

Bacterial biofilm in adults with ENT pathology

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ABSTRACT

Introduction. Chronic rhinosinusitis, a very common inflammatory condition, is a main public health issue affecting the quality of life. Furthermore, some patients do not respond to either medical or surgical intervention, which could be explained by the presence of the bacterial biofilm in the rhinosinusal zone.

Objectives. The aim of this study is to evaluate the influence of endoscopic sinus surgery on olfactory impairment caused by chronic sinusitis with and without nasal polyps (CRSNP and CRS), by testing the olfactory function and potential dysfunction before and after endoscopic sinus surgery. Another objective is to find a connection between the percentage of coverage with bacterial biofilm of the nasal mucosa from patients with CRSNP and CRS and to evidence the fountain of infection role of the bacterial biofilm, while demonstrating that antibiotic therapy is not efficient once the bacterial biofilm is formed in the nasal sinuses.

Materials and methods. We investigated 123 patients with CRSNP and CRS, which underwent functional endoscopic sinus surgery (FESS). The olfactory function was tested pre and post FESS. We also analyzed and compared the scores of endoscopic images of Lund-Kennedy and CT staging scale of Lund-Mackey for the two study groups. The degree of olfactory rehabilitation in patients with CRSNP and CRS was evaluated performing smell diskettes test. The presence of bacterial biofilm on the surface of the nasal mucosa extracted during FESS from patients with CRSNP and CRS was examined with the electronic microscope and the percentage of coverage with bacterial biofilm was measured with Carnoy software.

Results. Bacterial biofilm was present in a higher percentage in patients with CRS vs. CRSNP. By comparing the level of olfactory function, significant improvement was found after FESS intervention in both study groups. Postoperatively, Lund-Kennedy scores decrease significantly for the whole group ($Z = -9.66$ at $p < 0.001$, d Cohen = 4.40), indicating the major role of surgery in the treatment of CRS. The decrease in Lund-Kennedy score values is also significant for each group. In the case of subjects diagnosed with CRS, the mean values decrease from 6.57 (preoperative) to 0.90 (postoperative), respectively $Z = -6.779$ to $p < 0.001$. In the case of subjects diagnosed with CRSNP, the mean values decrease from 9.03 (preoperative) to 1.44 (postoperative), $Z = -6.927$ at $p < 0.001$. Out of the total number of patients included in the study, 59 patients tested positive with the Prick test for dust and mites and more than half of the patients with positive allergy test were from the lot diagnosed with CRSNP.

Conclusions. FESS plays an important role in the improvement of olfactory function in patients with CRS. Bacterial biofilm was present in both study groups but in higher percentage in the CRS group and was found in lower percentage in the group with positive allergy tests. The CRSNP group presented a higher positive result regarding the allergy Prick test and a lower percentage of coverage with bacterial biofilm of the nasal mucosa. In conclusion, chronic rhinosinusitis with or without nasal polyps that is refractory to antibiotic therapy should be directed to the ENT department in order to receive surgical therapy in order to improve olfactory function.

Keywords: chronic rhinosinusitis, nasal polyps, bacterial biofilm, olfactory impairment, allergy

INTRODUCTION

Chronic rhinosinusitis is by far one of the most common diseases of the upper respiratory tract. The main cause of this pathology is associated with the blockage of the osteo-meatal complex, caused by bacterial, viral or allergic inflammation [1]. Furthermore, chronic rhinosinusitis is represented by an inflammatory condition that seriously affects the quality of life, while some patients do not respond to either medical or surgical intervention. This could be explained by the presence of a bacterial biofilm in the rhinosinusal zone [2]. Bacterial biofilms are represented by three-dimensional structures of bacteria with special abilities gained because of their group structure, from which one of the most important is represented by antibiotics resistance. Bacterial biofilms have been proven to play an important part in chronic infections like endocarditis, periodontal disease, and otitis media, while new studies state that they play a role in chronic rhinosinusitis [2].

Chronic rhinosinusitis with nasal polyps (CRSNP) and chronic rhinosinusitis without nasal polyps (CRS) are chronic inflammatory diseases of the nasal mucosa and/or paranasal sinuses that are difficult to treat and have reduced health-related quality of life [3]. It is estimated, based on populational studies that between 2.1% and 4.3% of adults meet the criteria for chronic rhinosinusitis [4,5]. From those, about 20%-30% have chronic rhinosinusitis with nasal polyps [3,6]. Patients with CRSNP/CRS often have other chronic comorbidities like asthma, chronic obstructive pulmonary disease and diabetes [7,8].

Many studies have stated the role of bacterial biofilms in the pathogenesis and treatment outcome of CRS and CRSNP [9,10,11].

AIM

Through this study we aimed to observe the percentage of coverage of the nasal mucosa with bacterial biofilm in adult patients with chronic rhinosinusitis and nasal polyposis compared to patients with chronic rhi-

nosinusitis without nasal polyposis and their association with allergy.

MATERIALS AND METHODS

The present study was conducted in the ENT department of the Arad County Emergency Clinical Hospital from October 2013 until December 2020. In the present study we identified the presence of bacterial biofilms in the rhinosinusal mucosa removed after sinus surgery and isolated from adult patients with CRSNP and from patients diagnosed with CRS. We have estimated, using an image analysis program, the bacterial biofilm covering the surface of nasal mucosa removed during functional endoscopic sinus surgery (FESS) and we compared the percentage of contamination with bacterial biofilm in the two study groups. We analyzed a total of 123 patients, recruited with the help of family doctors based on symptoms and objective ENT (Ear Nose Throat) examination, Lund-Mackay computed tomography score and Lund-Kennedy endoscopic score.

The criteria for inclusion in the study were: Lund-Mackay computed tomography score greater than or equal to 4; Lund-Kennedy endoscopic score greater than or equal to 4; antibiotic treatment of at least 3 weeks a year 2 consecutive years and hyposmia/anosmia tested with the smell diskettes test. Objective ENT examination consists of performing ENT pan-endoscopy and establishing the Lund-Kennedy endoscopic score (Table 1) and the Lund-Mackay computed tomography score (Table 2).

TABLE 1. Lund Kennedy score for endoscopic evaluation

Characteristics nasal cavity Left / Right
Polyyps (0,1,2)
Edema (0,1,2)
Secretions (0,1,2)
Total
<i>Polyyps: 0 – absent, 1 – limited to the middle meatus, 2 – extension to the nasal cavity</i>
<i>Mucosal edema: 0 – absent, 1 – mild-moderate, 2 – polypoid degeneration</i>
<i>Secretions: 0 – absent, 1 – hyaline, 2 – thick and / or mucopurulent</i>

TABLE 2. Lund-Mackay computed tomography score

Paranasal sinuses Left / Right
Frontal (0,1,2)
Maxilar (0,1,2)
Etmoidal anterior (0,1,2)
Etmoidal posterior (0,1,2)
Sfenoid (0,1,2)
Complex ostiomeatal (0,1,2)*
Total
0 – without modifications, 1 – partial opacification, 2 – total opacification
* 0 – without obstruction, 2 – with obstruction

From the main study group (n = 123), based on the inclusion criteria, 60 patients were diagnosed with CRS and 63 patients were diagnosed with CRSNP. All patients selected for the study underwent the following investigations: complete ENT (ears, nose, throat) examination including olfaction test, video ENT endoscopy, serological analysis, lungs X-ray examination, allergy testing for all medicines to be administered, allergology testing for dust and mites, cardiological examination for general anesthesia. Follow-up for these patients was carried out at 3 months, 6 months, 1 year by performing nasal and nasopharyngeal video-endoscopic control.

Patients were properly examined to rule out a diagnosis of asthma. An intravenous line was installed in all patients regardless of age or sex for immediate access. Positive and negative results were measured.

ENT pan-endoscopy was performed with a 0° rigid endoscope with a diameter of 4 mm, the Storz TELECAM SL II camera and a Storz halogen 250 twin-light as a light source. All patients underwent functional endoscopic sinus surgery (FESS) to restore the permeability of the nasal cavity and rhino- sinuses ostia. Patients underwent FESS under general anesthesia with orotracheal intubation and biopsy material was collected from each patient to perform the morpho pathological examination and microscopic electronic examination.

In order to rule out asthma, patients were properly examined by performing allergology skin testing. An intravenous line was installed in all patients regardless of age or sex for immediate access. Positive and negative results were measured. A negative control excludes the presence of dermographism which, when present, makes it difficult to interpret the tests. Histamine control should be positive to ensure that test materials are applied correctly and to exclude negative skin prick test (SPT) results due to their potential interference with the drugs of the test subject. By measuring the largest diameter of each test, a positive test is considered a spot of 3 mm diameter. The inclusion of the longest pseudopod diameter does not increase the sensitivity for determining the degree of sensitization.

The olfactory capacity was examined with the Smell Diskettes © Olfaction Test, a medical evaluation to de-

termine the degree of olfactory function. The smell diskettes olfaction test contains 8 olfactory disks, each of them containing an odorant. It is a multiple-choice test and the patient must smell the disk and decide the right scent out of 3 on a form. The patient earns one point for one correct answer. The result is a score between 0 and 8. If a patient has 6-8 points, the sense of smell is considered normal. Olfactory impairment is considered when a lower score than 6 is achieved.

Tissue sections harvested for SEM (scanning electron microscopy) were transported in special conditions in containers from the ENT department of Arad County Emergency Clinical Hospital to the Microscopy Laboratory of the “Vasile Goldiș” Western University of Arad maintaining the internal temperature at 4 + / 2 degrees Celsius for at least 2 hours, where they were stored and processed according to the protocol for SEM. Fixation for SEM nasal mucosa samples was performed in 2.5% glutaraldehyde in PBS (phosphate buffered saline) buffer (pH 7.4, t 37° C) for 2 hours at 22° C. After fixation, the samples were dehydrated using graduated ethanol series and immersed 5 times in a hexamethyldisilazane solution for 10 minutes and allowed to dry overnight. The obtained specimens were prepared and the silver sputter was covered in the preparation of the terminal. We detected the bacterial biofilm using a FEI Quanta 250 scanning electron microscope from the Microscopy Laboratory of the “Vasile Goldiș” Western University of Arad. We measured the percentage of bacterial biofilm coverage on the surface of adenoid vegetations extracted from 123 patients included in the study, by scanning images obtained from scanning electron microscopy with Carnoy software – an image analysis application used in morphology to make the measurement easier, faster and more accurate.

The present study was developed under the project entitled „Human Resources Development - PhD students and postdocs - for research excellence in the fields of health and biotechnology (DPD) HRD / 159 / 1.5 / S / 141531“. This study was carried out with the agreement of the Ethics Commission of the “Vasile Goldiș” Western University of Arad, the Ethics Commission of the Arad County Emergency Clinical Hospital and the Ethics Commission of the Dr. Turcin Polyclinic in Arad. It is a multidisciplinary study carried out with the support of the Department of Microbiology, Otorhinolaryngology and Family Medicine from the Western University Vasile Goldiș in Arad and Arad County Emergency Clinical Hospital.

RESULTS

Out of the study group, 68 were men (55.28%), aged between 25 and 73 years, m (average) = 45.49

years, AS (standard deviation) = 13.267 years, and 55 were women (44.72%), with ages 23 to 73 years, m = 43.25, AS = 12.583. There are no statistically significant age differences between men and women in the study lot ($t(121) = 0.949$ at $p = 0.345 > 0.05$) (Fig. 1).

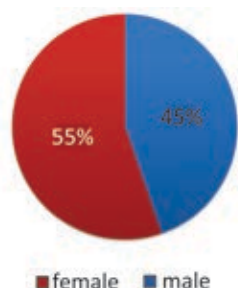


FIGURE 1. Gender distribution

From the total of 123 patients included in the study, 60 were diagnosed with CRS and the remaining 63 were diagnosed with CRSNP.

From the group of patients diagnosed with CRS, 25 were female and 35 were male, and from the group of patients diagnosed with CRSNP 30 were female and 33 male. There are no significant differences between the two groups in terms of gender distribution ($\chi^2 = 0.440$ at $p = 0.587 > 0.05$). The age of patients diagnosed with CRS varies between 25 and 73 years, with an average of 47.10 and a standard deviation of 12.769. In the case of those diagnosed with CRSNP, age varies between 23 and 65 years with an average of 42 years and the standard deviation of 12.748. The average age of those diagnosed with CRS is 5.10 years higher than that of those diagnosed with CRSNP, a difference that is statistically significant ($t(121) = 2.216$ at $p = 0.029 < 0.05$).

Out of the total number of patients included in the study, 59 patients tested positive for the allergy Prick test for dust and mites. From these, 17 were female and 21 male as part of the group of patients diagnosed with CRS. From the group of patients diagnosed with CRSNP, 8 were female and 13 were male (Fig. 2).

Using scanning electron microscopy the typical structure of the bacterial biofilm was observed in both study groups but in a different percentage. The difference between the two diagnostic groups is statistically significant: $t(60.207) = 40.177$, $p < 0.001$. The size of the effect is also important: d Cohen = 7.33, indicating that the percentage of bacterial biofilm coverage is significantly influenced by the presence of CRS. The difference remains statistically significant even when we control the age variable (because there is a significant age difference between the two subgroups): $F = 1,609,785$ at $p < 0.001$, $\epsilon^2 = 0.931$. With the help of scanning electron microscopy, the images obtained certify the presence of bacterial biofilm in the sinus mucosa in these patients.

After performing the control endoscopy at 1 month, all patients had a significantly improved Lund-Kennedy endoscopic score compared to the preoperative examination with a margin between 3 and 10 points.

Of the total number of patients diagnosed with CRS, all underwent FESS surgery and the percentage of nasal mucosa coverage with bacterial biofilm extracted from these patients is 80.91%. On scanning electron microscopy images, obtained from patients diagnosed with chronic rhinosinusitis, the morphology characteristic of the bacterial biofilm is observed almost entirely: the three-dimensional structure, the glycocalyx and the water channels (Fig. 3, Fig. 4).

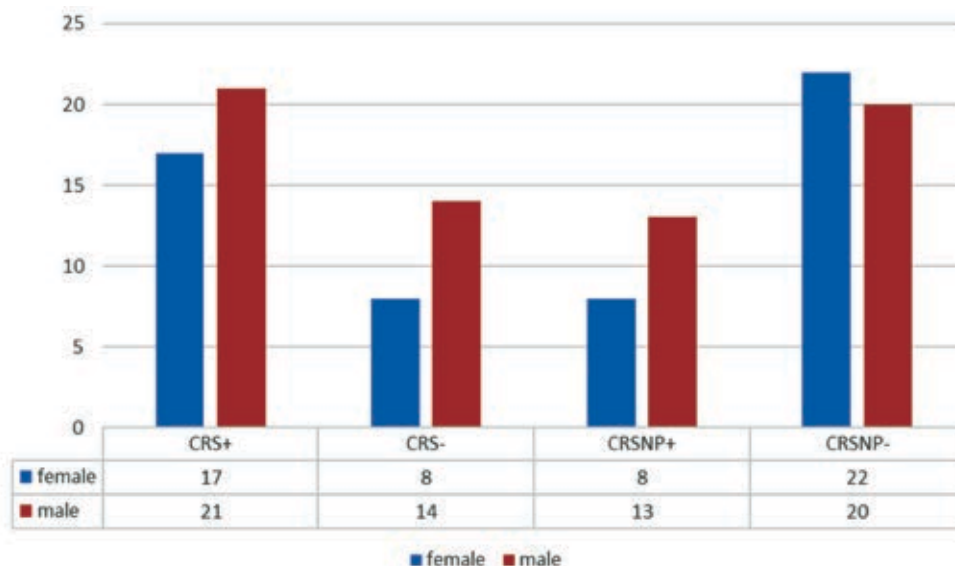


FIGURE 2. Diagnostic distribution according to gender

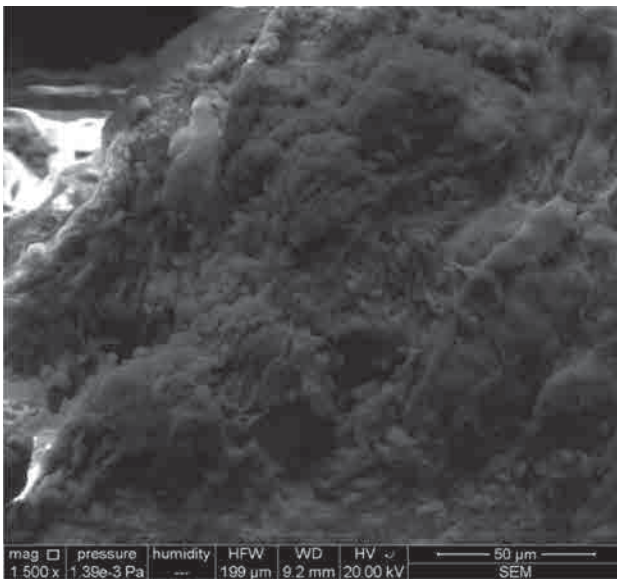


FIGURE 3. Nasal mucosal section with CRS – the three-dimensional structure specific to the bacterial biofilm

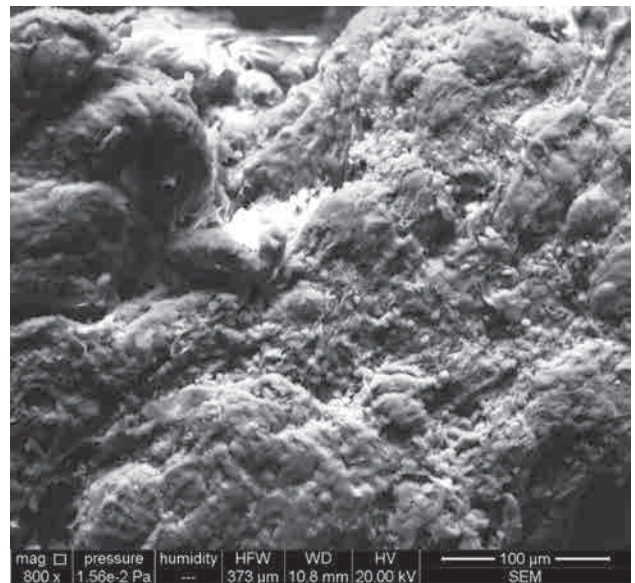


FIGURE 5. SEM image – CRS-section of nasal mucosa from patient with CRSNP

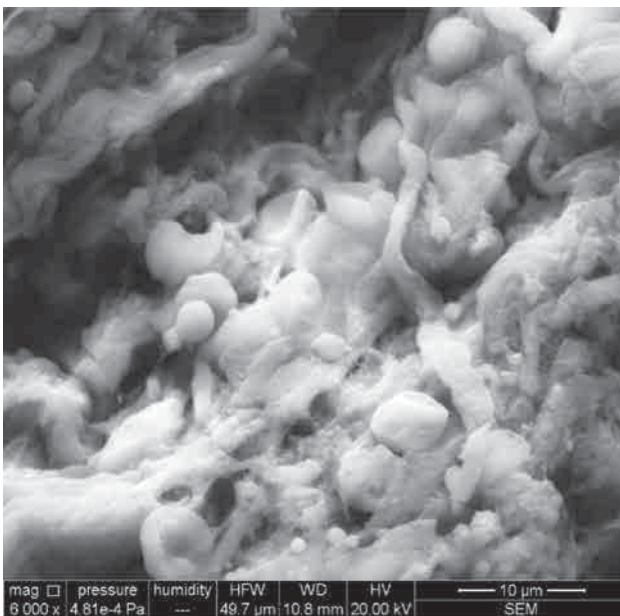


FIGURE 4. SEM image – Nasal mucosa section with CRS – the three-dimensional structure specific to the bacterial biofilm

Out of the total number of patients diagnosed with CRSNP, all underwent FESS intervention and the percentage of coverage with bacterial biofilm of the nasal mucosa extracted from these patients was 2.13% (Fig. 5).

On electron microscopy images, obtained from patients diagnosed with chronic rhinosinusitis, the morphological characteristics of the bacterial biofilm is only observed from zone to zone: three-dimensional structure, glycocalyx and water channels on the surface of an atrophied and / or hypertrophic nasal mucosa.

Patients with CRSNP tend to get higher Lund-Kennedy (preoperative) scores than those with CRS. The

difference is statistically significant: $Z = -7.398$ at $p < 0.001$. The effect is an important one, d Cohen = 1.76, indicating an important prognostic tool for patients pre surgery.

The values of the Lund-Kennedy score, preoperatively, correlate negatively with age ($r = -0.182$; $p = 0.044$), but the percentage of the common variance is relatively low (3.3%). Also the gender of the subjects does not significantly influence the values of the Lund-Kennedy test. The differences between the two diagnostic groups, CRS and CRSNP, remain significant when we control the age variable ($F = 86.731$; $p < 0.001$; $\epsilon^2 = 0.42$).

However postoperatively, Lund-Kennedy values decrease significantly for the whole group, $Z = -9.66$; $p < 0.001$; d Cohen = 4.40, indicating the major role of surgery in treatment of CRS.

The decrease in Lund-Kennedy score values is also significant for each subgroup. In the case of subjects diagnosed with CRS, the mean values decrease from 6.57 (preoperative) to 0.90 (postoperative), $Z = -6.779$; $p < 0.001$. In the case of subjects diagnosed with CRSNP, the mean values decrease from 9.03 (preoperative) to 1.44 (postoperative), $Z = -6.927$; $p < 0.001$.

The difference between CRS and CRSNP is statistically significant, respectively $Z = -2,774$; $p = 0.006$, those in the CRSNP group tending to obtain higher Lund-Kennedy scores not only preoperatively but also postoperatively. However, the magnitude of the difference decreases significantly (d Cohen = 0.54). The difference remains statistically significant when we control the age variable, $F = 12.327$; $p = 0.001$; $\epsilon^2 = 0.093$.

The descriptive statistical indicators for the Lund-Mackay computed tomography score are presented in the table below (Table 3). The age and the

gender of the subjects do not significantly influence the values of the Lund-Mackay computed tomography score, neither for the whole group, nor for each subgroup, separately.

We observe that subjects diagnosed with CRS have higher mean values of the Lund-Mackay score than those diagnosed with CRSNP. Because the distributions were not normal we used a nonparametric test. The difference between the scores of the two subgroups is statistically significant, respectively $Z = -7.935$; $p < 0.001$, and has a high magnitude: d Cohen = 1.99. The difference remains statistically significant when we control the age of the subjects: $F = 118.656$; $p < 0.001$; $\epsilon^2 = 0.497$.

A series of significant correlations (Table 3) are found between the investigated variables. Biofilm coverage was correlated negatively ($p < 0.01$) with pre- and postoperative Lund-Kennedy score and Lund-Mackay score, indicating that subjects with a higher bacterial biofilm coverage tended to score lower Lund-Kennedy and Lund-Mackay scores, with the common covariance percentages being 36.60 (with preoperative Lund-Kennedy score), 7.90 (with postoperative Lund-Kennedy score) and 34.90 (with Lund-Mackay score).

Subjects with higher preoperative Lund-Kennedy scores tend to obtain higher postoperative values ($\rho_{\text{Spearman}} = 0.197$; $p = 0.029$), even if the values decrease significantly, as we have shown previously.

The values of the preoperative and postoperative Lund-Kennedy score predict the values of the Lund-Mackay score ($\rho_{\text{Spearman}} = 0.394$; $p < 0.001$, respectively $\rho_{\text{Spearman}} = 0.255$; $p = 0.004$). Thus, subjects with high values of Lund-Kennedy score tend to obtain higher values in the Lund-Mackay computed tomography score.

Age correlates positively with bacterial biofilm coverage ($\rho_{\text{Spearman}} = 0.190$; $p = 0.035$) and negatively with preoperative Lund-Kennedy score values ($\rho_{\text{Spearman}} = -0.182$; $p = 0.044$), indicating that older subjects tend to have higher percentages of coverage with bacterial biofilm and obtain lower values at the preoperative Lund-Kennedy score.

In the case of subjects diagnosed with CRS, age has no significant influence on the percentage of bacterial biofilm coverage and the values of Lund-Kennedy and Lund-Mackay scores. The investigated variables do not correlate significantly with each other.

In the case of subjects diagnosed with CRSNP, significant correlation at the level of clinical indicators has been found between the degree of coverage with bacterial biofilm and the postoperative Lund-Kennedy score ($\rho_{\text{Spearman}} = -0.286$; $p = 0.023$) indicating the tendency of subjects with higher percentages of bacterial biofilm coverage to obtain lower values of the postoperative Lund-Kennedy score (Table 3).

Global statistical indicators show an increase in mean postoperative values both in the general group and in each subgroup separately. In the main group of patients ($n = 123$), an improvement in olfactory function, tested with a smell diskets test, was observed on average by 2.26 points compared to the score obtained preoperatively. In the group of patients diagnosed with CRS, there was an improvement in olfactory function on average by 2.37 points compared to the score obtained preoperatively, while and in the group of patients with CRSNP an average improvement of 2.16 points was found (Fig. 6).

When we compared the mean values for the general group and for each subgroup using the Wilcoxon test, we obtained the following results: $Z = -9.551$ at $p < 0.001$ for the whole study group, indicating a significant improvement in postoperative olfactory function for all patients. Of the 123 subjects included, 119 subjects showed an improvement in postoperative olfactory function, only one subject showed postoperative impairment of olfactory function and 3 subjects showed no differences. Regarding the CRS group we found a statistically significant test, respectively $Z = -6.577$ at $p < 0.001$, indicating a significant improvement in postoperative olfactory smell for those diagnosed with CRS. Of the 60 patients with CRS, 56 showed improvements in postoperative olfactory impairment,

TABLE 3. The correlations between Lund Kennedy, Lund-Mackay scores, age and the percentage of bacterial biofilm coverage

Spearman's rho		preoperative Lund-Kennedy score	Lund-Mackay score	postoperative Lund-Kennedy score
Bacterial biofilm coverage	Correlation coefficient	-0,605**	-0,591**	-0,281**
	p	< 0,001	< 0,001	0,002
	N	123	123	123
Lund-Kennedy preoperatory score	Correlation coefficient		0,394**	0,197*
	p		< 0,001	0,029
	N		123	123
Lund-Mackay score	Correlation coefficient			0,255**
	p			0,004
	N			123

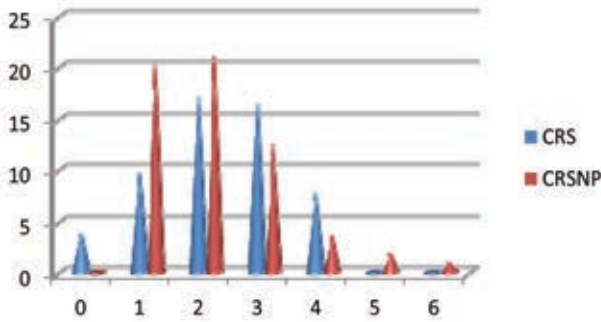


FIGURE 6. Comparison of postoperative improvement in olfactory function for patients with CRS vs. CRSNP

one subject showed olfactory impairment and 3 showed no differences. The results for the CRSNP group were also statistically significant, respectively $Z = -6.977; p < 0.001$, indicating a significant improvement in postoperative olfactory impairment for subjects diagnosed with CRSNP. All 63 subjects showed postoperative improvement in smell. The differences found, both in the general group and in each subgroup, in part, indicate the major role of surgery in improving olfactory function in patients with CRS and CRSNP. The sex and age of the subjects do not significantly influence the olfactory capacity of the patients in the study group.

The degree of coverage with bacterial biofilm correlates positively with the olfactory capacity, both preoperatively ($\rho_{\text{Spearman}} = 0.318; p < 0.001$) and postoperatively ($\rho_{\text{Spearman}} = 0.466; p < 0.001$), indicating that a higher degree of coverage with bacterial biofilm predicts a better smell. But, as we have shown above, the general group presents two significantly different sets of data on the percentage of bacterial biofilm coverage, those with CRS with high coverage, and those with CRSNP with low coverage, which could explain the paradoxical effect of the association between the sense of smell and the degree of coverage with bacterial biofilm. Analyzing the association of the two variables on each subplot, no statistically significant correlations are obtained.

Analyzing the difference between subplots, in terms of olfactory capacity, both preoperatively and postoperatively, we observe that there are statistically significant differences: preoperative: $Z = -4.873; p < 0.001$ and postoperative: $Z = -6.205; p < 0.001$. Patients diagnosed with CRS have a higher olfactory capacity, both preoperatively (on average by 1.90 points) and postoperatively (on average by 2.11) (Table 4).

DISCUSSIONS

The current evidence based recommendations for management of CRS and/or CRSNP include intranasal/

TABLE 4. Difference between subplots in terms of olfactory capacity

		Preoperative olfactory test	Postoperative olfactory test
Lund-Kennedy preoperative score	\tilde{N} Spearman	-0.286**	-0.352**
	p	0.001	0.000
	N	123	123
Lund-Mackay score	\tilde{N} Spearman	-0.232**	-0.356**
	p	0.010	0.000
	N	123	123
Lund-Kennedy postoperative score	\tilde{N} Spearman	-0.137	-0.197*
	p	0.129	0.029
	N	123	123

* - significant correlations at $p < 0.05$;
 ** - significant correlations at $p < 0.01$

oral corticosteroids with the purpose of reducing symptoms and avoiding complications [9,12]. Patients and health systems carry a direct and indirect high economic burden for the treatment of CRS [13,14]. There is a high need in finding reliable prediction (positive or negative) systems (mucosal biofilm coverage, Lund-Kennedy score, Lund-Mackay score) for the management of CRS and CRSNP [14].

The preoperative Lund-Kennedy score correlates negatively, for the whole group, with the preoperative olfactory test values, indicating a clear tendency for patients with high Lund-Kennedy scores to have low olfactory capacity values. The correlation remains significant with the postoperative olfactory capacity values, the high values of the preoperative Lund-Kennedy score. In a similar study but with a reduced number of participants Vandenhende-Szymanski C. at all. observed that CT scan scores could be a predictive factor of olfactory impairment severity and improvement after FESS in CRSNP [15].

Postoperative values of the Lund-Kennedy score correlate negatively with the postoperative values of the olfactory test, indicating the tendency for patients with high values of the postoperative Lund-Kennedy score to have an olfactory capacity improvement in lower postoperative period. In contrast, in another study on a lot of over 300 subjects olfaction scores were correlated with other objective measurements of CRS, respectively endoscopic and CT scores [16].

Lund-Mackay score correlates significantly and negatively with olfactory test values, both pre- and postoperative, in all patients included in the study. By further analyzing the two subplots separately (CRS vs. CRSNP), depending on the clinical diagnosis, we observe that in the CRS subgroup the preoperative Lund-Kennedy scores does not correlate significantly with olfactory test values, also postoperative Lund-Kennedy scores correlate significantly with postoperative olfactory test values.

A Czech study on 51 patients states that there were correlations with age and Lund-Mackay score changes after FESS, but no statistically significant difference in olfaction was found before and after the FESS intervention [18].

Lund-Mackay score correlates significantly and positively with olfactory capacity, both pre- and postoperatively. Therefore, for patients with CRS, the Lund-Kennedy score does not predict olfactory capacity, while the high Lund-Mackay score indicates better olfactory capacity both pre- and postoperatively.

For the CRSNP subgroup, Lund-Kennedy (pre- and postoperative) and Lund-Mackay scores do not correlate significantly with olfactory test values. For patients with CRSNP, the two clinical scores do not predict olfactory capacity. In another study on patients with CRS, olfactory scores were correlated with nasal endoscopy and CT scores, indicating that patients with high olfactory impairment are likely to have the most severe symptoms and significant CT scan and endoscopic findings [17].

Study strengths are represented by the correlations between the presence of bacterial biofilm and CRS with or without nasal polyps, but also by the positive results obtained regarding the symptomatic remission post FESS in all subjects.

The limitations of this research are represented by the financial implications and by the reduced number

of participants. Further studies are required on a larger number of patients.

CONCLUSIONS

Surgical treatment (FESS) is an effective therapeutic solution in the management of uncontrolled medical CRS and CRSNP. Surgery has a major part in improving the sense of smell in patients with CRS and CRSNP. Biofilm presence in both study groups has a role of fountain of infection. Also olfactory function was positively correlated with the FESS intervention in both of the study groups. It is clear that further research is mandatory in order to establish a correlation between all these parameters: diagnostic, biofilm coverage, imaging scores and allergy test results. Furthermore, the CRSNP group presented a higher positive result regarding the allergy Prick test and a lower percentage of coverage with bacterial biofilm of the nasal mucosa, while the CRS group had a higher percentage of bacterial biofilm presence and a reduced number of allergic subjects.

Regardless of the sex and age of the patient, it is indicated that a chronic rhinosinusitis with or without nasal polyps that is refractory to antibiotic therapy to be directed to the ENT department in order to establish the right surgical therapy.

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