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Retrospective comparison of cleft lip/palate patients and normal controls: cone beam computed tomograph imaging of foramen Husckhe morphology

Şuayip Burak DUMAN[1], Selin YEŞİLTEPE[2], İbrahim Şevki BAYRAKDAR[3], Yasin YAŞA[4]

[1]Assistant Professor, Inonu University, Faculty of Dentistry, Department of Oral and Maxillofacial Radiology, Malatya, Turkey, [2]Assistant Professor, Adnan Menderes University, Faculty of Dentistry, Department of Oral and Maxillofacial Radiology, Aydın, Turkey, [3]Assistant Professor, Eskisehir Osmangazi University, Faculty of Dentistry, Department of Oral and Maxillofacial Radiology, Eskişehir, Turkey, [4]Assistant Professor, Ordu University, Faculty of Dentistry, Department of Oral and Maxillofacial Radiology, Ordu, Turkey

SUMMARY

The foramen tympanicum, also known as the foramen of Huschke (FH), is a permanent anatomical variation situated in the anteroinferior section of the external auditory canal, posteromedial to the temporomandibular joint. The aim of the study is to determine the prevalence of the FH in Cleft Lip and Palate (CL/P) patients, compared to healthy individuals by using Cone Beam Computed Tomography (CBCT) data. We retrospectively analyzed the CBCT images of 272 individuals, who had been referred to our Oral and Maxillofacial Radiology clinic various reasons. For comparison, 226 randomly selected healthy individuals and 46 CL/P patients (35 unilateral and 11 bilateral) were evaluated. FH in 35 (12.9%) of the 272 individuals; 26 of them healthy individuals, 9 of them CL/P patients. The FH was higher in patients with CL/P (19.6%) than healthy individuals (11.5%). Clinicians should be aware of the variability of TME and especially the FH in the ear region when radiographically examining these sites prior to CL/P surgery to prevent postoperative reconstruction and complications. Moreover, to evaluate these anatomical variations, CBCT examinations can be used instead of CT scans.

Key words: Foramen tympanicum – Foramen Huschke – Cone beam computed tomography

INTRODUCTION

The foramen tympanicum, also known as the foramen of Huschke (FH), is a permanent anatomical variation situated in the anteroinferior section of the external auditory canal, posteromedial to the temporomandibular joint (TMJ) (Wang et al., 1991; Lacout et al., 2005; Rushton and Pemberton, 2005). The foramen was identified by Emil Huschke in 1889. An anomaly developing during embryogenesis of the tympanic circle causes abnormal ossification of the tympanic bone and possible development of a permanent FH (Fusconi et al., 2009). Genetic factors that delay ossification may also play roles. Usually, the FH gradually shrinks, wholly closing before the age of 5 years, but it oc-

Corresponding author: Suayip Burak Duman. Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Inonu University, Malatya, Turkey. Phone: +90 422 341 1100 .
E-mail: suayipburakduman@gmail.com

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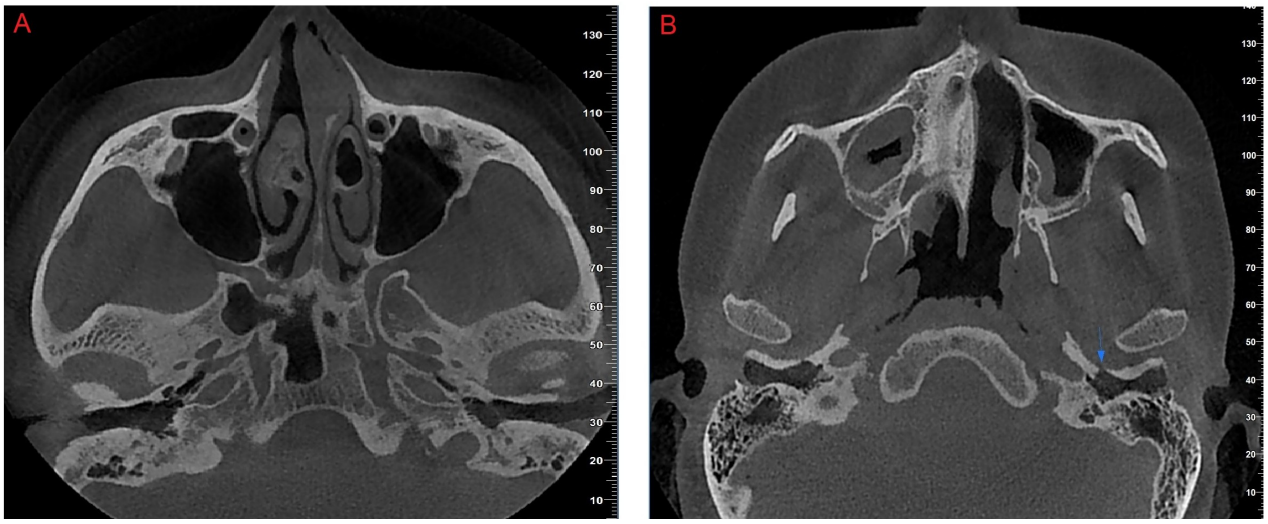

Fig 1. Axial images. **A:** Normal. **B:** Blue arrow: Foramen Husckhe

casionally persists (Mao and Nah, 2004). The FH may predispose the individual to TMJ pathology, or may trigger salivary discharge into the external auditory canal (EAC) during joint movement (Lacout et al., 2005). Accidental passage of arthroscopes into the EAC and otological complications have been reported during TMJ arthroscopy. FH persistence may predispose the person to the spread of infection or a tumor from the EAC to the infratemporal fossa or vice versa (Fusconi et al., 2009).

It is difficult to identify FH on conventional radiographs because of image distortion and superimposition of anatomical formations (Kalender et al., 2012). Cone-beam computed tomography (CBCT) requires a smaller radiation dose than conventional CT, and is widely used to investigate maxillofacial pathologies and bony structures such as the paranasal sinuses, skull base, and temporal bone. Three-dimensional CBCT reconstructions are helpful when planning surgery, as adjacent anatomical structures can be identified. In addition to CBCT is frequently used by dentists, otolaryngologists also favor the technique due to the excellent quality of bone images (Fakhran et al., 2014).

Cleft lip and palate (CL/P) deformations develop during intrauterine weeks 4 and 8 because of defects in the formation and growth of facial structures (Keçik and Enacar, 2009). CL/P accounts for 15% of all congenital abnormalities (Shapira et al., 1999). Consanguineous marriage; the use of tobacco, alcohol, and corticosteroids; deficiencies in folic acid and zinc; and maternal morbidity increase the risk of orofacial clefts (Burg et al., 2016).

Some studies have used CBCT to investigate FH prevalence in healthy individuals and patients with orthodontic malocclusions (Tozoğlu et al., 2012; Akbulut et al., 2014). However, to the best of our knowledge, no attempt has been made to investigate FH prevalence in CL/P patients. As CL/P may affect maxillofacial bone structure, we explored whether FH was more common in such patients, using CBCT to compare the FH incidence in CL/P patients and healthy individuals.

MATERIALS AND METHODS

We retrospectively analyzed CBCT images of 272 individuals who had been referred to our Oral and Maxillofacial Radiology clinic for various reasons such as implant planning, paranasal sinusitis, and other pathologies. All CBCT scans were obtained using a NewTom 5G (Quantitative Radiology, Verona, Italy) with patients in the standard supine position. (operating parameters: 110 kVp, 1-11 mA, 3.6 s). To ensure that the sagittal images were consistent, the Frankfort horizontal planes were oriented perpendicular to the table in all patients. Quantitative Radiology (QR) NNT version 2.21 imaging software was used to evaluate the CBCT images. We studied 226 randomly selected healthy individuals and 46 CL/P patients (35 unilateral and 11 bilateral). We identified each FH on axial images (Fig. 1) and confirmed it on sagittal images (Fig. 2), and then calculated prevalence percentages. All images were performed by one radiologist (S.B.D.) with 6 years of experience. The intraobserver reliability was assessed for all measurements using the intraclass correlation coefficient (ICC), and ICC was between 0.86 and 0.92. Patients with pathological disorders or with TMJ traumas and those requiring surgical procedures were excluded. Only high-quality scans were included, and the samples were gender balanced. Statistical analysis was performed using SPSS ver. 20.0 software for Windows (SPSS, Inc., Chicago, IL). The chi-squared test was employed to compare FH incidences; significance was set to $p < 0.05$. The study adhered to all relevant principles of the Declaration of Helsinki, including those in amendments and revisions thereof.

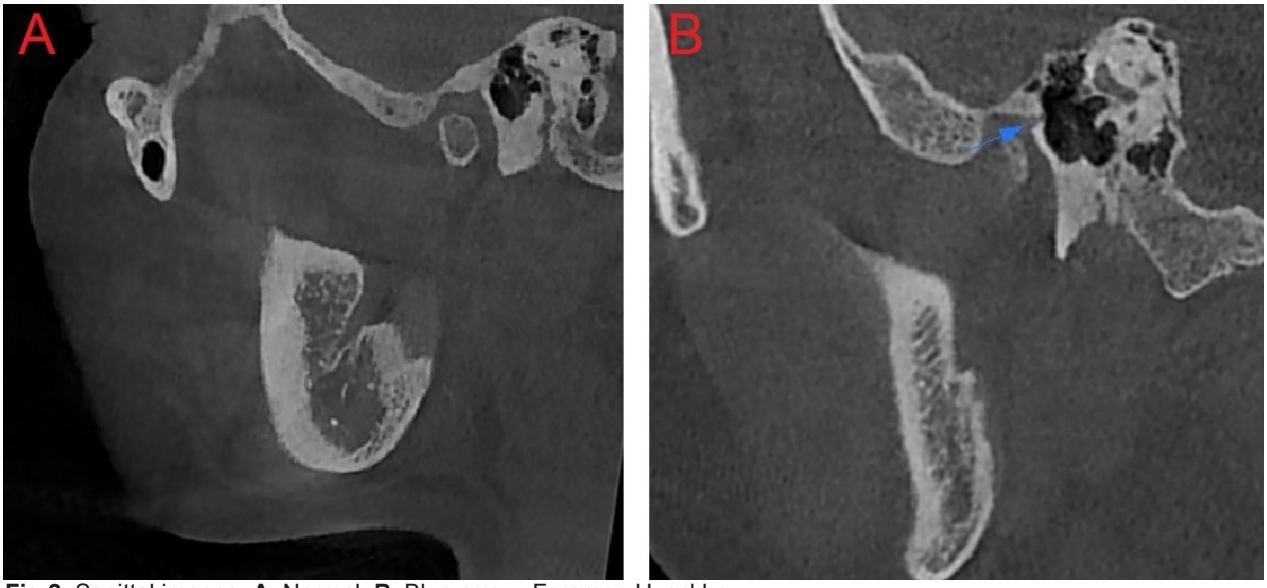

Fig 2. Sagittal images. **A**: Normal. **B**: Blue arrow: Foramen Husckhe

RESULTS

We evaluated 226 randomly selected healthy individuals and 46 CL/P patients (35 with unilateral and 11 with bilateral CL/P). We found FHs in 35 (12.9%) of the 272 individuals; 26 were healthy and 9 CL/P patients. The prevalence of FH was somewhat higher in CL/P patients (19.6%) than in healthy individuals (11.5%), but the difference was not significant (Table 1). Eleven of the 46 CL/P patients had bilateral, and 35 had unilateral CL/P. Six of the nine FHs in CL/P patients were on the left side. Of 28 patients with left-side CL/P, left-side FHs were found in four and right-side FHs in two; one FH was found in 1 patient with unilateral right-side CL/P (Table 2).

DISCUSSION

The FH is an osseous developmental defect in the anteroinferior portion of the EAC and extends inferior to the EAC in the first year of life. During skull growth, the FH closes anteriorly, usually closing entirely by the age of 5 years. However, in 5-46% of the affected population, the FH may persist for life (Rushton and Pemberton, 2005). The prevalence of persistent FH ranged from 3 to 25% in various studies; FH is now considered a normal developmental variation (Wang et al., 1991; Park et al., 2010; Kim et al., 2013).

Many factors affect ossification of tympanic bone. Mandibular pressure imposed on the bone by chewing, tearing, and breathing affects the development of maxillofacial bone after birth (Mao and Nah, 2004; Lacout et al., 2005). A persistent FH has been associated with herniation of soft tissues from the TMJ to the EAC or with formation of a fistula between the parotid gland and the EAC (Tasar and Yetiser, 2003; Langer and Begall, 2004). Patients with persistent FH may be asymptomatic and thus overlooked. In symptomatic patients, the FH usually manifests as otalgia, mandibular joint pain, external and middle ear inflammation, tinnitus, hearing loss, or salivary discharge from the EAC (Rushton and Pemberton, 2005; Toyama et al., 2009). Chewing can widen the defect, worsening symptoms (Toyama et al., 2009). In adults, a persistent FH thus triggers clinical and otological symptoms.

Some studies have used CBCT to investigate FH prevalence in healthy individuals and patients with orthodontic malocclusions. Akbulut et al. (2014)

Table 1. Distribution of the foramen of Huschke according to healthy individuals and CL/P patients

	Foramen of Huschke			p
Individuals	Absent	Present	Total	
Healthy	200 (88.5%)	26 (11.5%)	226 (100%)	0.05
CL/P	37 (80.4%)	9 (19.6%)	46 (100%)	
Total	237 (87.1%)	35 (12.9%)	272 (100%)	

Table 2. Distribution of the foramen of Huschke in CL/P patients

Foramen of Huschke	Unilateral CL/P		Bilateral CL/P	Total
	Right	Left		
Present (Right)	1 (14.3%)	2 (7.1%)	-	3 (6.5%)
Present (Left)	-	4 (14.3%)	2 (18.2%)	6 (13.1%)
Present (Total)	1 (14.3%)	6 (21.4%)	2 (18.2%)	9 (19.6%)
Absent	6 (85.7%)	22 (78.6%)	9 (81.8%)	37 (80.4)
Total	7 (100%)	28 (100%)	11 (100%)	46 (100%)

used CBCT to evaluate FH status in 185 such patients, recording FH occurrence, size, and location. FH status did not vary by sex or by the nature of the malocclusion. FHs were found in 42 patients (22.7%). Tozoğlu et al. (2012) found that the incidence of FH was 17.9% and that right-side (17.8%) was significantly more common than left-side FH (14.5%). Lacout et al. (2005), using high-resolution CT, found that the FH incidence was 4.6% and that FH was more common in females. In a cadaveric study, the prevalence of FH was 7.2% (Wang et al., 1991). We found a prevalence of 13.2%.

CL/P is a common birth defect whose incidence varies ethnically, geographically, and by socioeconomic status (Calzolari et al., 2007). It is characterized by complete or incomplete joining of the medial nasal prominences on one or both sides (Sadler, 2011). It is important to explore the relationship between CL/P and other malformations; this may increase our understanding of the embryogenic process underlying CL/P development (Sekhon et al., 2011). As CL/P may affect the maxillofacial bone, we explored whether FH was more common in CL/P patients; this was indeed the case (19.6 vs. 11.5%), although not significantly so. The FH rate was higher on the side of the cleft palate than the other side, but we found no direct cause-and-effect relationship. Most investigators have found that unilateral clefts were most often located on the left (Lee and Min, 1987; Baek et al., 2002). Thus, FH is more common on the left side in CL/P patients because CL/P is more common on that side.

CBCT delivers less radiation than standard CT when imaging anatomical landmarks prior to surgery. The quality of CBCT images of maxillofacial structures is equivalent to that of conventional CT (Ludlow and Ivanovic, 2008; Liang et al., 2010). CBCT differs from conventional CT in that all data are obtained during a single scan. The exposure time is generally less than 20 s, and image reconstruction requires less than 2 min. Although CT allows visualization of an FH, CBCT can produce images of equivalent diagnostic quality and resolution in a short time using less radiation (Patel and Dawood, 2007).

Conclusion

Clinicians should be aware of TMJ variability, and especially of FH, when imaging the ear prior to CL/P surgery to reduce any need for postoperative reconstruction and eliminate possible complications.

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