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ORIGINAL ARTICLE

Volumetric study of the olfactory bulb in patients with chronic rhinonasal sinusitis using MRI

Reda A. Alarabawy [a], **Mohamed A. Eltomey** [a,*], **Emad Mohammed Shehata** [b]

[a] *Radiology and Imaging department, Faculty of Medicine, Tanta University, Egypt*
[b] *Otorhinolaryngology Department, Faculty of Medicine, Tanta University, Egypt*

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KEYWORDS

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Abstract *Objective:* Olfaction plays an important role in human daily life. The olfactory bulb size is dependent on stimulation. Smell loss is one of the main symptoms in chronic rhinonasal sinusitis. MRI has been indicated to evaluate the size of the olfactory bulb in such patients.
The aim of this study was to assess the volumetric changes of the olfactory bulb in patients with sinonasal polyposis before and after treatment using MRI.
Patients and methods: Fifteen control subjects and 30 patients were included in the study, 24 of them patients underwent endoscopic sinus surgery. Volumetric analysis of their olfactory bulb volume was done using MRI and specialized software.
Results: It was found that the olfactory bulb volume was significantly smaller in patients (19.98 ± 5.88 mm^3) when compared to control mean (39.6 ± 13.8 mm^3) and there was a significant increase in the olfactory bulb volumes in patients who underwent surgery 6 months postoperatively (24.79 ± 5.11 mm^3).
Conclusions: MRI with volumetric analysis is a useful tool in assessment of the olfactory bulb volume in patients with olfactory loss and appears to be of help in assessment of the degree of recovery in patients after sinus surgery.

1. Introduction

Olfaction plays an important role in human daily life by warning us against and attracting us toward odorous items. Olfactory problems include loss in odor sensitivity and qualitative changes referred to as dysosmia (1).

The primary olfactory nerves in the nasal cavity, the olfactory bulbs and tracts, and numerous intracranial connections and pathways form the olfactory system (2).

The olfactory bulb is considered to be the first important relay station in the olfactory pathway, providing the link between the peripheral olfactory system and cortical structures (3).

In contrary to cells of the central nervous system that develop in the embryonic and early post-natal periods, the olfactory system sensory epithelium and the olfactory bulb

* Corresponding author.
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progenitor cells differentiate into neurons well into adulthood. This differentiation depends on olfactory stimulation (4).

It was found that a reduction in the olfactory bulb size by 25% occurs in cases of olfactory stimulus deprivation, and recovery occurs 40 days after normalization of olfactory stimulation (5,6).

Any cause of bilateral nasal obstruction can lead to decreased smell sensations by limiting airflow to the olfactory receptors. Paranasal sinusitis is relatively common disorder affecting approximately 30% of population, and one of the common symptoms of acute and chronic paranasal sinusitis is decreased smell sensation (2). Patients with nasal polyps show a higher incidence of olfactory disturbances and a higher incidence of anosmia than patients with chronic rhinosinusitis without polyps. This may be explained by the conductive olfactory loss induced by polyps and by the degenerative changes associated with recurrent infections, scaring, chronic nasal medication, exotoxins and enhanced secretion of cytokines (7).

MRI has been indicated as a non-invasive diagnostic tool that can evaluate the olfactory apparatus including the olfactory bulbs and olfactory tracts, and it can also help in assessment of the intracranial causes of olfactory dysfunction (8).

The aim of this study was to assess the volumetric changes of the olfactory bulb in patients with sinonasal polyposis before and after treatment using MRI.

2. Patients and methods

Between January 2014 and April 2015, 30 adult patients with severe (grade III sinonasal polyposis) refractory to medical treatment including both systemic and local corticosteroid therapy were included in the study. Twenty-four patients of them were subjected to Endoscopic Sinus Surgery (ESS) followed by short course prednisolone therapy 20 mg/day for 10 days and 6 months nasal saline irrigation and local steroid therapy, and 6 patients refused the surgery. Patients with history of previous ESS and facial or cranial trauma involving the nasal bones, sinuses and anterior cranial fossa were excluded from the study.

All the patients were evaluated clinically before surgery, 6 weeks, and 6 months post-surgery by the Sino-Nasal Outcome Test-22 (SNOT 22) Questionnaire ver.4 (9). MRI of the paranasal sinuses was performed in all patients and in the 24 patients that underwent surgery 6 months post-surgery.

A control group of 15 subjects with no sinonasal disease was included. All patients were referred from the Otorhinolaryngology department to the MRI unit at our institution.

2.1. Scanning protocol

All patients were scanned on a 1.5T Toshiba Titan Vantage MRI machine (Toshiba Medical Systems, Japan) using Atlas head coil. The sequence used for assessment of the olfactory bulb in all patients and control subjects is 3D Coronal T2-weighted Steady State Free Precession (SSFP) sequence TR 10/TE 5, Slice thickness 0.75 mm, slice spacing 0. The field of view covered the anterior and middle segment of the base of the skull. Additional sequences included standard axial T2WI and DWI of the brain to exclude any central causes of impaired olfactory function.

2.2. Volumetric analysis

Volumetric analysis of the olfactory bulb was performed using 3D Slicer software ver. 4.2.2-1 which is a multiplatform, free open source software package for visualization and medical image computing developed by Harvard University and approved for medical research (http://www.slicer.org/).

The olfactory bulbs were segmented using a semi-automatic method of tracing their outlines manually, and the software was preset not to exceed the outlines of the region of interest by assigning the MR numbers of the targeted areas. After each slice containing the regions of interest were segmented, a quantification process was run which rendered the volume of the olfactory bulb structure as well as generating a 3D graphical model of it (Fig. 1). This process was performed by 2 different observers and the average volume of both measurements was recorded as long as the difference between the 2 measurements was less than 10%; otherwise, a third measurement was taken and it was averaged with nearest of the first 2 ones.

2.3. Statistical analysis

Paired *t*-test and one-way ANOVA tests were performed using 95% confidence interval and *p*-value of <0.05 was considered statistically significant. Software package used for analysis was Minitab V.17 (Minitab Inc., USA).

The protocol of the study was approved by the local ethical committee of our institution, informed consent was obtained from all patients and their data were stored on secured digital files anonymously.

3. Results

This study included 15 control subjects, 10 males and 5 females, and their age ranged between 17 and 55 years (mean 33.2 ± 11.2). The patients group included 30 patients, 18 males and 12 females, and their age ranged between 18 and 65 years (mean 37.2 ± 12.9). No statistically significant difference was found between the ages of the control subjects and patients (T-value = −1.05, P-value = 0.301).

The mean preoperative SNOT 22 score was 63 ranging from 43 to 81, and obstructive symptoms were dominating with nasal blockage/congestion (100%), followed by the need to blow nose (93.3%) and then the altered smell/taste (90%). Twenty-two patients showed altered smell/taste, and in 17 of them total anosmia was reported while 5 patients reported hyposmia. The postoperative mean SNOT at 6 weeks and 6 months was 23.8 and 20.4 respectively and there was a statistically significant change in the score between pre- and post-operative SNOT 22 scores ($P < 0.001$) using one-way ANOVA test. At 6 months contrary to the dramatic improvement of nasal obstruction from average 4.8/5 to 1.3/5, 10 patients continued to report complete anosmia, however in the remaining 14 patients significant improvement was reported from 3.9/5 to 2.4/5 ($P = 0.046$).

The olfactory bulb volume in the control group ranged between 25 and 63.3 mm^3 (mean 39.6 ± 13.8), and in the patients group between 10 and 34 mm^3 (mean 19.98 ± 5.88) (Figs. 2 and 3). A statistically significant difference between the volume of the olfactory bulb in the 2 groups was found (T-value = 5.26, P-value < 0.001) (Fig. 4).