RESEARCH LETTER

The Nasal Keystone Region: An Anatomical Study

The nasal keystone region is an aptly named confluence of bone and cartilage at the junction of the upper and middle thirds of the nose. Its importance to the stability and structure of the nose is exemplified by the number of complications that may arise from poor surgical handling of this area. The keystone region consists of contributions from the paired nasal bones cephalically, paired upper lateral cartilages (ULCs) caudally, quadrangular cartilage anterior-inferiorly, and perpendicular plate of the ethmoid (PPE) posterior-inferiorly.

We sought to review the anatomy of fresh-frozen cadavers in regard to the keystone region, in concert with previous anatomical descriptions, to expand on the significance of this region for rhinoplasty.

Methods. Dissections were performed on 11 fresh-frozen and thawed cadaver heads without evidence of prior traumatic, surgical, or positional deviation of the external nose.

To expose the keystone, the soft-tissue envelope and the nasal septal mucosa were removed. After the cartilages and nasal bones had been adequately exposed, the periosteum and perichondrium were removed. Finally, the osseocartilaginous complex was removed from the skull en bloc by osteomies made along the maxillary crest, the frontal process of the maxilla, the nasofrontal suture and posteriorly through the PPE to the maxillary crest (Figure 1). After full dissection, the osseocartilaginous junctions were well demarcated and visible to the naked eye.

Measurements were performed with surgical calipers. The measurements were made in 9 males and 2 females, all of whom were white. Patient ages at the time of death ranged from 27 to 90 years.

Statistical analysis was performed, using a 2-tailed t test for continuous variables, comparing the length of midline overlap from the present study with the measurements obtained from a prior study by Kim et al.1 These data were obtained through personal correspondence with the study’s authors. Statistical calculations were performed with Microsoft Excel software (version 14.0; Microsoft Corp).

Results. A total of 5 separate measurements were made on each specimen (Table). (1) The dorsal articulation of the ULCs with the nasal bones (mean, 8.0 mm [range, 4.5-12.0 mm]) (Figure 1). (2) The unilateral length of the lateral articulations of the ULC with the nasal bones (mean, 11.3 mm [range, 6.0-18.0 mm]) (Figure 2). (3) The midline nasal bone overlap with the quadrangular cartilage (mean, 6.5 mm [range, 0.5-11.5 mm]). (4) The length of the quadrangular cartilage along the nasal dorsum, from the junction with the PPE under the nasal bones to the anterior septal angle (mean, 27.0 mm [range, 20.0-34.5 mm]). (5) The proportion of dorsal quadrangular cartilage overlapped by the nasal bone, measured as the ratio of measurement 3 to measurement 4 (mean, 23.8%) (Figure 3).

The measurements of the midline overlap (measurement 3) demonstrated no statistical significance when compared with the data set from the prior study by Kim et al1 (mean, 7.0 mm [range, 5.3-10.0 mm]) (P = .61), although less variability was seen among the Asian cadavers.

Comment. Historically, the keystone region has been recognized as an important surgical region. In 1917, Ay-mard2 reported the midline overlap to be 8 mm. An-
other study, by Lange and Mundorff-Vetter,\textsuperscript{3} showed the overlap to be 6.8 mm. Natvig et al,\textsuperscript{4} using cross-sections through the ULC–nasal bone junction, found as much as 9 mm of overlap in the midline; they also noted that the overlap tapered laterally terminating in end-to-end opposition.

Our current study confirms these prior reports, showing a 6.5-mm average of nasal bone overlap with the quadrangular cartilage. Also, our specimens, an entirely white cohort, revealed little difference from the 7.0-mm value that Kim et al\textsuperscript{1} measured in an Asian population. We also established that sex and age of the cadaveric specimens did not significantly influence the average overlap length. This finding deviates from the study by Kim et al,\textsuperscript{1} which found the overlap length decreased in older specimens, possibly a result of septal cartilage calcification with aging.

The developmental emergence of dorsal nasal structures contributes to the stability of the keystone region. Embryologically, the dorsum of the nose develops from the frontonasal prominence, and the septum develops from the medial nasal prominences. The keystone region derives its strength and stability from the overlap of cartilage and bone that occurs between the ULC and nasal bones,\textsuperscript{4} and between the nasal bones and quadrangular cartilage. Furthermore, at the level of the ULC–nasal bone junction, the quadrangular cartilage is contiguous with the ULC.\textsuperscript{3} These overlapped areas are further reinforced by periosteal-perichondrial and mucosal investments.

The quadrangular cartilage has an osseocartilaginous interface on 3 surfaces: inferiorly, the anterior nasal spine and maxillary crest, posteriorly along the PPE, and cephalically at the keystone. The thickening of the cartilage at these junctions serves to further buttress these regions. Holt\textsuperscript{6} noted that fractures of the septum tend to occur above or anterior to these buttresses. This was fur-

\begin{table}
\centering
\caption{Measurements From Each Specimen}
\begin{tabular}{|c|c|c|c|c|c|}
\hline
Sex/Age, y & Dorsal Articulation of NB-ULC & Lateral Articulation of NB With ULC & ULC Under NB & DQC Overlapped by NB & Proportion of DQC Overlapped by NB, Mean \\
\hline
M/40 & 8.0 & 7.0, 6.0 & 6.0 & 28.0 & 0.21 \\
F/70 & 7.0 & 10.0, 9.0 & 0.5 & 22.0 & 0.02 \\
M/90 & 12.0 & 11.0, 14.0 & 9.0 & 21.0 & 0.43 \\
M/65 & 11.0 & 8.0, 11.0 & 7.0 & 31.0 & 0.23 \\
M/78 & 7.0 & 13.0, 13.0 & 6.0 & 28.0 & 0.21 \\
M/70 & 7.0 & 12.5, 10.0 & 4.0 & 28.0 & 0.14 \\
F/56 & 6.5 & 9.0, 12.0 & 11.5 & 34.5 & 0.33 \\
M/72 & 9.0 & 11.0, 18.0 & 7.0 & 28.5 & 0.25 \\
M/58 & 6.0 & 11.0, 10.0 & 5.0 & 20.5 & 0.24 \\
M/71 & 10.0 & 15.0, 11.0 & 6.0 & 29.0 & 0.21 \\
M/27 & 4.5 & 12.0, 15.0 & 9.5 & 28.0 & 0.34 \\
Mean (SD) & 8.0 (2.3) & 11.3 (2.8) & 6.5 (2.9) & 27.1 (4.3) & 0.24 (0.11) \\
\hline
\end{tabular}
\footnotesize{Abbreviations: DQC, dorsal quadrangular cartilage; NB, nasal bone; ULC, upper lateral cartilage.}
\end{table}
the use of spreader grafts.9 Thus, the dorsal surface of the quadrangular cartilage is without bony fixation and relies on the osseocartilaginous interactions at the keystone for structural stability.

While the term “keystone” was initially coined to impress the structural importance of this anatomical region, its contribution to nasofacial aesthetics should not go understated. The keystone serves as a diverging point in the dorsal aesthetic lines on frontal view and further contributes to the nasofrontal angle on profile. Its location at the junction of the upper and middle thirds of the nose, and the inherent continuity it provides, allows for the dorsal contour; and by anchoring the dorsal quadrangular cartilage, it orients the nasal dorsum beyond the nasal bones.

In our measurements the quadrangular cartilage had an average dorsal length of 27 mm, originating from the keystone region. In proportion to the midline osseocartilaginous overlap of 6.5 mm, only 24% of the dorsal septum is securely fixed at the keystone. The remainder of the dorsal septum is only loosely supported by the ULCs and lower lateral cartilages. Accordingly, small changes in the orientation of the quadrangular cartilage at the keystone can result in considerable dorsal perturbations. Lateral deviations of the quadrangular cartilage at the keystone may especially result in failure of previously established aesthetic ideals.

Based on these observations, deliberation and care must be taken during surgical procedures that require manipulation of the middle vault and keystone regions. Dorsal hump reductions, as well as medial and lateral osteotomies, may eliminate these stabilizing contributions to the keystone. Dorsal reduction techniques that equally weigh the aesthetic and functional needs of the patient should be considered.8 Efforts to maintain the stability of the keystone during reconstructive rhinoplasty should further include preservation of the transverse ULCs and the use of spreader grafts.9

In our modest series, the minimum degree of overlap between the quadrangular cartilage and the nasal bones was 0.5 mm, even though the mean length was consistent with published norm. Furthermore, the average length of overlap was similar to that of a Korean population—a remarkably conserved measure despite known anthropometric differences between the white nose and the Asian nose. Surgeons operating in this area should not only be informed on the expected dimensions of the keystone region but also be aware that considerable variability can exist. Given this understanding, the key-

stone should be considered an area of great importance in reconstructive efforts of the nose, and a careful assessment of this area should be carried out during rhinoplasty.

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