Morphometry of Paranasal Sinus Anatomy in Chronic Rhinosinusitis

A Pilot Study

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Objectives: To test the null hypothesis that there is no relationship between anatomical variations around the ostiomeatal complex and a predisposition to chronic rhinosinusitis and to define such variations with increased precision.

Design: Case-control study of anatomical variations in diseased and normal sinuses. Eight homologous landmarks defining the ostiomeatal complex were located on coronal computed tomographic scans, and their x and y coordinates were digitized using image analysis.

Subjects: Ten patients with unilateral sinus disease and 10 subjects without sinus disease (scanned for facial pain) who were selected retrospectively by case-note analysis.

Results: Logistic regression showed that the only significant spatial change predictive of a person with rhinosinusitis was the vertical position of the middle turbinate ($P = .04$), although this was not confirmed by Wilcoxon testing ($P > .10$). When examined by sinus, however, the horizontal position of the uncinate process was more laterally placed in persons with rhinosinusitis ($P = .01$), confirmed on Wilcoxon testing ($P = .04$), but there was no significant difference when compared with sinuses in persons without rhinosinusitis.

Conclusions: Our findings suggest that there are no anatomical differences within the ostiomeatal complex between patients with and without rhinosinusitis. Patients with rhinosinusitis, however, are more likely to develop it in the side with a more laterally positioned uncinate process. Further studies, with more patients and more advanced techniques, including thin-plate spline analysis, are indicated.


PARANASAL RHINOSINUSITIS is now the most common chronic disease in the Western world and is therefore a major cause of morbidity. It is accepted that the functional anatomy of the region and disease within it are intimately related. Stammberger identified mucosal contact in the middle meatus, with subsequent ciliary dysfunction and mucus retention, leading in some cases to blockage of the maxillary or frontal sinus ostia, as a key factor in the pathogenesis of rhinosinusitis. Any anatomical abnormality that impairs sinus ventilation or leads to mucosal contact might therefore be expected to predispose to the development of rhinosinusitis.

The effects of a wide range of anatomical variations have been studied. It has been suggested that septonal deviation predisposes to rhinosinusitis; Yousem et al and Calhoun et al support this hypothesis. Other variations thought to contribute to the development of rhinosinusitis include concha bullosa (pneumatized middle turbinate), paradoxically angulated middle turbinate, abnormal angulation of the uncinate process, uncinate bulla, agger nasi and Haller cells, and the secondary middle turbinate. Also, the effects of different patterns of attachment of the uncinate process have been assessed. Reasonable evidence of an association with rhinosinusitis has been demonstrated only for concha bullosa, however, and doubt has even been cast on this.

The reported incidence of the above variations has differed markedly between studies. Until recently, accurate and reproducible assessment has been difficult, in part because of a lack of consensus about certain definitions, and this may account for some of the discrepancies. It is now possible, however, to digitize homologous landmarks and to compare their statistical and geometrical behavior. Morphometry itself is not new, but, to our knowledge, it has not been applied previ-
SUBJECTS AND METHODS

Ten coronal computed tomographic scans of patients with facial pain but no other clinical evidence of sinus disease, and whose findings on scans had been reported as normal, were selected retrospectively by case-note analysis. Ten other patients, with a history of at least 2 years of purely unilateral symptoms of facial pain, congestion, and mucopurulent nasal discharge and radiological evidence of purely unilateral sinus disease, were also selected. This group thus provided their own internal controls. Patients excluded from the study were those with a history of previous nasal or sinus surgery and those with a congenital maxillofacial abnormality.

The computed tomographic scans were examined by a single head and neck radiologist, blinded to the clinical features. The slice judged to be passing through the ostiomeatal complex was selected and enlarged directly from the scanner's hard drive. Eight homologous landmarks (Figure) on the left and right were then digitized using a standard digitizing tablet and custom-designed software. The accuracy of the digitization and interpretation of landmark definitions were checked by duplicate digitization of the same scan by the same operator. Landmarks showing a discrepancy of greater than 1% on subsequent digitization were excluded from the analysis.

The x and y coordinates of the landmarks were analyzed using the Kolgorov-Smirnov test for normality of distribution and the Levene test for equivalence of variance. Multivariate analysis was performed to identify which landmarks varied significantly between the groups studied. Comparisons were made both between the control and diseased group of patients and between the normal and diseased sides of the patients with rhinosinusitis.

The data were not normally distributed (Kolgorov-Smirnov) but exhibited equivalence of variance (Levene). Logistic regression was performed on the transformed data, with the presence or absence of disease as the dependent variable, and the results were confirmed using Wilcoxon testing.

Multiple linear regression showed a significant difference in the vertical position of the tip of the middle turbinate between the control and diseased groups (P = .04). This difference was not confirmed on Wilcoxon testing (P > .10), however. When the normal and diseased sides were compared in the patients with rhinosinusitis, the tip of the uncinate process was found to be more laterally placed on the diseased side (P = .01), which was confirmed on Wilcoxon testing (P = .04), but there was no significant difference when compared with the control group.

The 8 landmarks used to define the ostiomeatal complex: 1 and 2, the left and right supraorbital margins; 3, the junction of the ethmoid bullae and the lamina papyracea; 4, the margin of the ethmoid bulla opposite the tip of the uncinate process; 5, the lateral aspect of the middle turbinate opposite the tip of the uncinate process; 6, the tip of the uncinate process; 7, the inferior margin of the middle turbinate; and 8, the point of attachment of the inferior turbinate.

The role of the morphology of the paranasal sinuses in the pathogenesis of chronic rhinosinusitis warrants investigation because of the high incidence of rhinosinusitis and the potential link between the identification of morphological variation and the planning of surgical intervention. Therefore, this retrospective, controlled pilot study determined whether this approach to the study of sinus anatomy merits further investigation. The initial results suggest that there is no difference in ostiomeatal complex anatomy between persons who develop rhinosinusitis and those who do not. Those who develop rhinosinusitis, however, are more likely to do so on the side with the more laterally placed uncinate process. This finding concurs with that of Stammberger in that this lateral placement would presumably narrow the maxillary sinus ostium and could lead to mucociliary contact and predispose to the blockage of sinus drainage.
Neither of the landmarks relating to the middle turbinate showed any significant differences in their positions in either of the comparisons made. Therefore, we cannot confirm that the presence either of a concha bullosa or of paradoxical angulation of the middle turbinate contributes to the development of rhinosinusitis.

The role of septal deviation in the pathogenesis of rhinosinusitis was not addressed in this study. While the techniques we used would be well suited to an objective and quantitative assessment of septal deviation, we decided that the ostiomeatal complex should initially be studied in isolation.

No provision was made in the digitization protocol to take into account previously described anatomical variations, such as the secondary middle turbinate or agger nasi or Haller cells, so no conclusions can be drawn about their proposed role in the pathogenesis of rhinosinusitis. Subsequent studies would be planned so as to include landmarks defining these variations where possible.

Extreme caution must be exercised in interpreting the results, as the numbers in this study are small. Also, the retrospective manner in which the scans were selected may have introduced significant bias, and the analysis was performed in 2 dimensions only. However, the results have shown a statistically significant difference in the position of 1 landmark, and this finding would appear to be in accordance with previous work. Although we do not believe that we can categorically reject the null hypothesis at this stage, we do believe that the initial results are sufficiently encouraging to justify further studies. The first step will be to apply more sophisticated analytical techniques to the existing data using registration-free analysis, including thin-plate spline techniques.

Our study was concentrated almost exclusively on the ostiomeatal complex, and while the anatomy of this region may be important in sinus function, in future studies it would be important to consider other areas as well. For the future, we plan a prospective study with larger numbers of subjects and using 3-dimensional analytical techniques that would allow the whole nasal and paranasal region to be studied. We hope that these studies will help to clarify the relationship between morphology, function, and disease in this region and to guide future developments in surgery for chronic rhinosinusitis.

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