folkens 2000, Standring 2005, Rohen et al. 2006, McMinn 2008). Few texts or atlas describe the ZA and CP as being vertically separate, and hence it is generally considered that the ZA and CP overlap each other.

Accurate information on the topographic relationship between the ZA and CP is important not only for anatomists but also for plastic surgeons involved in

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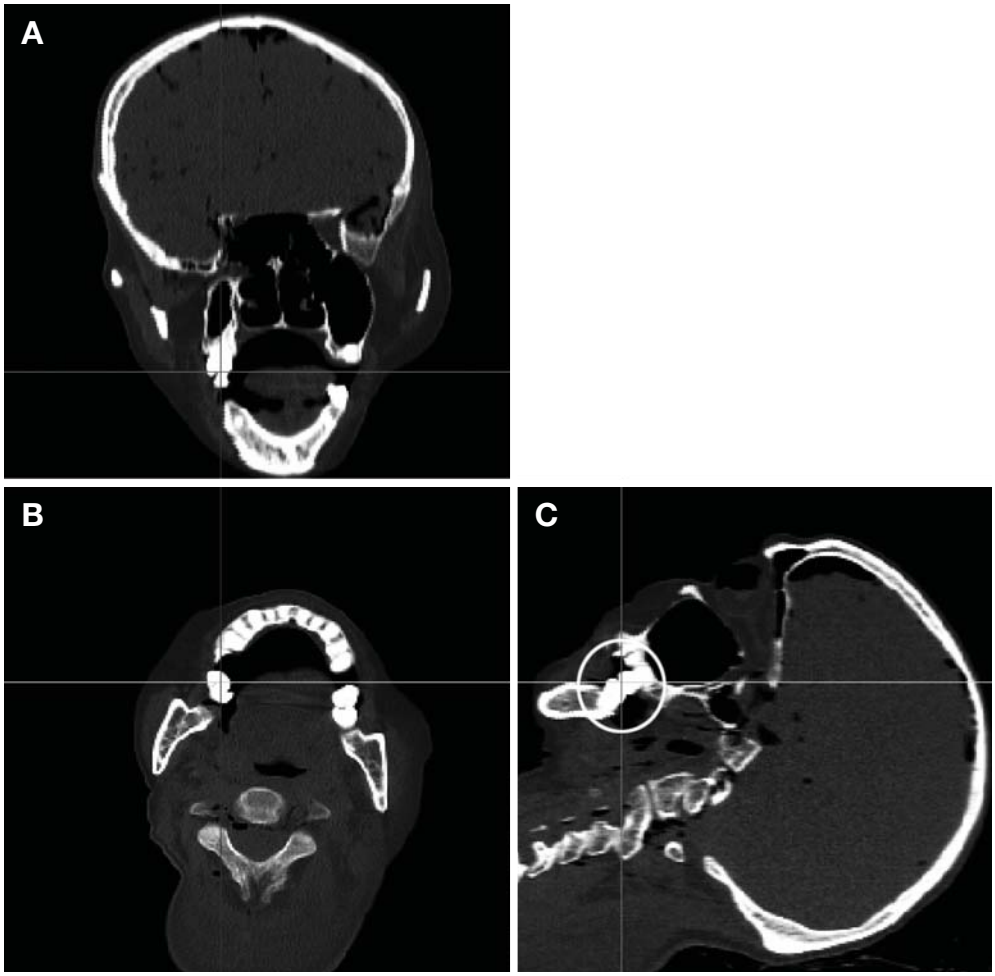

Fig. 1. Three planes of the CT data. (A) coronal plane, (B) transverse plane, (C) sagittal plane. The maxillary and mandibular molars faced each other in the white circle.

fractures and recovery in the ZA area. The purpose of the present study was very simple, that is, it was to investigate the vertical topographic relationship between the ZA and CP of the mandible.

Materials and Methods

The materials were three-dimensional (3-D) reconstructed models of human cadavers. The 3-D models and basic computed tomography (CT) data were acquired from the Digital Korean Human Model database (http://digitalman.kisti.re.kr). Data were obtained from 29 males and 28 females with a mean age of 51.7 years. Many cases had an edentulous mandible or maxilla or an opened mouth, and they were excluded from the present study. To verify the presence of a closed mouth, cross-sectioned CT images were transformed to sagit-

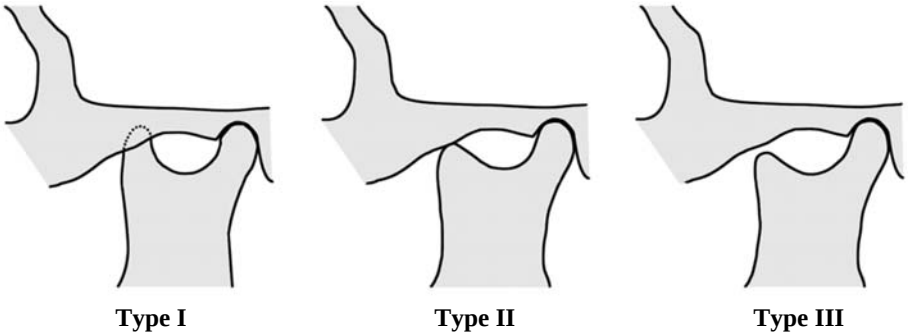

Fig. 2. Classification of the vertical relationship of the zygomatic arch and coronoid process into overlapped (type I), tangential (type II), and separate (type III) types.

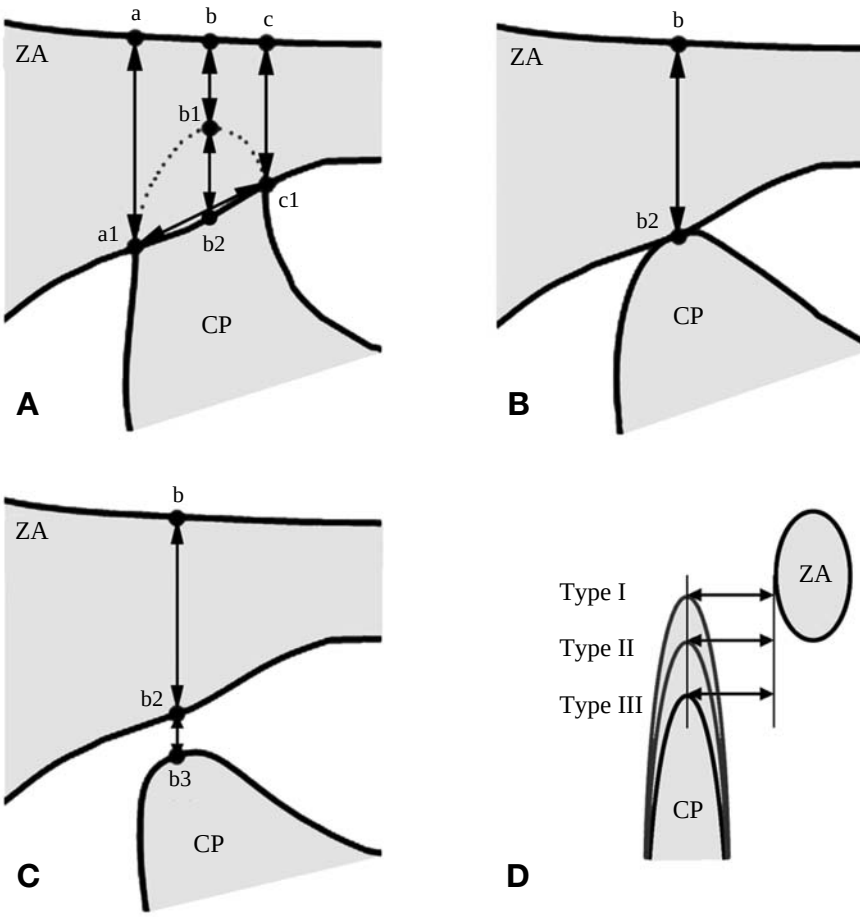

Fig. 3. Measurement of items according to three types. (A) type I, (B) type II, (C) type III, (D) coronal distance (depth) between tip of the coronoid process and internal surface of the zygomatic arch. ZA: zygomatic arch, CP: coronoid process.

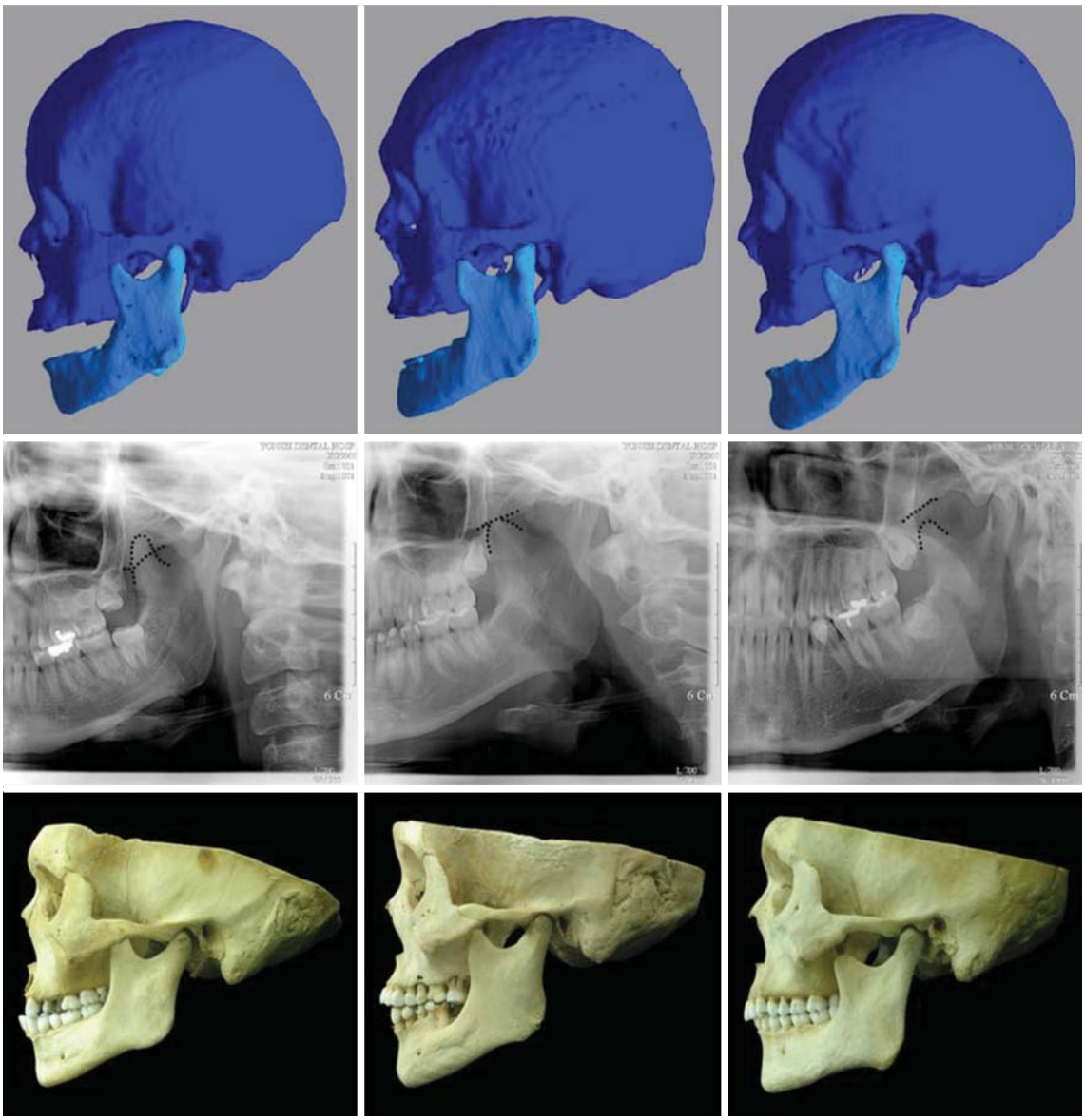

Fig. 4. The examples of three types in the 3-D model, panoramic radiograph, and dry bone.

tally and coronally sectioned images using a computer program (DataViewer, Ver. 1.2.2, Skyscan, Belgium). Based on three plane images, the samples that maxillary and mandibular molars contacted each other were included in the present study regardless of the occlusal type (Fig. 1). The samples were classified into three types: (I) overlapped, (II) tangential, and (III) separate (Fig. 2). The tangential type was defined as the pre-

Table 1. Incidence of the types according to the sexes

Type	Male	Female	Total
I	32.8% (19)	42.9% (24)	37.7% (43)
II	34.4% (20)	26.8% (15)	30.7% (35)
III	32.8% (19)	30.3% (17)	31.6% (36)

( ): number of cases

Table 2. Incidence of the types according to both sides

Type	Right	Left
I	43.8% (25)	31.6% (18)
II	24.6% (14)	36.8% (21)
III	31.6% (18)	31.6% (18)

( ): number of cases

sence of overlapping or where the separation was less than 2 mm. The separate type shows that the tip of the CP is not reach superiorly to the inferior border of the ZA. Measurements were performed using a computer program (Hyperworks, Ver. 7.0, Altair Engineering, MI, USA) to obtain basic anatomical data around this area. The measured dimensions are showing in Fig. 3. The statistical analysis was performed using standard computer software (SPSS for Windows, ver. 12.0, SPSS inc., Chicago, IL, USA).

Results

The three types showed generally similar incidences with a slight predominance of type I (37.7%) (Table 1). Some differences in the incidence according to sex were evident, but these were considered minor and possibly due to the small sample.

Comparing the right and left sides revealed that type I was more common than the other two types on the right side, whereas the incidences of the three types were similar on the left side (Table 2). However, there was no statistically significant difference between the right and left sides ($p > 0.05$). The overall incidence of both sides showing the same type was 70.1% (29.8%, 17.5%, and 22.8% for types I, II, and III, respectively) (Table 3).

Table 3. Bilateral coincidence of the types

Right	Left		
	I	II	III
I	29.8% (17)	10.5% (6)	3.5% (2)
II	1.8% (1)	17.5% (10)	5.3% (3)
III	0.0% (0)	8.8% (5)	22.8% (13)

( ): number of cases

Table 4. Measurement values in the 3-D models

Type	Items	Male	Female	Total
I	a-a1	16.5±2.1	14.5±1.9	15.4 ±2.2
	b-b1	8.6±2.5	8.3±1.8	8.5±2.1
	b1-b2	5.6±1.7	4.4±1.8	4.9±1.9
	b-b2	14.2±2.4	12.7±1.6	13.3±2.1
	c-c1	12.5±2.2	10.9±1.3	11.6±1.9
	a1-c1	9.2±1.6	7.4±2.0	8.2±2.0
	depth	8.5±1.9	7.6±2.3	8.0±2.2
II	b-b2	14.4±3.1	12.9±2.1	13.7±2.8
	depth	7.9±1.6	7.5±2.3	7.7±1.9
III	b-b2	17.0±2.7	16.5±2.7	16.8±2.7
	b2-b3	6.2±5.2	5.8±3.4	6.0±4.4
	depth	8.8±1.5	7.8±1.6	8.4±1.6

Mean±S.D., unit: mm

The overlap between the ZA and CP was 4.9±1.9 mm (mean±SD, range=2.1～10.0 mm) in type I, and the separation was 6.0±4.4 mm (2.1～21.0 mm) in type III (Table 4). Overall, the vertical height of the CP ranged from −10.4 to 6.8 mm relative to the inferior border of the ZA. The coronal distance between the tip of the CP and the internal surface of the ZA was similar among the three types, at about 8.0 mm. There was no case in which the CP was located higher than the superior border of the ZA.

Examples of the three types are shown in Fig. 4. In addition to 3-D models, the three types of the panoramic radiographs and dry bones were shown together for convenience of understanding. In the 3-D model of Fig.

4, the type III seems mouth-opened; however, it was exactly closed-mouth as mentioned above.

Discussion

The general factors that need to be considered when classifying the types of specific samples include laterality, sexual dimorphism, and aging. However, the former two factors did not differ significantly with incidence rates, and aging was also considered to not be a factor. Because it is unlikely that the CP would elongate due to long-term traction of the temporalis muscle. Moreover, the main muscle involved in mouth-closing is the masseter muscle rather than the temporalis muscle. In addition to general factors, the head size might affect the topographical type. The head and face were larger in males than in females regardless of the race or population (Song et al. 2009), suggesting that these are not indirect factors. Finally, individual characteristics of the mandible might affect the type, especially the size or shape of the ramus of mandible. Future studies of mandibular metrics should focus on the ramus of mandible, such as length of the CP.

The coronal distance between the tip of the CP and the internal surface of the ZA in the present study was similar to that found in our previous study of the ZA and temporal fossa (Song et al. 2008), where we referred to the space of the ZA, corresponding to the distance from the ZA to the temporalis muscle at the superior border level of the ZA. The level of the corresponding measurement in the present study was vertically lower than the space of the ZA, but both dimensions were about 8 mm.

In conclusion, the topographic relationship between the ZA and CP of the mandible was classified into overlapped, tangential, and separate types in the present study. The overlapped type was the most common, but the other two types showed similar incidences. Therefore, we suggest that the predominance of illustrations in almost all textbooks and atlases showing that the ZA and CP overlap is misleading (however, the present study was limited by comparable data for other races and populations not being available). This is the first study to investigate the topographic relationship between the ZA and CP of the mandible, and the obtained data represent important information for anatomists, surgeons involved in head and neck surgery, dentists, and medical students who are interested in the temporal fossa, ZA, and temporomandibular joint.

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광대활과 아래턱뼈 근육돌기의 국소해부학적 위치관계

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간추림 : 대부분의 해부학교과서나 그림책에는 광대활과 아래턱뼈 근육돌기가 수직으로 서로 겹쳐 있는 것처럼 그려져 있다. 광대활과 아래턱뼈 근육돌기의 국소해부학적 위치관계는 광대활골절의 복원과 같은 여러 상황에서 이 부위를 수술하는 성형외과 의사들에게 중요한 의미를 갖는다. 이 연구에서는 광대활과 아래턱뼈 근육돌기의 국소해부학적 위치관계를 한국인 3차원모델을 이용하여 알아보고자 하였다. 광대활과 아래턱뼈 근육돌기의 국소해부학적 위치관계는 겹친 형태, 접한 형태, 분리된 형태의 세가지로 분류되었다. 가장 빈도가 높은 경우는 겹친 형태(37.7%)였으나 접한 형태나, 분리된 형태도 비교적 높은 빈도로 나와 세 가지 형태가 비슷한 정도로 봐도 무방하다. 오른쪽-왼쪽, 또는 성별에 따른 각 형태의 빈도차이는 없었다. 양쪽이 같은 형태를 나타나는 경우는 70.1%였다. 결론적으로 대부분의 교과서나 그림책에서 광대활과 아래턱뼈 근육돌기가 접하여 있거나 분리된 형태를 합하면 겹친 형태보다 더 많기 때문에 항상 겹쳐 있는 것으로 그려진 것은 오해의 소지가 있다고 생각한다. 이러한 국소해부학적 위치관계는 해부학을 교육하는 해부학자 뿐 아니라 이 부위를 수술하는 성형외과 등의 임상의사들도 알아야 할 것으로 생각한다.

찾아보기 낱말 : 광대활, 근육돌기, 아래턱뼈, 국소해부학

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