Consistent Ipsilateral Development of the Posterior Extension of the Quadrangular Cartilage and Bony Spur Formation in Nasal Septal Deviation

Babak Saedi, MD¹, Ali R. Rashan, MD², Michael Lipan, MD², Jayakar V. Nayak, MD², and Sam P. Most, MD²

No sponsorships or competing interests have been disclosed for this article.

Abstract

Objective. Septal spurs are exceedingly common structural deformities that contribute to nasal obstruction and often require surgical correction. The posterior extension of the quadrangular cartilage (PEQC) and its relationship with septal spurs have not been previously examined. We seek to examine the anatomic and histologic relationship of the PEQC and concurrent septal spurs in patients undergoing septoplasty.

Study Design. Prospective cohort study.

Setting. Facial plastic and rhinology center in tertiary hospital setting.

Subject and Methods. Thirty patients with septal deviation are described in this series. The quadrangular cartilage and associated septal spur were removed en bloc from patients undergoing septoplasty. The length of the PEQC, the side of spur deviation, and the relationship of the PEQC to the spur (ipsilateral vs contralateral) were recorded.

Results. The mean length of the PEQC, beyond the bony-cartilaginous junction, was 30.06 ± 6.06 mm. The PEQC was present on the ipsilateral side of the spur deviation in all 30 patients (100%).

Conclusion. At sites of septal spur formation, the quadrangular cartilage possesses an average 3-cm extension beyond its junction with the bony components of the septum. This cartilaginous extension is exclusively found on the same side of spur deviation. These findings have implications on our understanding of the ontogeny of commonly found septal spurs and deviations, as well as treatment strategies and cartilage graft harvesting.

Keywords

septal deviation, septal spur, nasal septum, embryology, development, nasal obstruction, septoplasty, quadrangular cartilage, bony-cartilaginous junction

Received July 25, 2014; revised November 10, 2014; accepted November 26, 2014.
we present observations regarding the pattern of spur formation in consecutive patients.

**Subjects and Methods**

**Protocol Approval**

The study was conducted at Stanford University, with approval of the Institutional Review Board.

Thirty patients with septal deviation with septal spur formation were entered into this series from February 2013 to December 2013. All patients were undergoing septoplasty and/or septorhinoplasty in the treatment of nasal obstruction. A septal spur was defined according to Mladina’s septal deviation types 5 and 6, as an acutely angled horizontal expansion of the septum out of the sagittal plane.

**Type of Procedures**

All septoplasty/septorhinoplasty procedures were performed under general anesthesia. After elevation of bilateral mucoperichondrial flaps, the quadrangular cartilage and region of the septal spur were removed en bloc to preserve the relationship of these structures. All procedures were performed by the senior author using standard open technique without endoscopy. **Figure 1** provides an in situ image of a spur isolated in this study.

**Variables**

Demographic data were recorded. The length of the posterior cartilage extension from the quadrangular cartilage was measured according to the entire horizontal length of the PEQC, beginning at the bony junction. Also, the laterality and direction of the spur and PEQC were assessed (**Figure 2**).

**Tissue Processing**

For histologic analysis, specimens were fixed in 4% paraformaldehyde (Fisher Scientific, Pittsburgh, Pennsylvania) in phosphate-buffered saline (PBS; pH, 7.4) at 4°C overnight. Fixed tissues were then cryoprotected by successive incubations in 15%, 20%, and 30% sucrose/PBS. Tissues were embedded in 100% OCT compound (Sakura Finetek, Torrance, California) after 30 minutes of successive incubations in graduated concentrations of 30%, 50%, and 90% OCT in 30% sucrose/PBS. Serial frozen sections of 9-µm thickness were performed through a Leica CM1950 cryostat (Leica, Bannockburn, Illinois) onto SuperFrost charged glass slides (Fisher Scientific).

**Hematoxylin and Eosin Staining**

Acquired frozen sections were placed into PBS for 10 minutes to remove the OCT embedding compound and were rinsed in dH2O for 2 minutes. Tissue sections were then placed into Harris hematoxylin reagent (Fisher Scientific) for 1 minute. Samples were rinsed with a gentle flow of
H₂O for 5 minutes and rinsed in dH₂O for 2 minutes. Samples were then treated with bluing reagent (Fisher Scientific) for 30 seconds, followed by two 1-minute washes in dH₂O. Samples were then placed into eosin stain for 30 seconds (Sigma, St. Louis, Missouri) and rinsed with running H₂O for 5 minutes, followed by two 1-minute rinses in dH₂O.

Alcian blue solution (Sigma) was added for 30 seconds, then washed with running H₂O for 5 minutes and rinsed twice in dH₂O for 2 minutes each. Samples were then placed into 3 successive baths—95% ethanol, 100% ethanol, and finally 100% xylene—for 5 minutes each. Slides were mounted with Cytoseal 60 (Thermo Scientific, Waltham, Massachusetts) and cover-slipped. Imaging was performed on a Swift M10L Microscope (Swift Optical Instruments, San Antonio, Texas) in the Stanford Department of Otolaryngology.

Statistical Method

Data were analyzed with SPSS 18 for Windows (SPSS Inc, Chicago, Illinois). Values were evaluated through descriptive statistical methods (mean ± SD).

Results

Among 30 patients evaluated in this study, 12 (40%) were men, and 18 (60%) were women. The mean age was 32.0 ± 10.8 years (minimum, 18; maximum, 51). All suffered from significant nasal obstruction caused by septal deviation. All patients underwent concomitant bilateral inferior turbinate reduction.

In each resected spur specimen, we identified the bony-cartilaginous junction and measured the posterior cartilaginous extension beyond this point (ie, PEQC). The average length of the PEQC beyond the bony-cartilaginous junction was 30.06 ± 6.06 mm (range, 18-41 mm; see Figure 1). Spur laterality was roughly equal, with 17 patients (57%) having a left-side deviation/spur and 13 (43%) a right-sided deviation.

Each specimen demonstrated the PEQC overlying the spur. The PEQC cartilage was ipsilateral to the septal spur deviation in all 30 patients studied (Figure 1, Table 1). Based on hematoxylin and eosin staining of cross sections of the 3 septal spurs, at the site of deviation, superiorly based cartilage is splayed atop the inferior-based bony spur (Figure 3). As expected, there are no inflammatory infiltrates present at this junction site, but an increased density of cell bodies was noted at this junction point in 2 of 3 specimens. This reliable relationship was identified in all 3 spurs subjected to histopathologic analysis.

Discussion

Here we describe a new concept regarding the anatomy and histology of the septal spur and, in particular, the relationship between the PEQCs and the septal spur. The results of our series demonstrate the novel finding that the quadrangular cartilage uniformly overlies the spur on the ipsilateral side of the spur deviation in all patients, which is contrary to previous concepts that indicate divergent directions of bone and cartilage in septal spurs. Moreover, this finding possibly suggests a cellular and/or mechanical interaction at the interface of the cartilage and bone at the B:C junction within the nasal septum that may stimulate aberrant growth in bony and cartilaginous tissues at this overlapping junction point. This may contribute to an additional 3 cm of posterior extension of cartilage atop the spur site.
Development of nose begins at 3 to 10 weeks of gestation, and toward the end of this period, the septum forms from neural crest cells. These multifunctional cells develop between the nasal cavities and directly overlie the buccal cavity. From these facts, Vetter et al's primary proposed theory for nasal and maxillary development is that septal growth has a strong influence—specifically, the cartilaginous septum produces a growth signal that influences the development of the maxilla and adjacent facial structures. These growth patterns can define the tight attachment of lower parts of quadrangular cartilage to the maxillary crest. Vetter et al showed that there is age-dependent growth activity in what their group termed the “suprapremaxillary area.” This area directly corresponds to the PEQC.\textsuperscript{11,12}

The direction of growth of the nasal septum is inferior and anterior, which would theoretically induce a “pulling effect” on the premaxillary bone through the septopremaxillary ligament.\textsuperscript{13} Interference with this force gradient can be inferred to contribute to septal deviation, as is observed in the cleft nose. Also, the abnormal development of the maxillary crest can affect posterior growth of the septum and generation of septal spurs. Other studies show a strong relationship between nasal septum deviation and facial growth asymmetry. All these reports support the septal growth theory of facial development.\textsuperscript{14-16}

In the current study, we sought to evaluate the anatomic relationship of the PEQC and septal spurs (Mladina types 5 and 6).\textsuperscript{7} In contrast to Mladina, who described the cartilage as being located opposite the side of the spur direction, we have determined that the septal cartilage is consistently located on the same side as the septal spur. The strong positive correlation between the direction of the spur and cartilage may indicate a critical interaction at the bony-cartilaginous junction between the PEQC and underlying bony tissue of septum, thereby leading to spur formation. The factors involved in this growth remain to be determined. Some evidence suggests that similar growth factors induce the growth of chondrocytes and osteocytes, with dysregulation of one factor effecting abnormal growth or deformity of the other.\textsuperscript{17} If such a relationship between the cartilage and bone did not exist, an even distribution of the cartilage to the ipsilateral or contralateral sides of the septal spurs examined would be expected.

The timing of the growth of the bony-cartilaginous components of the spur cannot be described from this study; however, 3 possibilities exist. First, the bony spur forms, and then the cartilaginous extension grows posteriorly over it, although this is unlikely given the consistent presence of the cartilage on the side of the spur deviation. Second, the spur and cartilage extension form at the same time. Finally, the quadrangular cartilage extension forms and then stimulates bony growth, resulting in the spur. We favor the last theory, given how consistent the relationship of the 2 structures has been in our series. It suggests a strong interaction between the PEQC and the underlying bony septum. In most of the cases we examined, the septal cartilage extension reached beyond the apex of the spur. If the bony spur preceded posterior cartilaginous growth, we would expect to see less posterior extension.

Finally, regarding immediate practical application of these findings, the PEQC averages 3 cm in length and represents a potential source of cartilage for grafting in septorhinoplasty that is often overlooked. It may require meticulous dissection but can provide valuable graft material when other intranasal sources of cartilage are exhausted.

**Conclusion**

The developmental and structural basis for the common septal spur formation is poorly understood. We show here that the PEQC is consistently found on the same side of deviation identified in bony septal spurs. This may be an indication of growth abnormalities that underlie this deformity, but further studies are needed to substantiate this relationship. Additionally, the PEQC can be considered a potential source for graft material in septorhinoplasty when autologous donor tissue sources are limited.

**Author Contributions**

**Babak Saedi,** data analysis, drafting, final approval, accountability for all aspects of the work; **Ali R. Rashan,** data analysis, drafting, final approval, accountability for all aspects of the work; **Michael Lipan,** data analysis, drafting, final approval, accountability for all aspects of the work; **Sam P. Most,** data analysis, drafting, final approval, accountability for all aspects of the work.

**Disclosures**

**Competing interests:** None.

**Sponsorships:** None.

**Funding source:** None.

**References**


