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Clinical Adaptation According to Anatomical Types of Nasal Septum

Adaptación Clínica Según Tipos Anatómicos de Tabique Nasal

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SUMMARY: The purpose of this study was to inform the anatomical types of the nasal septum of which including variations by dissection and to provide guidelines for clinical adaptation. For this purpose dissections were performed on 70 nasal septums of formalin fixed Korean adult cadavers (20 males, 11 females, and 39 of unknown sex) with an age at death of 13-105 years. The septal deviation was checked before midsagittal section the nasal cavity with the aid of a laryngoscope. The mucosa on the nasal septum was then removed to observe the morphology of the nasal septum. The shape of each component of the nasal septum was identified, and photographs were taken from a midsagittal plane. This study has discovered various anatomical types of the nasal septum and its variations. The correlations between septal types according to their proportions were also analyzed. The results reported herein provide detailed anatomical knowledge that can be used as a valuable reference for rhinoplasty procedures.

KEY WORDS: Anatomical types; Nasal septum: Korean cadaver; Midsagittal plane; Rhinoplasty.

INTRODUCTION

In modern rhinoplasty and nasal reconstruction, the cartilaginous or bony part of the nasal septum is removed for grafting. The septal cartilage (SC) is the most common source of autologous cartilage graft material in rhinoplasty because it lies within the surgical field and therefore is not associated with additional donor-site morbidity; the relative flatness, thickness, and hardness of the septum make it the optimal choice for rhinoplasty (Quatela & Jacono, 2002; Kim *et al*., 2010a,b,c; de Pochat *et al*., 2011; Kim *et al*., 2014; Hidalgo & Doft, 2015; Kim, 2015). In situations where the SC is used for grafting but it does not provide sufficient material, a bony implant taken from the perpendicular plate of the ethmoid bone (PPE) and the vomer can be used as a filler material or for splinting the dorsal and/or caudal segment of the SC after reshaping using rongeurs (Dini *et al*., 2011; Apaydin, 2013). On rare occasions these materials can even be used for the total reconstruction of the septum (Apaydin, 2013). Moreover, columellar struts can be harvested from multiple septal sites including the maxillary crest (Quatela & Jacono, 2002), and the resected parts of the maxillary crest can be thinned and used for grafting (Apaydin, 2013).

The variations in the thickness of the nasal septum according to site and the junctions between the septal components have clinical implications. The SC is thickest at its posterior portion connected to the PPE and the vomer (Quatela & Jacono, 2002; Kim *et al*., 2010a,b,c). Therefore, when making a strong support in Asian patients using an SC graft, such as a shield graft or columellar strut in rhinoplasty, it is recommended to use the posterior portion of the septum (Kim *et al*., 2010a,b,c). The vomer is always markedly thicker than the PPE and the septum due to its bilaminar origin (Apaydin, 2013). In addition, the deviation of the septum occurs usually at the union of the PPE and the vomer, or along the union of the vomer and the SC (Scott-Brown *et al*., 1965; McVay, 1984). The vomer-to-PPE suture line, which is the main part of the bony deviation, is most commonly resected and is rarely reported to be used during septal surgery due to its irregular shape and volume (Apaydin, 2013). These features mean that accurate knowledge about the anatomical types and variations of each septal component is needed during the preoperative planning of rhinoplasty procedures.

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The nasal septum is mainly composed of the SC, the PPE, and the vomer. The nasal crests of the maxilla and the palatine bones also contribute partially to the nasal septum (Woodburne & Burkel, 1994; Standring, 2008). Although there have been several reports on changes in the areas and proportions of the various components of the nasal septum, and their correlations with age (Kim *et al*., 2008, 2010a,b,c; Park *et al*., 2014), no studies have investigated the anatomical types of septal components and their frequencies. In addition, anatomical variations of the nasal septum such as the long sphenoidal process (SP) of the SC and the premaxillary wing appeared to affect the morphology and location of the septal components in the present study.

The purpose of this study was to inform the anatomical types of the nasal septum of which including variations by dissection and to provide guidelines for clinical adaptation that will be helpful for related types of nasal surgery.

MATERIAL AND METHOD

Dissections were performed on 70 nasal septums of formalin fixed Korean adult cadavers (20 males, 11 females, and 39 of unknown sex) with an age at death of 13-105 years. The septal deviation was checked before midsagittal section the nasal cavity with the aid of a laryngoscope. The mucosa on the nasal septum was then removed to observe the shape of the nasal septum. The shape of each component of the nasal septum was identified, and photographs were taken from a midsagittal plane. A median line was drawn on each photograph between the septal components (Fig. 1), and then the area of each septal component was measured using software (version 17, Mimics, Materialise, Belgium).

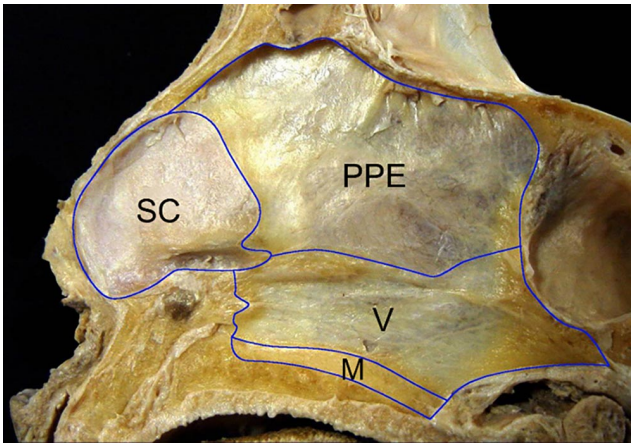

Fig. 1. Showing the lines drawn between the various septal components to observe the anatomical types of the nasal septum and to measure the area of each component. M = nasal crest of the maxilla; PPE = perpendicular plate of the ethmoid bone; SC = septal cartilage; V = vomer.

Calculations and statistical analyses were performed using standard computer software (version 18.0, SPSS for Windows, SPSS, Chicago, IL, USA). Bivariate correlation analysis was used to determine relationships among the areas of the various components of the nasal septum. We used independent-samples t-tests to analyze differences according to sex, and paired-samples t-tests to analyze differences among the component areas. In all analyses, $p<0.05$ was taken to indicate statistical significance.

RESULTS

The shapes and proportions of the septal types of the nasal septum varied between the cadavers. The area proportions of the SC, the PPE, the vomer, and the nasal crest of the maxilla relative to the total area of the nasal septum were 25.6±6.1 % (mean±SD; range: 15.1-45.6 %), 43.0±9.3 % (21.0-61.8 %), 25.8±8.3 % (6.9-48.7 %), and 5.6±2.7 % (1.4-15.7 %), respectively, in the 70 cadavers. The proportion of the PPE relative to the total area of the nasal septum was larger than the proportions of the SC and the vomer ($p<0.001$), while there was no significant difference between the proportions of the SC and the vomer. The relative proportion of the PPE was larger in males than in females ($p<0.05$), but the proportions of the SC, the vomer, and the nasal crest of the maxilla did not differ significantly with sex. There was a significant negative correlation ($r=-0.714$, $p<0.001$) between the proportions of the PPE and the vomer, a weak negative correlation ($r=-0.454$, $p<0.001$) between the proportions of the PPE and the SC, and no correlation ($r=-0.235$, $p=0.05$) between the proportions of the SC and the vomer.

The morphology of the nasal septum was divided into three main types according to the proportion of each septal type (Fig. 2).

1. The total mean proportions of the SC, the PPE, the vomer, and the nasal crest of the maxilla were similar among 32 of the 70 cadavers (45.7 %).
2. The proportions of the SC, the PPE, and the vomer were similar to each other (with a difference of <15 %) in 17 cadavers (24.3 %).
3. The proportion of the PPE exceeded 50 % of the total area of the nasal septum in 16 cadavers (22.9 %).

The proportions of the vomer and the SC exceeded 40 % of the total area of the nasal septum in three cadavers (4.3 %) and two cadavers (2.9 %), respectively. There were no cases in which the proportion of the PPE was less than 20 %.

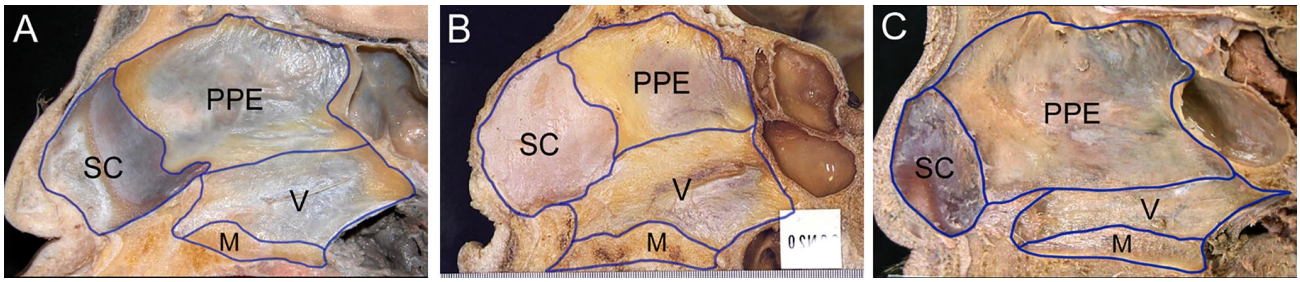

Fig. 2. Anatomical types of the components of the nasal septum according to the proportions of the different septal components. (A) The cadavers in the present study mostly exhibited similar mean proportions for the SC, PPE, V, and M. (B) A cadaver in which the proportions of the SC, PPE, and V were similar to each other (with a difference of <15 %). (C) A cadaver in which the proportion of the PPE exceeded 50 % of the total area of the nasal septum.

Some anatomical variations of the nasal septum were evident. The SP of the SC extended for longer between the PPE and the vomer in six cadavers (8.6 %) (Fig. 3). In cadavers in which the SC had a longer SP, the mean proportions of the SC, the PPE, the vomer, and the nasal crest of the maxilla were 30.5 %, 42.7 %, 22.5 %, and 4.4 %, respectively, indicating that the proportion of the SC had increased by approximately 5 % while those of the PPE, the vomer, and the nasal crest of the maxilla were similar or only slightly lower. The premaxillary wing was elevated between the SC and the vomer in 52 cadavers (74.3 %) (Fig. 4A). The extent of the elevated premaxillary wing varied, resulting in a greater diversity in the anteroinferior part of the nasal septum. The elevated premaxillary wing contacted the anteroinferior margin of the PPE in 10 cadavers (14.3 %) (Fig. 4B). In these cadavers the premaxilla was more elevated and the proportion of the PPE usually exceeded 50 % of the total area of the nasal septum. Cases with a more-elevated premaxilla separated the SC from the vomer, resulting in the elevated premaxilla being located inferior to the SC and the vomer being located inferior to the PPE, rather than inferior to the SC.

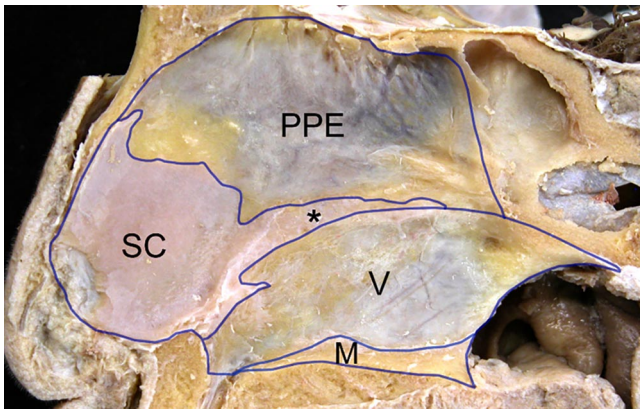

Fig. 3. Showing a long sphenoidal process (*) of the SC extending between the PPE and the V.

The suture line between the SC and the PPE, posterior margin of the SC, was oblique and linear in 49 cadavers (70 %) and convex posteriorly in 21 cadavers (30 %). The PPE-to-vomer suture line was oblique or transverse: it was oblique and upward in 45 cadavers (64.3 %) and transverse in 25 cadavers (35.7 %), and usually linear. The PPE-to-vomer suture line was oblique when

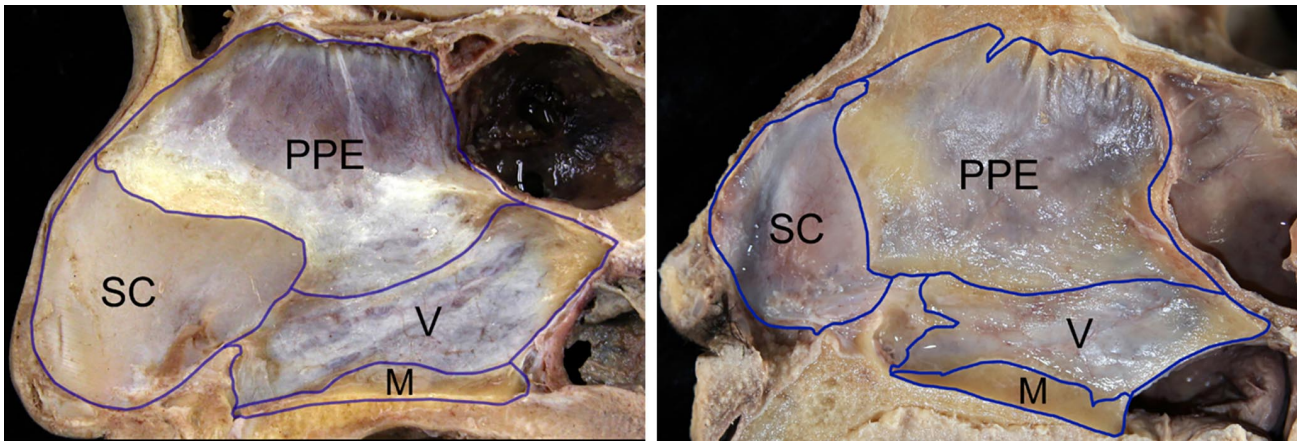

Fig. 4. Showing the elevated premaxillary wing. (A) A cadaver with the premaxillary wing elevated between the SC and the V. (B) A cadaver with the elevated premaxillary wing contacting the anteroinferior margin of the PPE.

the area of the vomer was larger, due to the inclined margin of the vomer. When the SP extended for longer, the vomer-to-PPE suture line was linear. The direction of the SP of the SC was consistent with that of the vomer-to-PPE suture line. When the vomer-to-PPE suture line was transverse, the SP of the SC was also transverse (four cadavers, 5.7 %), while when this suture line was obliquely upward, the SP of the SC was also oblique (two cadavers, 2.9 %).

DISCUSSION

Septorhinoplasty is the most difficult and complicated type of facial plastic surgery because of the complex interrelationships of the various involved anatomical structures (Prabhu *et al*., 2009). The present study has discovered the anatomical types, variations, and correlations among the various types of the nasal septum, including their changes with age, whereas the previous studies have only addressed the changes in the proportions and correlations of individual septal types separately according to age (Kim *et al*., 2008, 2010a,b,c; Park *et al*., 2014).

In the present study, the mean area proportions of the SC, the PPE, the vomer, and nasal crest of the maxilla relative to the total area of the nasal septum were 25.6 %, 43.0 %, 25.8 %, and 5.6 %, respectively. Previous studies found that the mean area proportions of the SC, the PPE, and the vomer relative to the total area of the nasal septum were 27.7~34 %, 38.5~42.4 %, and 25~33.8 %, respectively (Miles *et al*., 2007; Kim *et al*., 2010a,b,c, 2014). These values obtained in the previous studies and the present study are broadly similar, and a consistent finding has been that the mean proportion of the PPE is the highest among the nasal septal types. The minor discrepancies in incidence between the studies might be due to the use of different methods to measure the septal types and the inclusion of different subjects, such as cadavers or CT or MRI images of living subjects.

Nearly all of the nasal septum is cartilaginous joint in neonates. The PPE is produced by the endochondral ossification of the cartilaginous joint septum during childhood, while the vomer is formed by intramembranous ossification. The cartilaginous joint septum reaches adult dimensions—in terms of its lateral surface area—at the age of 2 years, and its subsequent growth is due to expansion of the PPE (Van Loosen *et al*., 1996). The total nasal septal area did not change significantly with age in the present study. The area of the SC decreased and that of the PPE increased with age, while the area of the vomer did not vary with age (Kim *et al*., 2010a,b,c). In males aged 15 or 16 years there was a significant decrease in the SC area and a significant increase in the PPE area, which occurred simultaneously (Park *et al*., 2014). The posterior area of the SC, which is part of the zone of endochondral ossification in the septoethmoidal junction, is permanently replaced by bone from the PPE until an age of about 40 years (Vetter, 1984).

Kim *et al*. (2010a,b,c) found that the areas of the PPE and the SC showed an inverse relationship with age. In the present study, there was a weak negative correlation between the proportions of the PPE and the SC, which is thought to be due to ossification changes of the posterior area of the SC to the PPE and expansion of the PPE during subsequent growth of the septum. The relationships between the vomer and other components have differed between previous studies. Miles *et al*. (2007), and Kim *et al*. (2010a,b,c), reported that the areas of the PPE and the vomer appear to be independent, whereas Prabhu *et al*. (2009), described that the PPE and the vomer made inversely proportional contributions to the total bone surface area of the nasal septum. The present study found a significant negative correlation between the proportions of the PPE and the vomer, and no correlation between the proportions of the SC and the vomer.

The PPE is reportedly the primary source of bone grafts (Dini *et al*., 2011). Bony implants from the PPE have been used to correct and reconstruct the caudal septum (Metzinger *et al*., 1994; Slavit *et al*. 1995). The PPE is thin and relatively strong, allowing the construction of a more-stable caudal septum-strut complex without sacrificing the patency of the airway (Metzinger *et al*., 1994). The vomer represents an alternative source, and even the spur from the maxillary crest can be used as a last option (Dini *et al*., 2011). An L-shaped strut graft obtained from the PPE or thinned vomer can be used in noses with severe trauma (Apaydin, 2013). In the present study, the mean proportion of the area of the PPE was 43 %, which represented the largest among the septal components. The proportion of the PPE relative to the total area of the nasal septum exceeded 50 % in 22.9 % of cases. These findings imply that the PPE can be a good source of material for grafting from the nasal septum in rhinoplasty.

The SC is irregularly quadrilateral or triangular in shape, and may extend back (especially in children) for some distance between the vomer and the PPE (Woodburne & Burkel, 1994; Standring, 2008). Although the SP is thinner and more irregular than the anterior cartilage portion of the septum, it can be used as a source of additional cartilage graft material (Kim *et al*., 2014). A

long SP is formed by delayed ossification of the SC. Kim *et al*. (2010a,b,c, 2012) found that the SP was significantly longer in patients with a deviated nasal septum. During septal surgery, surgeons frequently find that the SP is located at the top of the deviated septum, especially at the septal spur or ridge (Kim *et al*., 2012). The SC had a long SP in 8.6 % of the cases in the present study. The mean proportion of the SC that had the long SP was increased approximately 5 % of the proportion. Moreover, the mean proportions of the other components were similar with those of other components that did not have the longer SP. It therefore seems that the presence of a long SP of the SC does not affect the shapes and proportions of the other septal components.

A detailed knowledge of the framework of the premaxillary area is essential when performing septal surgery. At birth there are two premaxillary bone structures that become component parts of the nasal septum: the anterior nasal spine and the premaxillary wings. The premaxillary wings arise from the posterior half of the upper face of the premaxilla (Klaff, 1956). The premaxillary wing was observed in 74.3 % of the present samples. When the premaxillary wing was present and was more elevated, it resulted in the anteroinferior part of the nasal septum taking various shapes. Therefore, the presence of an elevated premaxillary wing should be considered during septal surgery.

Vomeronasal cartilage is a small portion of cartilage that appears alongside the lower edges of the SC. It is connected with a little blind pouch from the nasal cavity, the vomeronasal organ, that extends backward between the two cartilaginous structures. The vomeronasal organ, which is rudimentary and not always discernible in humans, is large and lined by olfactory epithelium in some mammals. In most amphibia, reptiles, and mammals, the vomeronasal organ is the peripheral sensory organ of the accessory olfactory system (Standring, 2008). The vomeronasal cartilage has also been described in a few textbooks (McVay, 1984). However, the vomeronasal cartilage was not seen in the cadavers observed using a surgical scope in the present study.

This study has discovered various anatomical types of the nasal septum and its variations. The correlations between septal types according to their proportions were also analyzed. The results reported herein provide detailed anatomical knowledge that can be used as a valuable reference for rhinoplasty procedures.

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RESUMEN: El propósito de este estudio fue informar los tipos anatómicos del tabique nasal incluyendo las variaciones por disección y brindar pautas para la adaptación clínica. Para este propósito, se realizaron disecciones en 70 tabiques nasales de cadáveres adultos coreanos fijados con formalina (20 hombres, 11 mujeres y 39 de sexo desconocido) con una edad de muerte de 13 a 105 años. La desviación septal se comprobó antes de la sección medio sagital de la cavidad nasal con la ayuda de un laringoscopio. A continuación, se retiró la mucosa del tabique nasal para observar la morfología del tabique nasal. Se identificó la forma de cada componente del tabique nasal y se tomaron fotografías desde un plano mediano sagital. En el estudio se descubrieron varios tipos anatómicos del tabique nasal y sus variaciones. También se analizaron las correlaciones entre los tipos septales según sus proporciones. Los resultados informados en este documento proporcionan un conocimiento anatómico detallado que se puede utilizar como una referencia valiosa para los procedimientos de rinoplastía.

PALABRAS CLAVE: Tipos anatómicos; Tabique nasal: Cadáver coreano; Plano mediano; Rinoplastía.

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