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Correlation of frontal sinus recess anatomy with ethnicity, gender, and pathology

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ABSTRACT

Purpose: Research on frontal sinus cells has been conflicting regarding relationship between frontal sinus cells and frontal sinus disease. There are no published studies regarding gender differences in frontal sinus disease. No comparisons between African Americans and Caucasians and frontal sinus disease have been published. This study attempts to define the above relationships as well as the relationship between number and types of cells and disease.

Methods: A retrospective chart review was performed on sinus CT scans done from 2003 to 2011 at an academic medical center. Exclusion criteria included previous frontal sinus surgery, sinus malignancy, obvious trauma, congenital anomalies, and poor quality of scan. Number and type of frontal cells were recorded for 602 scans. Statistical analysis performed demographic comparisons and compared number and types of cells to evidence of disease.

Results: Males were more likely than females to have frontal sinus disease. Patients with Type 3 and Type 4 cells were more likely to have disease. No significant ethnic related differences in disease were found using a multivariate logistic regression model. Total number of cells did not significantly affect likelihood of disease.

Conclusions: This is one of the largest collections of data on frontal sinus cells as predictors of frontal sinus disease. These results suggest that gender and certain types of cells affect likelihood of disease. This study is the first to demonstrate a lack of difference in disease in African Americans and Caucasians. These results are significant regarding gender, race, number and type of cells as predictors of disease.

1. Introduction

Endoscopic frontal sinus surgery requires a detailed understanding of frontal sinus anatomy. The frontal recess and frontal sinus outflow tract vary greatly in their anatomy, often due to pneumatization of the frontal recess, which results in frontal recess cells. A normal variant in much of the population, frontal cells have the potential for causing frontal sinus disease, largely due to obstruction of the frontal sinus outflow tract [1]. Because of the implications of these cells in frontal sinus disease and the various types of cells seen, a frontal sinus cell classification system was developed by Kuhn to allow prediction of prognosis and to facilitate communication regarding frontal recess anatomy [2]. Frontal recess cells include the frontal cell types I-IV, agger nasi, supraorbital ethmoid, frontal bullar, suprabullar, and interfrontal sinus septal cell [3]. A significant body of research has focused on the description and prevalence of frontal cells and their relationship to frontal disease. The presence of frontal cells has been associated with frontal sinus mucosal thickening, concha bullosa, and frontal sinusitis. Although research has established a connection between frontal cells and frontal sinus disease, the exact relationship between the prevalence of frontal sinus cells and incidence of frontal disease is unknown.

To our knowledge, no studies have been published specifically investigating gender differences and prevalence of frontal sinusitis. Ethnic differences in frontal sinusitis have been a focus of research, but no published research was found comparing African American and Caucasian populations. This study attempts to define the above relationships as well as the relationship between number and types of cells and disease to facilitate the identification and treatment of frontal sinus disease as it relates to gender, ethnicity, and frontal cell incidence.

2. Materials and methods

This study was performed at an academic medical center (University of Mississippi Medical Center in Jackson, Mississippi). This study was approved by the Institutional Review Board at the University of Mississippi Medical Center. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. We retrospectively identified all patients that underwent sinus

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Table A
Modified Kuhn classification of frontal sinus cells.

Frontal sinus cell Type 1	A single frontal recess cell above the agger nasi cell
Frontal sinus cell Type 2	A tier of two frontal recess cells above the agger nasi cell
Frontal sinus cell Type 3	A single large frontal recess cell above the agger nasi that pneumatizes into the frontal sinus; posterior wall is a free partition in the frontal sinus
Frontal sinus cell Type 4	A single frontal recess cell above the agger nasi cell that is isolated in the frontal sinus; posterior boundary is cell wall, not posterior frontal sinus table

computed tomography (CT) scans at the University of Mississippi Medical Center performed between the years 2003–2011. These scans were not limited to specific providers or specific diagnoses. Exclusion criteria included previous frontal sinus surgery, sinus malignancy, congenital anomalies, significant maxillofacial trauma, lack of axial, coronal, and sagittal CT scan views, and poor quality of scan. A total of 832 sinus CT scans were performed during the study time frame, and 602 scans met inclusion criteria. All CT scans had 0.6 mm axial cuts. Frontal sinus cell types I-IV, agger nasi cells, supraorbital ethmoid cells, suprabullar cells, frontal bullar cells, and interfrontal sinus septal cells were reviewed by the first author for each scan, right and left sides. The original frontal sinus cell classification system developed by Kuhn was used to define frontal sinus cells, with more detailed descriptions from recent publications (Table A).

The right and left sides of each scan were evaluated for evidence of frontal sinusitis. Frontal sinusitis was defined as >3 mm of mucosal thickening involving the frontal sinus or the dependent portions of the frontal sinus, a commonly used definition based on previous studies.

Demographic comparisons of those with frontal sinus disease to those without frontal sinus disease were made with *p*-values computed according to Pearson's chi-square statistic, with the exception of age, which was computed using a two sample *t*-test. A logistic regression, adjusted for ethnicity and gender, compared the proportion of patients exhibiting each type of cell between those with frontal sinus disease and those without frontal sinus disease. Frontal sinus cell comparisons were also made using a multivariable logistic regression model for ethnicity and gender as independent predictors of cell count. The total number of frontal sinus cells was compared between those with frontal sinus disease and those without frontal sinus disease.

Table B
Demographic comparisons of those with frontal sinus disease (Sinus Dx) to those without frontal sinus disease (No Sinus Dx) with *p*-values computed according to Pearson's chi-square statistic with the exception of age, which was computed using an independent samples *t*-test ($p < 0.05$ marked in bold).

		All patients $N = 602$	No Sinus Dx $N = 508$	Sinus Dx $N = 94$	*p*-Value
Age		46.1 (16.29)	45.78 (16.31)	47.82 (16.15)	0.2652
Race	African American	261 (43.4%)	228 (44.9%)	33 (35.1%)	0.0789
	Caucasian	341 (56.6%)	280 (55.1%)	61 (64.9%)	
Sex	Male	193 (32.1%)	152 (29.9%)	41 (43.6%)	**0.0090**
	Female	409 (67.9%)	356 (70.1%)	53 (56.4%)	

p-Values are based on either the chi-square (categorical variables) or the two-sample *t*-test (continuous variables).

3. Results

602 scans met inclusion criteria. The majority of the sample did not have evidence of frontal sinus disease (84.4%) (Table B). The age distribution was similar for those with sinus disease (mean age: 47.82 ± 16.15) and those without sinus disease (mean age: 45.78 ± 16.31). The two main ethnic groups in our region's patient population are Caucasian and African American, and these groups were relatively evenly represented (56.6% Caucasian and 43.4% African American). There were more females than males in our study (67.9% versus 32.1%).

Males were found to have a significantly higher proportion of sinus disease (21.2%) compared to females (13.0%, $p = 0.0090$). No statistically significant differences in sinus disease were found between Caucasians and African Americans ($p = 0.0789$).

A logistic regression, adjusted for ethnicity and gender, was used to compare proportions that exhibited each type of cell between those with frontal sinus disease and those without frontal sinus disease (Table C). After combining left and right sides, frontal sinus cell types III and IV were found to be significantly associated with sinus disease ($p = 0.0291$ and 0.0315, respectively). The odds of expressing frontal sinus cell type III were 1.74 times higher for those with sinus disease than those without sinus disease (95% confidence interval 1.06, 2.86). The odds of expressing frontal sinus cell type IV were 2.06 times higher for those with sinus disease than those without sinus disease (95% confidence interval 1.07, 3.97). In our sample, those with interfrontal sinus septal cells were less likely to develop sinus disease [OR = 0.51 (0.26, 0.99)], and these results were statistically significant (0.0475).

Frontal sinus cell comparisons were made using multivariable logistic regression model for ethnicity and gender as independent predictors of cell count. Males were more likely to have frontal sinus cell types I and IV.

Total number of frontal sinus cells was not a predictor of frontal sinus cell disease (Fig. A). The marginal cell mean for those with sinus disease was 3.68 ± 0.18 and for those without sinus disease was 3.46 ± 0.09, and the means were not significantly different ($p = 0.2428$).

4. Discussion

Research on frontal sinus anatomy and frontal sinusitis has attempted to define the relationships between frontal sinus cells and frontal sinusitis, specifically, to determine which cells are more likely to cause frontal sinusitis. The ultimate goal of these studies seeks to apply known relationships between cells and sinus disease to rhinologic surgeons' decision making regarding endoscopic sinus surgery. The largest published study, to our knowledge, is Meyer's 2003 review of 768 scans [4]. Our study is one of the largest collections of data on frontal sinus cells, with a sample size of 602.

Table C
Comparisons of the proportion of patients who exhibited each type of cell between those with frontal sinus disease to those without frontal sinus disease, with *p*-values and odds ratios (95% confidence intervals) based on a logistic regression, adjusted for ethnicity, sex, smoking status, and year ($p < 0.05$ marked in bold).

Cell	No Sinus Dx $N = 508$	Sinus Dx $N = 94$	OR (95% CI)	*p*-Value
Frontal cell type 1 (FC1)	192 (37.8%)	31 (33.0%)	0.86 (0.56, 1.31)	0.4815
Frontal cell type 2 (FC2)	80 (15.7%)	15 (16.0%)	0.90 (0.51, 1.59)	0.7244
Frontal cell type 3 (FC3)	87 (17.1%)	24 (25.5%)	1.74 (1.06, 2.86)	**0.0291**
Frontal cell type 4 (FC4)	33 (6.5%)	13 (13.8%)	2.06 (1.07, 3.97)	**0.0315**
Agger nasi cell (ANC)	459 (90.4%)	90 (95.7%)	1.45 (0.89, 2.36)	0.1394
Supraorbital ethmoid cell (SOEC)	86 (16.9%)	18 (19.1%)	0.93 (0.55, 1.57)	0.7747
Suprabullar cell (SBC)	183 (36.0%)	35 (37.2%)	1.05 (0.71, 1.56)	0.7892
Frontal bullar cell (FBC)	104 (20.5%)	23 (24.5%)	1.31 (0.80, 2.15)	0.2831
Interfrontal sinus septal cell (IFSS)	113 (22.2%)	11 (11.7%)	0.51 (0.26, 0.99)	**0.0475**

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