ELSEVIER

Auris, Nasus, Larynx 30 (2003) 21–24

AURIS NASUS LARYNX
INTERNATIONAL JOURNAL OF ORL & HNS

www.elsevier.com/locate/anl

The effects of the chorda tympani damage on submandibular glands: biometric changes

Murat Cem Miman [a,*], Ahmet Sigirci [b], Orhan Ozturan [a], Erkan Karatas [a], Tamer Erdem [a]

[a] *Otorhinolaryngology Department, Medical Faculty, Inonu University, Malatya 44300, Turkey*
[b] *Radiology Department, Medical Faculty, Inonu University, Malatya 44300, Turkey*

Received 12 February 2002; received in revised form 7 May 2002; accepted 24 May 2002

Abstract

Objective: It was aimed to analyze the biometric changes in ipsilateral submandibular glands of patients with unilateral chorda tympani (ChT) section during otological operations, compared with change in size of the contralateral glands and with those of healthy subjects. *Methods:* 29 patients with unilateral complete ChT section and 29 healthy subjects with identical ages, genders, and weights to the patient group were examined ultrasonographically. The patients having a mean duration to follow-up examination of 32 months (2–84 months) were subdivided into two groups by their time to follow-up as short-term patient group (2–12 months, 14 patients) and long-term patient group (13–84 months, 15 patients). The ultrasonographic dimensions and volumes of submandibular glands were compared statistically between the groups. *Results:* In the patient group, the glands on the contralateral, non-operated side were found to be greater than the ipsilateral, denervated glands in terms of both paramandibular depth dimension ($P < 0.05$) and volume ($P < 0.01$). The differences could be determined only in long-term patient group. When comparing the submandibular glands of the patient group with those of the control group, it was found that paramandibular depth dimension and volume of the submandibular glands on the contralateral, non-operated side were statistically greater ($P < 0.01$). There was no difference between submandibular glands on the operated side of the patient group and those of the control group ($P > 0.05$). *Conclusion:* The late (13–84 months) biometric results of ChT damage on submandibular gland were significant for increase in the size of the contralateral, non-denervated submandibular gland. An atrophying effect was not ascertained in the submandibular glands denervated parasympathetically due to the section of the ChT.

Keywords: Chorda tympani damage; Biometric changes; Submandibular gland; Ultrasonography

1. Introduction

The chorda tympani (ChT) is a mixed nerve transmitting afferent sensory and efferent secretory impulses. The latter component contains the preganglionic parasympathetic axons that innervate the sublingual and submandibular glands [1]. The ChT is vulnerable to injury as it arises from the vertical portion of the facial nerve and travels exposed through the middle ear. Therefore, it may become compromised secondary to various disease processes affecting the middle ear [2] or iatrogenically during otological surgical procedures [3].

The effect of ChT damage on the submandibular gland function has been a subject of many animal model and human studies, each demonstrating decreased secretion due to lack of parasympathetic efferent stimulation [4,5]. These findings have led to trials of therapeutic ChT section in an attempt to treat excessive salivation in patients with central nervous system trauma and in children with cerebral paresis [3]. The atrophying effect of ChT damage on the submandibular gland has also been studied in experimental studies using animal models [6,7]. To the best of our knowledge, however, the submandibular gland's biometric changes have never been studied in humans after ChT section.

* Corresponding author. Tel.: +90-422-3410-660x4606; fax: +90-422-3410-728
E-mail address: mcmiman@inonu.edu.tr (M.C. Miman).

0385-8146/02/$ - see front matter
PII: S0385-8146(02)00027-5

B-mode ultrasonography is an accepted diagnostic tool for the evaluation of head and neck masses. It may also be used to measure the biometric dimensions of the neck organs, including the salivary glands [8]. In spite of many studies reporting the findings of B-mode ultrasonography in benign and malignant salivary glands, few authors [9] are interested in assessing salivary gland size in normal, healthy subjects.

The objective of this study was to analyze the biometric changes occurring in the ipsilateral submandibular glands of patients with unilateral ChT section during otological operations, compared with the change in size of the contralateral glands and with those of healthy subjects.

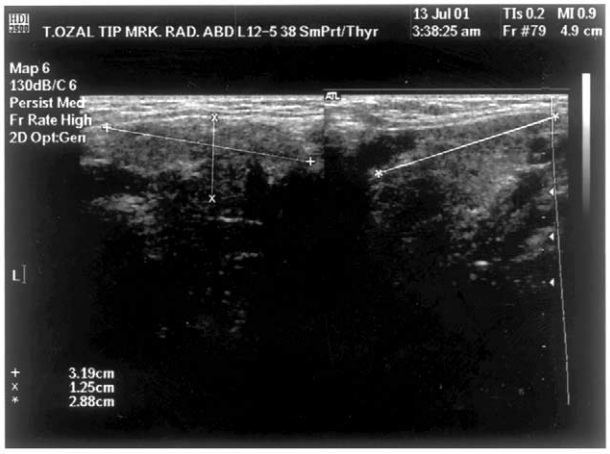

Fig. 1. Ultrasonographic image of a submandibular gland in both planes: (+) paramandibular anterior–posterior length; (×) paramandibular depth; (*) frontal lateral–medial width.

2. Materials and methods

An analysis of 29 patients with unilateral complete ChT section was performed for this study. 29 healthy subjects were recruited as a control group with identical ages, genders, and weights to the patient group.

The groups consisted of 21 women and eight men with a mean age of 31 years (12–60 years) and a mean weight of 63.3 kg (35–83 kg) in both groups. All subjects were free of diseases that could alter the size of the salivary glands (e.g. autoimmune diseases, tumors, status post radiation, and any consumptive disease).

All ChT sections were intraoperative, either iatrogenic or as necessary sequelae of extensive middle ear surgery. The patients had undergone unilateral canal wall-down timpanoplasty (18 cases), radical mastoidectomy (10 cases), and stapedectomy (one case). The primary pathology of 28 of the patients was extensive middle ear and mastoid cholesteatomas. The single stapedectomized patient was diagnosed with otosclerosis. 14 right ears and 15 left ears were operated on. The patients having a mean duration to follow-up examination of 32 months (2–84 months) were subdivided into two groups by their time to follow-up as short-term patient group (2–12 months, 14 patients) and long-term patient group (13–84 months, 15 patients). All patients were questioned about any complaint of mouth dryness.

In each subject, submandibular gland size was investigated by ultrasonographic examination, using the same paramandibular and frontal scanning method as Dost [8,9]. The glands were scanned at an angle that enabled maximum possible visualization of the glandular tissue. The anterior–posterior length, the frontal–lateral–medial width, and the paramandibular depth were measured in millimeters (mm) (Fig. 1). The software of the ultrasonic devices used in this study (HDI 5000 and 3500 Diagnostic Ultrasound System; ATL, Bothell, WA) included a feature to calculate the volume in milliliters (ml) based on the measured dimensions.

The statistical comparisons of submandibular gland dimensions and volumes were done between the ipsilateral, sectioned side, and contralateral, unaffected side within the patient group as well as among the short-term and the long-term patient group. The submandibular glands of the control group were initially compared against their contralateral partners and against those of the patient group. The normal distribution of the groups was analyzed by Kolmogorov–Smirnov test; the equality of variances in compared groups was analyzed by Levene test. For the statistical analysis of results, a two-tailed, unpaired Student's t-test with equal variance was performed using the SPSS 6.0 statistical software package.

3. Results

None of the patients complained of mouth dryness during the postoperative period. Table 1 exhibits the ultrasonographic biometric results of the study.

In the control group, the left and right submandibular glands showed no difference in biometric measurement ($P > 0.05$). However, in the patient group, the glands on the contralateral, non-operated side were found to be greater than the ipsilateral, denervated glands in terms of both paramandibular depth dimension ($P < 0.05$) and volume ($P < 0.01$). In the short-term patient group, the biometry of the submandibular glands was not statistically different ($P > 0.05$), whereas the long-term patient group exhibited a significant difference in paramandibular depth dimension ($P < 0.05$) and volume ($P < 0.05$).

When comparing the submandibular glands of the patient group with those of the control group, it was found that the paramandibular depth dimension and volume of the submandibular glands on the contra-

Table 1.
Ultrasonographic biometric results of all patients and control subjects

Groups	Side	n	a.p.	p.d	f.	V
Patient group All	operated side	29	31,94 ± 4,17	12,08 ± 2,95	28,60 ± 4,30	5,87 ± 2,02
	contralateral side	29	33,83 ± 3,41	13,84 ± 2,89	31,03 ± 5,56	7,68 ± 2,43
Patient group short-term	operated side	14	33,12 ± 4,47	13,58 ± 2,55	28,05 ± 4,12	6,76 ± 2,00
	contralateral side	14	34,51 ± 3,61	14,94 ± 2,34	31,11 ± 5,67	8,42 ± 2,29
Patient group long-term	operated side	15	30,85 ± 3,69	10,67 ± 2,65	29,11 ± 4,55	5,04 ± 1,69
	contralateral side	15	33,20 ± 3,21	12,83 ± 3,06	30,95 ± 5,66	7,00 ± 2,43
Control group	right side	29	32,41 ± 3,92	12,69 ± 1,59	26,61 ± 4,37	5,80 ± 1,58
	left side	29	32,07 ± 3,67	12,09 ± 1,66	28,32 ± 3,79	5,78 ± 1,42

(**n**=number of the subjects, **a.p.**= paramandibular anterior-posterior length, **p.d.**=paramandibular depth, **f.**=frontal lateral-medial width, **V**=volume. [a.p., p.d., f. in mm; V in mL])

lateral, non-operated side were statistically greater ($P < 0.01$). There was no difference between submandibular glands on the operated side of the patient group and those of the control group ($P > 0.05$).

4. Discussion

The ChT arises from the vertical portion of the facial nerve approximately 6 mm proximal to the stylomastoid foramen. In the middle ear, it initially travels cranially parallel to the facial nerve and then leaves the middle ear cavity through a small aperture between the base of the pyramid and the bony tympanic annulus [1]. Because of this free passage of the nerve in the middle ear cavity, suppurative or cholesteatomatous chronic otitis media may cause the functional loss of the nerve [2]. Inadvertent damage of the nerve is underestimated during the middle ear surgeries, as there are no reports about the incidence of iatrogenic damage of ChT in the literature. Nevertheless, ChT injury usually causes temporary and/or minor complaints in patients. Unilateral section of ChT did not lead to any complaint such as mouth dryness in our study. Chilla et al. [3] reported persistent reduced secretory ability of the submandibular gland after ChT damage during middle ear surgery. However, they noticed that neither general hyposalivation nor gustatory dysfunction was revealed from patients even 4.5 years after the section. Therefore, unilateral ChT section is of controversial benefit for the treatment of drooling in bulbar motor neuron disease, following brain trauma, and in mentally retarded patients [4].

The importance of parasympathetic innervations of the submandibular gland also has been proven by several experimental studies in animal models [7,10,11]. Electrical stimulation of the parasympathetic innervation to the submandibular gland of rats resulted in increased thymidine uptake into DNA demonstrating that the parasympathetic nerve initiates a proliferative response [10]. The effects of denervating salivary glands have also been of interest to physiologists for more than a century. In animal study, Kyriacou and Garrett [6] showed that parasympathetic denervation soon caused ipsilateral atrophy in both acinar and granular tubule cells, and a substantial reduction in gland wet weight. There was an apparent increase in the fibrous connective tissue of the glands. Thus, they demonstrated that parasympathetic impulses have an important role in maintaining the normality of rabbit submandibular gland. Interestingly, contralateral glands showed some changes not seen in the glands of control, such as increased turnover of secretory granules indicating hyperactivity. This histologically proven compensatory hypersecretion of the other major salivary glands could explain the inadequacy of unilateral ChT section in the treatment of drooling. Moreover, instead of an atrophying effect of ChT section, a compensatory contralateral hypertrophy was noted in our patients, especially among the long-term patient group. This hypertrophy was manifested especially in paramandibular depth dimension and volume. The lack of any biometric changes during the postoperative first year may be explained by the slow rate of compensation. The present authors also plan a study to determine the functional status of glands

after ChT damage using submandibular gland scintigraphy for the same patient group as the current paper.

This study carries importance because it is one of the few studies investigating the submandibular gland's ultrasonographic biometry. Although many studies of ultrasonic diagnosis in salivary glands have been published in the medical literature, specifications about the size of normal functioning salivary glands are not common. Dost [8,9] reported the ultrasonographic biometry in normal submandibular salivary glands, and no statistically significant difference was found in the dimensions of submandibular gland dimensions among populations matched for age, gender, and body weight. Our findings were in accordance with his study. However, his method of estimating the submandibular gland volume using the Simpson formula was discordant from those cadaveric submandibular gland volumes. Our volume results found automatically by the software of the ultrasonography devices were within the limits of the real volume of the gland measured by displacement of water (6.9 ± 2.3 ml) reported in his studies [8,9].

5. Conclusion

The late (13–84 months) biometric results of ChT damage on submandibular gland were significant for increase in the size of the contralateral, non-denervated submandibular gland. In our study, the paramandibular depth dimension and the volume were found to increase significantly. An atrophying effect was not ascertained in the submandibular gland denervated parasympathetically due to the section of ChT. The complaint of mouth dryness was not recorded in the patient group.

References

[1] Sooy CD, Boles R. Neuroanatomy for the otolaryngology—head neck surgeon. In: Papparella MM, Shumrick DA, Gluckman JL, Meyerhoff WL, editors. Otolaryngology, vol. 1, 3rd ed.. Philadelphia, PA: W.B. Saunders, 1991:125–6.

[2] Gedikli O, Dogru H, Aydin G, Tuz M, Uygur K, Sari A. Histopathological changes of chorda tympani in chronic otitis media. Laryngoscope 2001;111:724–7.

[3] Chilla R, Nicklatsch J, Arglebe C. Late sequelae of iatrogenic damage to chorda tympani nerve. Acta Otolaryngol 1982;94:461–5.

[4] Grant R, Miller S, Simpson D, Lamey PJ, Bone I. The effect of chorda tympani section on ipsilateral and contralateral salivary secretion and taste in man. J Neurol NeuroSurg Psychiatry 1989;52:1058–62.

[5] Rourke K, Edwards AV. Submandibular secretory and vascular responses to stimulation of the parasympathetic innervation in anesthetized cats. J Appl Physiol 2000;89:1964–70.

[6] Kyriacou K, Garrett R. Morphological changes in the rabbit submandibular gland after parasympathetic or sympathetic denervation. Arch Oral Biol 1988;33:281–90.

[7] Harrison JD, Fouad HMA, Garrett JR. Variation in the response to ductal obstruction of feline submandibular and sublingual salivary glands and the importance of the innervation. J Oral Pathol Med 2001;30:29–34.

[8] Dost P. Ultrasonographic biometry in normal salivary glands. Eur Arch Otorhinolaryngol 1997;254:S18–9.

[9] Dost P, Kaiser S. Ultrasonographic biometry in salivary glands. Ultrasound Med Biol 1997;23:1299–303.

[10] Schneyer CA, Humphreys-Beher MG, Hall HD, Jirakulsomchok D. Mitogenic activity of rat salivary glands after electrical stimulation of parasympathetic nerves. Am J Physiol 1993;264:935–8.

[11] Muir TC, Pollock D, Turner CJ. The effects of electrical stimulation of the autonomic nerves and of drugs on the size of salivary glands and their rate of cell division. J Pharmacol Exp Ther 1975;195:372–81.