ORIGINAL STUDY

Is there a relationship between Lund-Mackay scale, olfactory bulb depth and width, and Keros classification in patients with nasal polyps?

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ABSTRACT

OBJECTIVE. We investigated the relationship between Lund-Mackay scale, olfactory bulb depth and width, and Keros classification in patients with chronic rhinosinusitis with nasal polyps (CRSwNP).

MATERIAL AND METHODS. In this retrospective study, paranasal sinus computed tomography (PNSCT) images of 47 patients with CRSwNP and 47 healthy subjects (control) were evaluated. In the CRSwNP group, PNSCT scans were assessed based on Lund-Mackay scale. In both groups, olfactory fossae (OF) depth and width, and Keros classification were evaluated.

RESULTS. The total Lund-Mackay score was 17.1±5.9. There were no significant differences between OF depth and width values of the nasal polyps group and control group. For both groups, Type II Keros was the most detected type; secondly, Keros type I and rarely Keros type III were detected. There was no significant correlation between Lund-Mackay score (All items and total score) and OF depth and width, and Keros type. There were negative correlations between ipsilateral OF depth and width ($p<0.05$), whereas there were positive correlations between contralateral OF depth and width ($p>0.05$). Keros type was positively correlated between ipsilateral and contralateral OF depth and Keros type ($p<0.05$). In older patients, left OF depth and Keros type decreased ($p<0.05$).

CONCLUSION. As a conclusion, there was no correlation between Lund-Mackay score and olfactory fossa dimensions (depth and width). When considering age, one could notice that Keros type decreased in older patients.

KEYWORDS: chronic rhinosinusitis with nasal polyps, Lund-Mackay scale, olfactory fossae depth, olfactory fossae width, Keros classification.

INTRODUCTION

Surgery for chronic rhinosinusitis with nasal polyps (CRSwNP) is recommended when medical treatment fails to heal the symptoms. During endoscopic sinus surgery, bloodless surgical field is required to enhance view in the operation field. The orbital wall, the skull base and the cribriform plate are more important areas[1].

CRSwNP has a wide variability in the effects of presentation and quality of life in patients affected. Various symptom surveys, "computed tomographic (CT) classification", "endoscopic scores" and "quality of life (QOL) surveys" are used to evaluate chronic rhinosinusitis (CRS). In the CRSwNP subcategories, a non-standard clinical classification according to severity or cause is currently widely used[2,3]. Lund-Mackay scale was used to classify the polyp tissue according to the opacification in paranasal sinuses and obstruction in the ostiomeatal complex[4].

In the present study, we investigated the relationship between Lund-Mackay scale, olfactory bulb depth and width, and Keros classification in patients with nasal polyps. We wanted to evaluate whether the polyp status according to the Lund-Mackay scale affected the anatomic structure of the cribriform plate.

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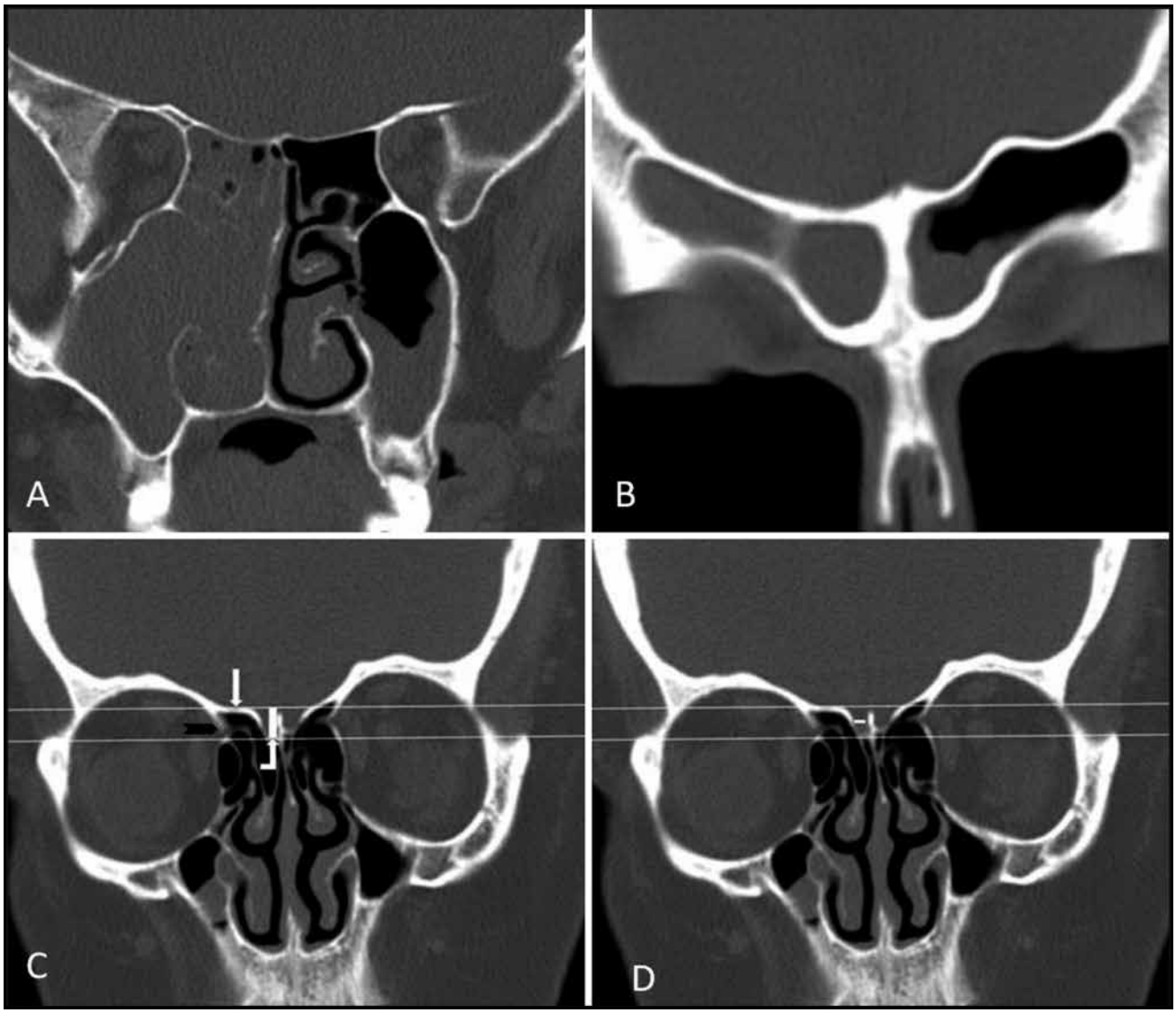

Figure 1. Coronal PNSCT, **A.** In the right maxillary sinus and anterior ethmoid sinus, there was a soft tissue density, evaluated as Lund-Mackay scale 2. In the left maxillary sinus, there was a soft tissue density, evaluated as Lund-Mackay scale 1. The left anterior ethmoid sinus was evaluated as Lund-Mackay scale 0. **B.** In the right frontal sinus, there was a soft tissue density, evaluated as Lund-Mackay scale 2. In the left frontal sinus, there was a soft tissue density, evaluated as Lund-Mackay scale 1. **C.** The measurement of the OF depth is shown. Parallel lines that cross the fovea ethmoidalis and the cribriform plate were drawn in the section where the anterior ethmoidal artery notch was seen on the orbita medial wall. To cut these two parallel lines perpendicularly, the OF depth measurement and Keros classification were performed. (White arrow: Fovea ethmoidalis, curling white arrow: cribriform plate, black arrow: anterior ethmoidal artery notch). **D.** The measurement of the OF width is shown. Parallel lines that cross the fovea ethmoidalis and the cribriform plate were drawn in the section where the anterior ethmoidal artery notch was seen on the orbita medial wall. As paralel to lines, OF width measurement was performed.

MATERIAL AND METHODS

This retrospective study was conducted in Kırıkkale University, Faculty of Medicine, Otorhinolaryngology and Radiology Departments according to the principles of the Declaration of Helsinki. Paranasal Sinus Computed Tomography (PNSCT) images were obtained from the database of the Kırıkkale University, Faculty of Medicine, Radiology Department. Ethics committee approval was obtained from Kırıkkale University Clinical Researches Ethics committee (Date: 06.03.2019, Number: 2019.03.03).

Subjects

This study was performed retrospectively. PNSCT images of 94 adult subjects (≥18 years) were selected randomly from the database containing patients with CRS / healthy patients from a digital radiology database of our Hospital from the current time to the past.

Group 1 consisted of the PNSCT of 47 patients with chronic rhinosinusitis with nasal polyps

(CRSwNP) (15 males and 32 females). Mean age was 47.2±12.6 years. In Group 1, the Lund-Mackay polyp classification (1-3) was performed for both sides.

The control group (Group 2) consisted of 47 patients without nasal polyposis (15 males, 32 females) with normal PNSCT results in our Hospital's Picture Archiving and Communication System (PACS). In these patients, PNSCT was performed for cephalgia and the suspicion of rhinosinusitis; the results were reported as normal. They were also selected by screening the PACS from the current time to the past. The mean age of the patients included in this group was 46.9± 11.9 years.

Subjects with sinonasal tumors, previous trauma or surgery history, CSF leak, marked nasal septal and facial deformity were not included in the study.

Lund-Mackay scale

PNSCT scans were assessed by the same expert radiologist based on the Lund-Mackay scale[4]. Each paranasal sinus ("Maxillary, anterior ethmoid, posterior ethmoid, sphenoid, frontal") was graded from 0 to 2 depending on the level of opacification (0: without abnormalities; 1: partial opacification; 2: total opacification). The ostiomeatal complex was evaluated as 0 or 2 (0: no obstruction, 2: obstructed). The evaluation was performed for the right and left sides seperately. The total score was "0-24 points", and the highest value showed a "greater severity of the disease". Only pneumatized sinuses were scored. The total score showed the "bilateral diseases' total score" and the maximum score was 24[4-6] (Figure 1A-B).

CT imaging and analysis

All of the scans were obtained with routine PNS-computed tomography imaging in the supine position, with no contrast or sedation being used for the procedures. The images were acquired using a 64-slice CT (MSCT; Brilliance 64, Philips Medical System, Best, the Netherlands). For all the scans, the following parameters were used: tube voltage = 120 kV, effective mAs = 350, slice thickness = 1.00 mm, field of view (FOV) = 180 mm, image matrix = 768 × 768. The images were transferred to a commercially available Workstation (Philips Medical System), and the raw data was reconstructed using bone algorithms. After scanning, the coronal, axial and sagittal images were reconstructed with a slice thickness of 1.00 mm. The coronal and axial plan was often preferred. All cases included in the study were assessed by the same expert radiologist.

The following measurements were performed:

1. The depth of the olfactory fossae (OF depth):

The depth of the olfactory fossae was measured as "the length of the vertical line drawn from the medial ethmoid roof to the horizontal plane of the cribriform plate (the medial ethmoid roof height)"[7,8] (Figure 1C).

2. OF width:

The measurement was performed in the OF (between the vertical line drawn from the medial ethmoid roof to the horizontal plane of the cribriform plate) at the largest distance of the horizontal width (Figure 1D).

3. Keros classification:

Keros classified the depth of the olfactory fossae into 3 types based on the height of the lateral lamella[9]. The depth of the olfactory fossae is "1-3 mm in Type I, 4-7 mm in Type II, and 8-16 mm in Type III"[10] (Figure 1C).

Statistical analysis

SPSS for Windows 16.0 (SPSS, INC, an IBM Company, Chicago, Illinois). For the statistical analysis, we used independent samples t-test, Paired samples t-test, Chi-square test, Pearson correlation test and Spearman's correlation rho efficient test. A p-value < 0.05 was considered statistically significant.

RESULTS

Lund-Mackay scale of the nasal polyp group was shown in Table 1. In Table 1, frontal, anterior ethmoid, posterior ethmoid, maxillary and sphenoid sinuses polyps, Lund-Mackay scale and ostiomeatal complex occlusion status are presented bilaterally.

The total Lund-Mackay score was 17.1±5.9.

OF depth and OF width values of the nasal polyp and control groups were shown in Table 2. In Table 2, the incidence of bilateral OF depth and width, Keros types were presented in the nasal polyps and control groups.

OF depth

There were no significant differences between OF depth values of the nasal polyps group and control group bilaterally ($p > 0.05$) (Table 2). For the nasal polyps group, OF depth values on the right side were significantly higher than those on the left side ($p < 0.05$).

OF width

There were no significant differences between OF width values of the nasal polyps group and control group bilaterally ($p > 0.05$) (Table 2).

Keros types

Keros types of the groups were shown in Table 2. For both groups, Type II Keros was the most detected type bilaterally. The second detected Keros type was Type I. Type III Keros was detected less in both groups bilaterally ($p > 0.05$) (Table 2).

Correlation test results in nasal polyps group are shown in Table 3:

- There was negative correlation between ipsilateral OF depth and width. It means that, as the ipsilat-

Table 1. Lund-Mackay scale of the nasal polyps group.

Sinuses	Right			Left		
	0 (without abnormalities)	1 (partial opacification)	2 (total opacification)	0 (without abnormalities)	1 (partial opacification)	2 (total opacification)
Frontal	12 (25.5%)	15 (31.9%)	20 (42.6%)	9 (19.1%)	15 (31.9%)	23 (48.9%)
Anterior Ethmoid	4 (8.5%)	14 (29.8%)	29 (61.7%)	3 (6.4%)	14 (29.8%)	30 (63.8%)
Posterior Ethmoid	5 (10.6%)	18 (38.3%)	24 (51.1%)	5 (10.6%)	21 (44.7%)	21 (44.7%)
Maxillary	3 (6.4%)	18 (38.3%)	26 (55.3%)	2 (4.3%)	19 (40.4%)	26 (55.3%)
Sphenoid	11 (23.4%)	18 (38.3%)	18 (38.3%)	10 (21.3%)	22 (46.8%)	15 (31.9%)

Ostiomeatal complex	Right	Left
2 (Occluded)	42 (89.4%)	43 (91.5%)
0 (Not-occluded)	5 (10.6%)	4 (8.5%)

Table 2. Olfactory fossae (OF) depth and width values, and Keros types of the nasal polyps and control groups.

OF depth and OF width		Group 1 (Nasal polyps) (n=47)			Group 2 (Control) (n=47)			P*
		Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	
OF depth	R	4.92	4.80	1.45	4.73	4.70	1.77	0.581
	L	4.50	4.50	1.36	4.54	4.10	1.75	0.886
	P**		0.021			0.351		
OF width	R	3.31	3.40	0.66	3.39	3.40	0.67	0.602
	L	3.43	3.50	0.85	3.56	3.60	0.77	0.442
	P**		0.382			0.075		

Keros types		Group 1 (Nasal polyps) (n=47)		Group 2 (Control) (n=47)		P***
Right		n	%	n	%	
Keros	Type I	5	10.6	10	21.3	P = 0.218 $\chi2 = 3.051$
	Type II	40	85.1	33	70.2	
	Type III	2	4.3	4	8.5	
Left						
Keros	Type I	9	19.1	10	21.3	P = 0.331 $\chi2 = 2.209$
	Type II	37	78.7	33	70.2	
	Type III	1	2.1	4	8.5	

*p-value shows the results of Independent samples t-test; **p-value shows the results of Paired samples t-test; ***p-value shows the results of Chi-square test

Table 3. Correlation test results in nasal polyps group.

			Right			Left		
			OF depth	OF width	Keros Type**	OF depth	OF width	Keros Type**
Right	OF depth	r		-0.212	0.727	0.663	-0.040	0.485
		P*		0.040	0.000	0.000	0.701	0.000
	OF width	r	-0.212		-0.153	-0.232	0.465	-0.157
		P*	0.040		0.140	0.024	0.000	0.132
	Keros Type	r	0.727	-0.153		0.517	-0.038	0.551
		P**	0.000	0.140		0.000	0.718	0.000
Left	OF depth	r	0.663	-0.232	0.517		-0.057	0.761
		P*	0.000	0.024	0.000		0.582	0.000
	OF width	r	-0.040	0.465	-0.038	-0.057		-0.129
		P*	0.701	0.000	0.718	0.582		0.216
	Keros Type	r	0.485	-0.157	0.551	0.761	-0.129	
		P**	0.000	0.132	0.000	0.000	0.216	
Lund-Mackay Scale								
Right	Frontal	r	-0.057	-0.059	-0.040	-0.089	-0.129	-0.053
		P**	0.701	0.695	0.788	0.551	0.387	0.721
	Anterior Ethmoid	r	-0.102	0.163	-0.131	-0.154	-0.196	-0.039
		P**	0.494	0.274	0.380	0.302	0.187	0.792
	Posterior Ethmoid	r	-0.161	-0.015	-0.162	-0.107	-0.224	-0.042
		P**	0.280	0.920	0.277	0.475	0.130	0.781
	Maxillary	r	-0.022	0.133	-0.248	0.006	-0.194	0.103
		P**	0.884	0.375	0.092	0.969	0.191	0.492
	Sphenoid	r	-0.022	0.089	-0.113	-0.157	-0.156	0.002
		P**	0.882	0.550	0.451	0.292	0.297	0.990
	Ostiomeatal complex	r	0.020	0.334	-0.234	0.036	-0.115	0.021
		P**	0.892	0.022	0.113	0.812	0.443	0.886
Right	Frontal	r	0.071	-0.096	-0.106	0.013	0.046	-0.118
		P**	0.633	0.520	0.480	0.932	0.759	0.428
	Anterior Ethmoid	r	0.094	0.079	0.129	-0.023	0.092	-0.015
		P**	0.531	0.597	0.388	0.876	0.540	0.918
	Posterior Ethmoid	r	0.004	-0.010	-0.025	-0.192	0.026	-0.179
		P**	0.977	0.949	0.869	0.195	0.861	0.230
	Maxillary	r	0.085	-0.199	-0.043	0.088	-0.102	0.063
		P**	0.568	0.181	0.775	0.556	0.494	0.675
	Sphenoid	r	-0.140	0.007	-0.049	-0.005	-0.117	-0.012
		P**	0.349	0.962	0.746	0.976	0.433	0.934
	Ostiomeatal complex	r	0.098	0.096	-0.055	0.065	0.104	0.055
		P**	0.510	0.522	0.716	0.666	0.486	0.712
Total Lund-Mackay Score		r	-0.031	0.037	-0.099	-0.035	-0.078	-0.044
		P*	0.837	0.805	0.508	0.818	0.602	0.771
Age		r	-0.096	0.157	-0.160	-0.226	0.079	-0.241
		P*	0.358	0.130	0.124	0.029	0.452	0.019
Gender (Code 1: Males, Code 2: Females)		r	0.095	0.019	0.053	0.019	-0.107	-0.020
		P**	0.362	0.853	0.614	0.853	0.303	0.849

*p-value shows the results of Pearson Correlation test; **p-value shows the results of Spearman's correlation rho efficient test

eral OF depth is higher, the ipsilateral OF width gets smaller ($p < 0.05$) (Table 3). On the contrary, there was positive correlation between contralateral OF depth and width. It means that, as the contralateral OF depth is higher, the contralateral OF width is also higher ($p < 0.05$) (Table 3). Keros type is positively correlated between ipsilateral and contralateral OF depth and Keros type. It means that, as the ipsilateral and contralateral OF depth gets higher, the ipsilateral and contralateral Keros type also gets higher ($p < 0.05$) (Table 3).

- There was no significant correlation between Lund-Mackay scale (All items and total score) and OF depth and width, and Keros type ($p > 0.05$) (Table 3). Lund-Mackay scale of the nasal polyps was not related with the OF depth and width, and Keros type. According to these results, nasal polyps' development process may not affect the cribriform plate and OF depth.
- Age: In older patients, left OF depth ($p<0.05$) and Keros type decreased ($p<0.05$) (Table 3). The decrease in the Keros type may be related to the degenerative process in the neural tissue during aging.

In the end, the Lund-Mackay scale of the nasal polyps was not related to the OF depth and width, and Keros type.

DISCUSSIONS

While medical management of nasal polyps is aimed at minimizing inflammation, surgical treatment focuses on removing the mechanical obstruction in the nasal cavity and paranasal sinuses[11].

After the surgery for chronic sinusitis with nasal polyps, complications such as orbital damage, cerebrospinal fluid leaks, intracranial penetration, severe bleeding may occur[12]. In case of the patients with higher Lund-Mackay scores, more extensive surgeries were applied[13]. The Lund-Mackay score was related with the reduction of the symptoms (SNOT-22 scores), complication and revision rates after polypectomies[13]. Mortuaire et al.[1] reported that the Lund-Mackay CT score was useful for predicting intra-operative bleeding in patients who underwent endoscopic ethmoidectomy. Using topical steroids and antibiotics, as weel as hypotensive anesthesia may help to reduce these complications. However, in patients with previous polypectomy, there was no correlation between Lund-Mackay CT score and bleeding, which may be related to a more fibrous nasal mucosa after polypectomy.

In the present study, we investigated the relationship between Lund-Mackay scale, olfactory bulb depth and width, and Keros classification in patients with nasal polyps. The total Lund-Mackay score was 17.1±5.9. There were no significant differences between OF depth and width values of the nasal polyps group and control group. For both groups, Type II Keros was the most detected type; secondly, Keros type I and rarely Keros type III were detected. There was no significant correlation between Lund-Mackay score (All items and total score) and OF depth and width, and Keros type.

In our study, we found that, as the ipsilateral OF depth is higher, the ipsilateral OF width gets smaller. As the contralateral OF depth is higher, the contralateral OF width is also higher. Our results also revealed that, as the ipsilateral and contralateral OF depth gets higher, the ipsilateral and contralateral Keros type also gets higher. In older patients, left OF depth and Keros type decreased. The decrease in the Keros type in this population category may be related to the degenerative process in the neural tissue during aging.

In nasal polyps, the studies on symptom scores and endoscopic and radiologic scores (i.e., Lund-Mackay score) showed no correlation or poor correlation between diseases severity and symptoms[14]. Hopkins et al.[13] reported that 21% of 1840 patients who underwent nasal surgery had Lund-Mackay scores similar to the asymptomatic patients.

In our study, no correlation between Lund-Mackay score and olfactory fossa dimensions (depth and width) was detected. If the nasal polyp destructures the bony structure, or if it is too much expanded, the olfactory fossa may be affected. However, it was not detected in our patients.

CONCLUSIONS

As a conclusion, there was no correlation between Lund-Mackay score and olfactory fossa dimensions (depth and width). When considering age, one could notice that Keros type decreased in older patients.

In nasal polyps patients, it is important to plan and apply the appropriate treatment.

Conflict of interest: All authors declare they have no conflict of interest.

Ethics committee approval: This study is retrospective. Ethics committee approval was obtained from Kırıkkale University Non-invasive Research Ethics Committee (Date: 06.03.2019, Number:2019.03.03). There was no need to take informed consent because the data was evaluated retrospectively.

Contribution of authors: Ziya ŞENCAN: Planning, designing, data collection, literature survey,

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