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Correlation between olfactory acuity and sinonasal radiological findings in adult patients with chronic rhinosinusitis

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ABSTRACT

Objective: This study aimed to clarify the correlation between olfactory disorder severity and radiological findings in patients with chronic rhinosinusitis (CRS) in the preoperative stage.
Methods: From 2007 to 2014, 272 adult patients (163 men, 109 women; age range 22–80 years) with olfactory disorder due to bilateral CRS who were scheduled to undergo primary endoscopic sinus surgery (ESS) were enrolled. Two groups were studied: eosinophilic CRS (ECRS, $n = 193$); and non-ECRS ($n = 79$). T&T olfactometer recognition and intravenous olfaction tests were used. Computed tomography (CT) scores for sinuses and olfactory clefts (OC) were applied. Correlations between olfactory acuity and CT score were statistically analysed.
Results: In both groups, recognition threshold correlated significantly with CT score. Recognition threshold and CT score were significantly more severe in ECRS than in non-ECRS. CT score at OC showed the strongest correlation with recognition threshold. CT scores for total sinuses and OC in patients showing a positive response to the intravenous olfaction test (239 patients) were significantly milder than those in the negative group (29 patients), but ethmoid CT score was not.
Conclusion: Olfactory disorder severity correlated significantly with CT opacification. Olfactory disorder and CT findings were more severe in patients with ECRS than in those with non-ECRS.

1. Introduction

Olfactory disorders can markedly reduce quality of life. Chronic rhinosinusitis (CRS) reportedly represent the main common cause of olfactory disorder [1]. It is reported that 60–80% of patients with CRS have olfactory disorder [2–4]. CRS with nasal polyps (CRSwNP) is thought to cause transport olfactory disorders due to obstruction of airflow to the olfactory clefts (OCs) [5]. Moreover, inflamed OC epithelium may cause sensory olfactory disorder in not only patients with CRSwNP, but also CRS without nasal polyps (CRSsNP).

Clinical features of CRSwNP with eosinophil-dominant inflammation as 'eosinophilic CRS' (ECRS) were first reported in Japan in 2001 [6]. Recently, an increase in the number of patients with ECRS has been reported in Japan [7]. The characteristics of patients with ECRS have been recognized to include bilateral nasal polyposis (CRSwNP), olfactory disorder in the earlier stage, blood eosinophilia, severe eosinophil infiltration into sinonasal mucosae and polyps, predomination of lesions at the ethmoid sinuses and OCs on computer tomography (CT), lack of response to macrolide therapy, effectiveness of topical and systemic corticosteroids, and a tendency towards recurrence of nasal polyps (NP) after surgery [8–10]. Diagnostic criteria have recently been proposed based

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on the Japanese Epidemiological Survey of Refractory Eosinophilic Chronic Rhinosinusitis Study (JESREC study), a multicentre study [7]. Differentiating ECRS from non-ECRS is critical to improve prognoses [11,12].

For the management of olfactory disorders due to CRSwNP, pharmacotherapy using topical and/or oral corticosteroids is recommended [13–16]. Surgical treatment, comprising endoscopic sinus surgery (ESS) to remove NP and improve airflow, is required for CRS refractory to medical therapy. Combined therapy with medication and ESS has more effect on olfactory disorders [17].

The purpose of this study was to investigate correlations between degree of olfactory disorder and CT findings in patients with CRS in the preoperative stage. Furthermore, we compared correlations in ECRS to those in non-ECRS, and examined the mechanisms underlying olfactory disorder.

2. Materials and methods

2.1. Patients

Between January 2007 and July 2014, a total of 272 adult patients (163 men, 109 women) with olfactory disorder due to bilateral CRS who underwent primary ESS were enrolled. Median age was 51 years (range, 22–80 years). The study utilized a case series design involving a medical college centre, and conformed to the regulations of the ethics committee at Hyogo College of Medicine (approval number 1512). CRS was diagnosed based on guidance provided by the Japan Rhinologic Society, and referring to previous reports from Europe [13] and the United States [2]. ECRS was definitely diagnosed, based on the JESREC study [7]. The criteria indicate ECRS for a total score $\geq$11 from the following four items: (i) bilateral lesion (3 points); (ii) nasal polyps (2 points); (iii) ethmoid sinus dominant or pansinusitis on CT (2 points); and (iv) blood eosinophils >2% but $\leq$5%, 4 points; >5% but $\leq$10%, 8 points; and >10%, 10 points. Patients with normosmia (mean recognition threshold $\leq$1.0 using T&T olfactometer which stands for Takagi and Toyota), any history of previous sinonasal surgery, unilateral CRS, or tumour-associated disease were excluded from this study. Tests in this study, including blood examination, olfactory testing, and radiological testing, were performed before any medical treatments. A total of 193 patients fulfilled the criteria for ECRS (Group A). The remaining 79 patients were classified as the non-ECRS group (Group B). Table 1 shows background characteristics for patients in Groups A and B.

Table 1
Background between groups A and B.

	Group A (ECRS) $n=193$	Group B (non-ECRS) $n=79$
Age	54 (23–79)	49 (22–80)
Gender	110 men and 83 women	53 men and 26 women
Blood eosinophilia	7.7% (2.1–24.0)	2.0% (0.2–5.0)
Sinonasal CT		
Total CT score	20 (4–28)	14 (2–28)
Ethmoid CT score	7 (1–8)	4 (0–8)
CT score at OC	4 (0–4)	2 (0–4)
Olfaction		
Mean recognition threshold	5.8 (1.2–5.8)	4.4 (1.2–5.8)
Intravenous olfaction test	Positive: $n=172$ (91%) Negative: $n=18$ (9%)	Positive: $n=67$ (86%) Negative: $n=11$ (14%)

2.2. Olfactory tests

Olfactory acuity was evaluated using a T&T olfactometer recognition threshold test and intravenous olfaction test, and both of which are covered by health insurance in Japan [11].

The T&T olfactometer consists of five odorants: (A) β-phenyl ethyl alcohol, which smells like a rose; (B) methyl cyclopentenolone, which smells like burning caramel; (C) isovaleric acid, which smells like sweat; (D) γ-undecalactone, which smells like peach; and (E) skatole, which smells like garbage (Daiichi Yakuhin Sangyo, Tokyo, Japan). Severity of olfactory disorder was categorized into four classes according to the mean T&T recognition threshold: mild hyposmia, 1.2–2.4; moderate hyposmia, 2.6–4.0; severe hyposmia, 4.2–5.4; and anosmia, 5.6–5.8.

Intravenous olfaction testing was performed using prosultiamine, which smells like garlic or onion (alinamin; Takeda Pharmaceutical Company, Osaka, Japan). A dose of 10 mg (2 ml) of alinamin was injected into an antecubital vein at a constant rate over 20 s. Whether patients perceived a smell resembling garlic/onion was then examined after injection. The latency interval and duration of smell sensation were measured. Patients were divided into positive (response to prosultiamine) and negative (no response to prosultiamine) groups as described in our previous report [11].

2.3. Sinonasal CT scoring

CT findings for the maxillary, frontal, anterior and posterior ethmoid and sphenoid sinuses, and OC on both sides were scored using the following scale in accordance with the Lund–Mackay scoring system: no opacification, 0 points; partial opacification, 1 point; and complete opacification, 2 points [18,19]. The ostiomeatal complex was scored as 0 (no opacification) or 2 points (opacification). The total score was considered as the total CT score (possible range: 0–28 points). In particular, total score of the anterior and posterior ethmoid sinuses on both sides was considered as the ethmoid CT score (possible range: 0–8 points), because one of the characteristics of ECRS is reported to be 'ethmoid-dominant inflammation'.

2.4. Statistical analysis

We examined correlations between olfactory acuity and CT score using Spearman rank correlations. We further investigated and compared differences between Groups A and B. With regard to results of intravenous olfaction testing, differences between positive and negative groups were analysed. Results of comparisons between groups were analysed using the

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