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Correlation between Nasal Cavity Anatomy and Susceptibility to *Staphylococcus Aureus* Colonization

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ABSTRACT

Background

Staphylococcus aureus is a frequent inhabitant of the nasal cavity and can change from an opportunistic pathogen to a threat, particularly in clinical environments. Although the sociobiology and immunobiology of colonization have been thoroughly examined, the possibility of the nasal structure assisting bacterial retention is still under investigation. Examine the relationship between the structural variations of the nasal cavity and the susceptibility to colonization of Staphylococcus aureus among fully grown adults without any nasal infections.

Keywords

Staphylococcus aureus, nasal colonization, nasal anatomy, septal deviation, turbinate hypertrophy, nasal valve angle, MRSA, nasal cavity volume

Methods
This cross-sectional study from January 2023 to January 2024 was conducted at Hayatabad Medical Complex, Peshawar, with 79 adult participants. Clinical examination and nasal endoscopic evaluation were performed, and the following anatomical parameters were recorded: bilateral septal deviation, turbinate hypertrophy, nasal valve angle, and volumetric assessment of the nasal cavity. Nasal swabs were taken bilaterally for microbiological culture and sensitivity testing. Data analysis was performed using SPSS version 25, and a significance level of $p < 0.05$ was applied.
Results
Colonization with *S. aureus* was identified in 43% of participants, with 35% being MRSA strains. Significant associations were observed between colonization and moderate-to-severe septal deviation ($p = 0.032$), turbinate hypertrophy ($p = 0.040$), narrower nasal valve angle ($p = 0.011$), and reduced nasal cavity volume ($p = 0.004$). Smoking was also significantly associated with colonization ($p = 0.041$), while daily nasal hygiene was linked to a lower colonization rate ($p = 0.027$).
Conclusion
Certain features within the nasal cavity that cause constriction or blockages could facilitate S. aureus colonization. The ability to recognize and follow up such individuals with these defined structures might be useful in clinical and surgical practice, especially concerning infection control in vulnerable and susceptible groups.

INTRODUCTION

Inhaled air enters through the nasal cavity, which is lined with a delicate mucosal surface responsible for filtering, humidifying, and defending against pathogens. One of the most prevalent bacteria found in the anterior naris region is Staphylococcus aureus. A microorganism that can exist harmlessly, as a commensal, or be dangerous by causing localized and systemic infections. S. aureus nasal colonization is common, and it poses a major risk of subsequent infections, especially in hospitals and for people with weak immune systems[1-3].Histological features of nasal epithelial cells play a key role in colonization of *S. aureus* pathogens. They bear receptors for the cell wall teichoic acid (WTA) of the *S. aureus[4, 5]*.

Various immune factors, hygiene practices, and antibiotics have been researched regarding S. aureus colonization; however, nasal anatomy poses a rather understudied area of focus. Structural changes in the nose, like septal deviation and turbinate hypertrophy, along with differences in the nasal cavity's volume, could affect airflow patterns and mucociliary clearance, which are critical in establishing the probability of bacterial colonization. Restriction or narrowing of spaces may form microenvironments that enrich for persistent bacteria by decreasing oxygen and changing mucosal surface exposure patterns[6-8]. Only recently has an interest emerged in anatomical predisposing factors for microbial carriage due to the increasing incidence of methicillin-resistant S. aureus (MRSA). Learning how nasal anatomy might influence surgical or medical professional colonization and the possibility of haphazard nasal surgical procedures in healthcare may help identify at-risk patients[9-11].

This study evaluated the relationship between nasal cavity anatomy and *Staphylococcus aureus* colonization in adults with no active nasal infection. By assessing structural and demographic

factors, the research aims to clarify whether specific anatomical patterns are significantly associated with colonization, thereby contributing to preventive strategies in clinical practice.

METHODOLOGY

This cross-sectional study was done at the Department of ENT and Microbiology, Hayatabad Medical Complex, Peshawar, from January 2023 to January 2024. The key objective was to determine the association between nasal anatomical variations and Staphylococcus aureus colonization in the absence of nose infection. Through non-probability consecutive sampling, 79 participants were enrolled. The Institutional Review Board of Hayatabad Medical Complex granted ethical clearance. The study assured respondents that their information would be kept secret and that all steps were taken in line with accepted ethical research practices.

Participants aged 18 years and above were eligible if they were not experiencing upper respiratory infections and had not used antibiotics in the previous two weeks. Those with a history of recent nasal surgery, intranasal medication use, known immunodeficiency, or posttraumatic nasal deformities were excluded. Informed written consent was obtained from all individuals before data collection.

Demographic information, including age, gender, smoking status, personal nasal hygiene habits, and comorbidities such as diabetes mellitus, was recorded using a structured proforma. Each participant underwent nasal examination by an ENT specialist using anterior rhinoscopyand nasal endoscopy. Anatomical features assessed included the degree of septal deviation, turbinate hypertrophy, nasal valve angle (in degrees), nasal cavity volume (estimated via acoustic rhinometry), mucosal thickening, nasal polyps, and nostril size asymmetry.

Nasal swabs were collected aseptically from both nostrils and immediately transported to the microbiology laboratory for processing. Samples were inoculated onto Mannitol Salt Agar and incubated for 24 to 48 hours at 37°C. Gram staining, catalase, and coagulase tests confirmed suspected colonies as Staphylococcus aureus. Methicillin resistance was identified using the Kirby-Bauer disc diffusion method following CLSI guidelines. Antibiotic sensitivity patterns were also documented.

All data were analyzed using SPSS version 25. Frequencies and percentages were used for categorical variables, while means and standard deviations were calculated for continuous data. The Chi-square or Fisher's exact test was applied for categorical comparisons, and independent t-tests were used for continuous variables. A p-value of less than 0.05 was considered statistically significant.

RESULT

The demographic characteristics of the study population revealed that age and gender were not significantly associated with *Staphylococcus aureus* colonization. The average age was comparable between colonized and non-colonized groups. Similarly, the male-to-female ratio showed no significant difference. However, a significant relationship was found with smoking status, where smokers were more likely to be colonized ($p = 0.041$), suggesting that smoking may contribute to altered nasal immunity or mucosal changes. Another important finding was that participants who practiced daily nasal hygiene had significantly lower colonization rates ($p = 0.027$), indicating a protective effect of routine cleaning. Neither recent antibiotic use nor diabetes mellitus showed a statistically meaningful association with nasal colonization in this cohort.

Table 1: Demographic Characteristics and Association with *S. aureus* Colonization

Variable	***S. aureus* Positive (n=34)**	***S. aureus* Negative (n=45)**	**pvalue**

Age (mean ± SD)	31.8 ± 9.4	30.6 ± 10.1	0.542
Gender (Male/Female)	20 / 14	26 / 19	0.889
Smoking Status (Yes/No)	17 / 17	15 / 30	0.041*
Recent Antibiotic Use	9 (26.5%)	14 (31.1%)	0.661
Diabetes Mellitus	4 (11.8%)	3 (6.7%)	0.456
Nasal Hygiene (Daily/None)	9 / 25	20 / 25	0.027*

*p < 0.05 considered statistically significant

When assessing anatomical variables, several notable associations emerged. Participants with moderate to severe nasal septal deviation were significantly more likely to be colonized (p = 0.032), possibly due to impaired airflow and mucociliary clearance. Turbinate hypertrophy is also linked considerably with colonization (p = 0.040), likely reflecting chronic mucosal congestion. A narrower nasal valve angle and smaller nasal cavity volume were significantly associated with colonization (p = 0.011 and p = 0.004), suggesting structural restrictions might predispose to bacterial retention. While mucosal thickening and nostril asymmetry showed trends toward significance, they did not meet the statistical threshold. The presence of nasal polyps was not significantly related to colonization status.

Table 2: Nasal Cavity Anatomy and *S. aureus* Colonization

Anatomical Variable	***S. aureus* Positive (n=34)**	***S. aureus* Negative (n=45)**	**pvalue**
Septal Deviation (Mod–Sev)	18 (52.9%)	13 (28.9%)	0.032*
Turbinate Hypertrophy (Present)	21 (61.8%)	17 (37.8%)	0.040*
Nasal Valve Angle (mean ± SD)	8.3° ± 1.4°	9.1° ± 1.1°	0.011*
Nasal Cavity Volume (cm^3)	11.6 ± 2.1	13.2 ± 2.4	0.004*
Nostril Size Asymmetry > 2 mm	12 (35.3%)	9 (20.0%)	0.119
Nasal Polyps (Present)	5 (14.7%)	2 (4.4%)	0.140
Mucosal Thickening (Present)	16 (47.1%)	12 (26.7%)	0.059

*p < 0.05 considered statistically significant

Among those colonized, 64.7% carried methicillin-sensitive *Staphylococcus aureus* (MSSA), while 35.3% harbored methicillin-resistant strains (MRSA). Half of the positive cases showed bilateral colonization, indicating a more widespread nasal involvement. The remaining cases were split between the left and right nostrils. The bacterial load was moderate to high in most cases, with 38.3% showing high concentrations of colonization. Regarding antibiotic resistance, most MRSA strains were resistant to erythromycin (66.7%), a third were resistant to ciprofloxacin, but all remained sensitive to vancomycin. These findings reinforce the concern about growing antibiotic resistance and the importance of continuous monitoring.

Table 3: Colonization Patterns and Microbiological Variables

Variable	**Frequency (n=34)**	**Percentage (%)**
Culture Type		
– MSSA	22	64.7%
– MRSA	12	35.3 %

Colonization Site		
– Left Nostril	10	29.4%
– Right Nostril	7	20.6%
– Bilateral	17	50.0 %
Bacterial Load		
– Low (<10^3 CFU/mL)	6	17.6%
– Moderate (10^3–10^5 CFU/mL)	15	44.1%
– High (>10^5 CFU/mL)	13	38.3 %
Antibiotic Resistance (MRSA only)		
– Erythromycin	8 / 12	66.7%
– Ciprofloxacin	4 / 12	33.3%
– Vancomycin	0 / 12	0.0%

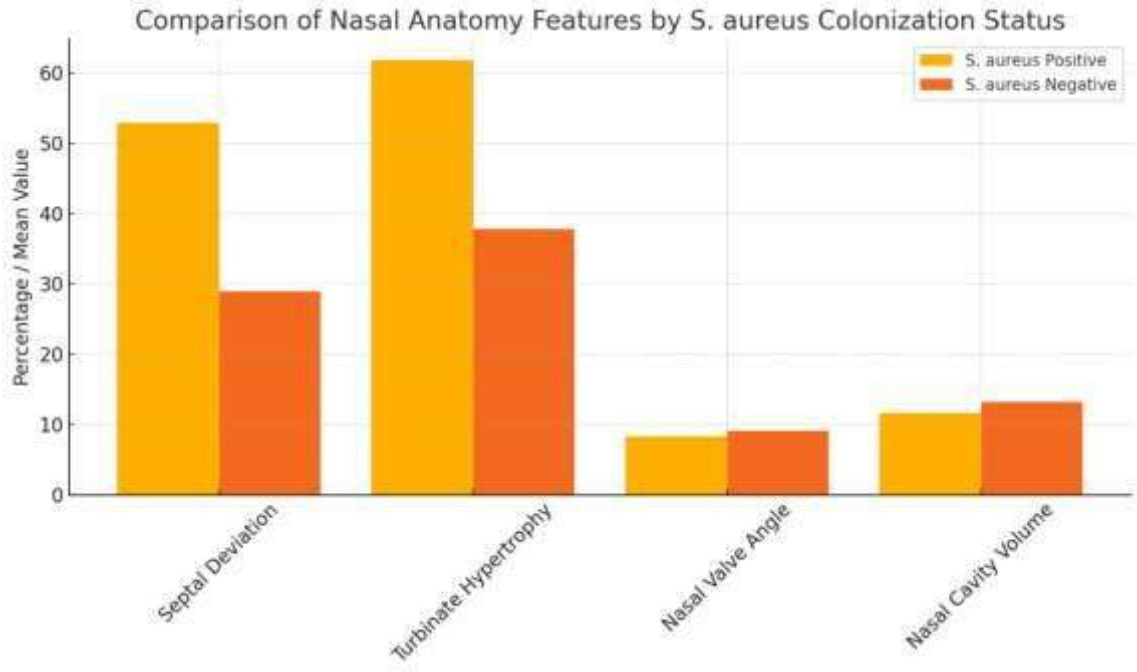

Figure 1

The bar graph suggests distinct differences in the nasal features of those infected with Staphylococcus aureus compared to those who are not. Colonized participants had greater septal deviation than non-colonized participants, with more than half exhibiting moderate to severe deviation versus less than a third in the non-colonized group. In the colonized group, more hypertrophy was present, suggesting that obstructive nasal structures may lead to increased retention. In terms of measurable features, the colonized group had a narrower average nasal valve angle, which was also associated with decreased overall nasal cavity volume. Such structural attributes may lead to decreased ventilation through the nasal passages, encouraging nasal passage bacterial colonization. The graph highlights the extent to which internal structures of the nose may influence an individual's susceptibility to nasal S. aureus carriage.

DISCUSSION

The researcher seeks to understand the relationship between Staphylococcus aureus colonization and structural variations in the nasal cavity. The results indicate that certain features of the nose's anatomy strongly associate with the S. aureus organism, suggesting that S. aureus colonization is influenced by the nasal structure[12-14].

A significant association was observed between septal deviation and *S. aureus* colonization. Participants with moderate to severe deviation were more frequently colonized, possibly due to disrupted airflow and impaired mucociliary clearance. This finding aligns with studies reported that structural obstruction in the nasal passages could create favorable conditions for bacterial retention and biofilm formation[15-17].

Turbinate hypertrophy was another anatomical factor significantly associated with colonization. Enlarged turbinates can reduce airflow and lead to stagnant mucosal surfaces, which may support microbial growth. These observations are consistent with studies that demonstrate chronic nasal obstruction, including turbinate enlargement, increases susceptibility to bacterial colonization due to compromised nasal ventilation[18-21]. The study also found that individuals with narrower nasal valve angles and reduced nasal cavity volumes were likelier to carry *S. aureus*. A narrower valve angle may reduce effective ventilation, allowing organisms to persist in a relatively low-oxygen, humid environment. This supports the theory that nasal architecture influences air passage and microbial ecology. reached a similar conclusion, finding that airflow dynamics directly impact the distribution of commensal and pathogenic bacteria in the nasal cavity[22].

In terms of demographic variables, smoking showed a statistically significant association with colonization. Tobacco exposure may impair nasal immunity and damage the mucosal lining, making the site vulnerable to bacterial adherence. Previous research, has highlighted this, where smokers demonstrated higher carriage rates of *S. aureus*than non-smokers. Daily nasal hygiene was also shown to have a protective role, suggesting that regular cleansing might reduce microbial load or disrupt biofilm formation[23].

Interestingly, while other studies have implicated comorbidities such as diabetes or prior antibiotic use in increased colonization risk, this study did not find a significant relationship between these variables and nasal colonization. This discrepancy might be attributed to differences in sample size, population health status, or duration of antibiotic exposure.

The microbiological profile in this study showed that nearly one-third of colonized individuals harbored methicillin-resistant strains (MRSA), reinforcing the need for routine surveillance in both hospital and community settings. The high resistance to erythromycin and ciprofloxacin among MRSA isolates is concerning and supports existing literature emphasizing the growing challenge of antibiotic resistance.

Overall, these findings underscore that the nasal cavity is not merely a passive conduit for airflow but an active site where anatomy, behavior, and microbiological factors interact. Recognising anatomical predispositions could be beneficial in identifying individuals at higher risk of persistent colonisation, particularly in healthcare workers or surgical patients, where *S. aureus* carriage can lead to serious infections.

CONCLUSION

This study concludes that specific nasal anatomical features, including septal deviation, turbinate hypertrophy, narrower nasal valve angles, and smaller nasal cavity volumes, are significantly associated with an increased risk of *Staphylococcus aureus* colonization. Behavioural factors such as smoking were also linked to higher colonisation, while regular nasal hygiene offered protection. These results highlight the importance of considering anatomical and lifestyle factors in infection control strategies. In clinical settings, individuals

with such nasal characteristics may benefit from targeted screening or decolonization protocols, particularly in high-risk environments like hospitals. Future research with larger sample sizes and advanced imaging techniques is recommended to further elucidate the interplay between nasal structure and microbial colonization.

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