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**Are hearing and middle ear statuses at risk  
in Chinese patients undergoing orthognathic surgery?**

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**Running head:** Orthognathic surgery and hearing

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## ABSTRACT

Orthognathic surgery, which is performed to correct dentofacial abnormalities, has been associated with post-operative reduction in hearing sensitivity and middle ear dysfunction. In this study, the pre- and post-operative hearing status and middle ear function of 37 Chinese subjects who underwent orthognathic surgery, as well as subjective reports of aural symptoms, particularly hearing loss, tinnitus, fullness and otalgia were investigated. There was a significant increase in the number of subjects with measured loss, perceived loss and aural fullness from pre-surgery to one-week post surgery. However, the percentage of increase was small compared to previous findings. This difference in findings was attributed to the type of surgical techniques used, and to the fact that the Chinese population appears to be less susceptible to middle ear effusion. Subjective complaints of aural symptoms may not be accompanied by measured loss.

**Keywords:** hearing loss, Eustachian tube function, aural symptoms, tinnitus, fullness, otalgia

## Introduction

Dentofacial abnormalities refer to an abnormal position of the mandible, the maxilla, or both. Patients with dentofacial abnormalities may experience problems in mastication and in producing clear speech. Some also have temporomandibular joint (TMJ) syndrome. Concern for cosmetic appearance is another issue prompting patients to request surgical intervention. Orthognathic surgery is performed to correct the position of the maxilla and/or the mandible, with the aims of improving speech, mastication and appearance.<sup>1-4</sup> Of particular relevance to ear symptoms is the advancement and elongation of the maxilla, moving the attached palatal tissues with it and disturbing its length of action.<sup>5</sup> Surgical aedema or lymph aedema, and haematoma from nasotracheal intubation may also cause swelling of the soft tissues in the nasopharyngeal area, blocking the Eustachian tube and precipitating middle ear effusion. Post surgical changes in hearing sensitivity and middle ear status have been reported (Table 1)<sup>5-7</sup> and monitoring of ear status has been recommended.<sup>5-7</sup>

*Insert Table 1 about here*

With the exception of one study,<sup>5</sup> the presence of other aural symptoms (e.g., tinnitus) has not been investigated. As many patients with dentofacial abnormalities also have temporomandibular joint (TMJ) disorders that are associated with aural symptoms, tinnitus, fullness or otalgia may be more common than in patients without this condition<sup>8</sup>. Movement of the mandible in orthognathic surgery may exacerbate TMJ problems. Increased tension of the muscles of mastication and excessive force on the TMJ may result in aural symptoms. Surgical movements of the mandible also affect tinnitus.<sup>9</sup>

In summary, previous studies on Western populations have shown decreased hearing sensitivity and middle ear dysfunction immediately after orthognathic surgery. Subjective aural symptoms have seldom been investigated. Anecdotal reports suggest a much lower prevalence of subjective aural symptoms among the Chinese population. The difference may

be related to a lower prevalence of middle ear problems in Chinese<sup>10</sup> and to reports that Chinese patients often do not perceive a hearing problem until the loss becomes more severe.<sup>11</sup> Additionally, the surgical procedure that we employ is composed mainly of bi-maxillary procedures in which surgical movement of the maxilla is only one part of the overall procedure so that Eustachian tube function is less likely to be affected. Teeth are removed and the front portion of the maxilla is moved forward or backward to reduce the extent of movement of the rear portion of the maxilla. A study is therefore needed to verify whether hearing and middle ear status are at risk in Chinese patients undergoing orthognathic surgery. In this study, we address the following issues in our Chinese population:

1. Does hearing change as a result of orthognathic surgery?
2. Is orthognathic surgery associated with changes in the middle ear?
3. Are changes in hearing sensitivity or middle ear associated with subjective perception of hearing loss, tinnitus, fullness or otalgia?

## **METHOD**

### **Subjects**

Consecutive candidates for orthognathic surgery were recruited to the study. A total of 37 subjects (16 women and 21 men) were studied, with an age range of 15 to 40 years. These patients complained of problems with skeletal aesthetics (20 subjects), dental aesthetics (13 subjects), speech production (8 subjects), mastication (20 subjects), temporal mandibular joint syndrome (5 subjects) and facial asymmetry (2 subjects). Before surgery, these patients exhibited skeletal and dental malformations that could involve the maxilla, mandible or both. Two subjects reported a history of chronic middle ear problems and five reported possible hearing problems. During surgery, the maxilla and/or the mandible were sectioned; and moved forward, downward, upward, or a combination of these movements to correct the conditions.

## **Procedures**

Hearing sensitivity and middle ear function were assessed one week before the operation, and one week, six weeks, three months and six months after the operation. Bilateral air- and bone-conduction hearing thresholds were assessed via pure-tone audiometry using a Madsen OB 822 audiometer for the octave frequencies of 250 to 8000 Hz.

Tympanometry was performed using a GSI 33 Middle Ear Analyzer with a 226-Hz probe tone. Eustachian tube function was assessed using an inflation-deflation procedure. To identify the presence of hearing or middle ear problems, the following criteria were used:

1. For the ear to be identified with sensorineural loss, the bone conduction thresholds must be worse than 25 dB HL at each of the octave frequencies of 250 to 8000 Hz.
2. For test results to be classified as indicative of possible middle ear problems, there must exist:
  - a) an air-bone gap of 20 dB or more at 500 Hz; or
  - b) an air-bone gap of 10 dB or more at 500 Hz and a peak compensated admittance (Peak  $Y_{tm}$ ) lower than 0.3 ml and/or normal equivalent ear canal volume ( $V_{ea}$ ) with tympanometric width (TW) exceeding 140 daPa.
3. To identify subjects with Eustachian tube (ET) dysfunction, a change of Tympanometric peak pressure (TPP) of less than 15 to 20 daPa is expected.

Subjective evaluation of hearing and middle ear status before the surgery and subsequent changes after the surgery were obtained via a questionnaire designed by the investigators.

## **RESULTS**

Table 2 summarizes the audiometric findings. Pre-operatively, eight subjects had measurable hearing loss at one or more frequencies between 250 and 8000 Hz. Six of these subjects had a bilateral and two subjects had a unilateral hearing loss. The loss for 4 subjects

was sensorineural in nature. Five ears (6.8%) had a mild conductive loss and one had a moderate to severe mixed loss.

*Insert Table 2 about here*

The first aim of the study was to identify post-surgical hearing changes. As shown in Table 2, the number of ears with measurable conductive hearing loss increased significantly from 6.8% pre-operatively to 10.8% at one week post-operatively (McNemar test,  $p < 0.001$ ). Number of ears with other types of loss did not change. Number of ears with measurable loss then decreased significantly compared to the pre-operative period to 12.2% at six weeks post-operatively (McNemar test,  $p < 0.001$ ). The results of a One-way ANOVA indicated no significant difference in air-conduction hearing thresholds at the octave frequencies of 250 to 8000 Hz before and after the operation at any of the post-operative evaluations ( $p > 0.05$ ). In other words, although there was a significant increase in the percentage of subject ears with conductive hearing loss at one week post-operation, because the hearing loss was mild in each case, it did not result in a significant increase in the group mean thresholds. Individual results were reviewed. No ear, including the 14 ears that had a hearing loss before the surgery, was found to have a worsened sensorineural loss at any post-surgical interval. The conductive problem subsided for two subjects with unilateral loss pre-surgically.

As depicted in Table 3, pre-operative measurable loss was found to have a mild to moderate correlation with subjective complaints of perceived loss, tinnitus and fullness pre-operatively and at 6<sup>th</sup> week post-operation ( $\varphi = 0.29$  to  $0.45$ ). Occurrence of otalgia was not related to any pre-operative measurable hearing loss. Table 4 summarizes the percentage of subjects with aural symptoms. Pre-operatively, 24.3% (or 18) of the ears experienced at least one aural symptom. This percentage includes less than half of the subjects (8.1% of all ears) with pre-operative hearing loss and 12 ears (or 6 subjects) without pre-operative loss. All of these subjects reported pre-operative tinnitus. Fewer subjects perceived hearing problems,

fullness or otalgia. There was an initial increase at one week post-operatively in the number of subjects experiencing at least one of the aural symptoms (to 40.3%). The number of subjects reporting hearing problems increased from 12.3% to 18.9%; and fullness from 6.8 to 22.2%. That is, some subjects without pre-operative loss or aural symptoms were experiencing post-operative symptoms. Aural symptoms affected less than 22.2% of the ears post-surgically at six months. The percentage of ears experiencing fullness and otalgia returned to pre-operative figures while the number of ears perceiving hearing problems and tinnitus reduced significantly to 2.8% and 15.3% (McNemar test,  $p < 0.05$ ), respectively. Some patients reported persistent aural symptoms.

*Insert Tables 3 & 4 about here*

Table 2 also shows that more than 58% of the subjects had Eustachian tube dysfunction. The percentage did not change significantly in the post-operative periods compared to pre-operatively (McNemar test,  $p > 0.05$ , corrected for multiple comparisons). Among the subjects who had neither loss nor complaints of ear conditions, only three ears consistently tested negative during the study.

## **DISCUSSION**

Most patients (81% of all ears or 31 subjects) in this study had no pre-operative hearing loss. There was no significant deterioration in sensorineural hearing following orthognathic surgery. Indeed, the number of ears exhibiting a hearing loss decreased significantly at six weeks post-operation. Based on the results from this and three previous studies,<sup>4-6</sup> we conclude that orthognathic surgery does not cause permanent sensorineural loss.

However, the results from post-operative observations at one week and at six weeks were quite different from those of other studies. Although there was no significant change in overall hearing thresholds across the test frequencies between pre- and post-operative



periods, the percentage of ears exhibiting conductive hearing loss increased significantly by about 4% at one week-post-operation. This increase is small compared to a previous report of 64% increase in the number of subjects exhibiting hearing loss at three weeks post-operatively.<sup>6</sup> Other studies did not measure hearing status at such an early post-surgical stage. Results at six weeks were similar to findings measured at about 3 months post-operatively in other studies,<sup>4,6</sup> indicating a reduction of subjects exhibiting hearing loss.

This difference in findings could be related to the surgical procedures used and/or the reduced susceptibility of Chinese patients to middle ear effusion.<sup>11</sup> Our clinical experience has indicated that the prevalence of middle ear effusion is lower among Chinese patients with cleft palate than their Western counterparts. These findings suggest that surgeries involving the nasopharyngeal area may not have as much effect on middle ear conditions in the Chinese population as in Western populations.

Pre-operatively, only half of the subjects with hearing loss reported hearing or middle ear problems. This is consistent with a previously published finding that Cantonese-speaking people appear not to perceive a hearing problem until the loss gets to about 40 dB HL.<sup>11</sup> Interestingly, as many as 40% of ears reported ear symptoms when there was no measurable post-operative loss or conductive component. These results suggest that patients undergoing orthognathic surgery often complain of aural symptoms.

More subjects (15.3 to 24.7% of ears) reported tinnitus than hearing problems, fullness or otalgia. Even so, this percentage is not higher than the 14% to 32% prevalence of tinnitus for a normal population.<sup>12-14</sup> More subjects complained of perceived loss and fullness at first week post-operatively, although in most cases these problems were not associated with pre-operative measured loss.

The percentage of subjects with ET dysfunction was relatively high (58.1 to 68.5%) and did not change significantly over the course of the post-operative period. Eustachian

Tube dysfunction was not accompanied by low Peak Ytm, wide TW or excessively negative peak pressure. The lack of relationship between the findings of ET dysfunction and tympanometric measures has been previously reported.<sup>6</sup> These procedures often fail to produce dramatic peak-pressure shifts<sup>15</sup>, and the poor resolution of most commercial instruments may lead to non-interpretable or inaccurately judged results. Therefore, results from ET function tests should be evaluated conservatively. When other tympanometric findings are available, results from ET function test could provide supplementary information.

## **CONCLUSION**

Although previous studies<sup>5-7</sup> have reported reduced hearing sensitivity and middle ear dysfunction in many subjects undergoing orthognathic surgery, this study did not show the same among Chinese patients. There was only a slight increase in the number of subjects with measurable post-operative conductive hearing loss at one week post-operation; the mean changes in hearing thresholds were not significant. Discrepancies in the findings may be attributed to differences in surgical approach and to the fact that the subject population may be less susceptible to middle ear problems. Among the subjective symptoms evaluated, the number of subjects experiencing aural fullness and perceived loss increased at one week post-operation. Pre-operative complaints of aural symptoms persisted for some subjects. Some who had no pre-operative problems experienced occasional problems post-operatively. The increase in the number of ears with measured loss and aural symptoms at one week post-operation suggests that patients should be counseled about possible post-surgical hearing loss immediately after surgery. However, the small increase in number of ears exhibiting hearing loss post-operatively and the fact that most ears return to pre-operative status indicate hearing loss is not a significant risk for this population.

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Table 1. Audiometric and middle ear findings from previous studies (the numbers represent percentage of ears in each study).

Disorder	Pre-surgery	Post-surgery						
		2-8d	3w/1m	6w	3m	6m	9m	12m
<u>Vallino<sup>4</sup></u>								
Hearing loss	0	--	--	--	0	0	0	0
Middle ear	0	--	--	--	8.8	8.8	8.8	5.8
<u>Baddour et al.<sup>5</sup></u>								
Middle ear	0	55.0	0	--	--	--	--	--
<u>DeRuyter &amp; Diefendorf<sup>6</sup></u>								
Hearing loss	7.0	--	71.0	50.0	7.0	--	--	--
Eustachian tube	43.0	--	86.0	50.0	7.0	--	--	--
Middle ear	29.0	--	86.0	50.0	7.0	--	--	--
<u>Gotzfried &amp; Thurmfar<sup>7</sup></u>								
Hearing loss	36.5	53.8*	--	--	--	36.5	--	--
Middle ear	30.8	44.2	--	--	--	26.9	--	--

d = days

w = weeks

m = months

\* 2 subjects experienced sensorineural loss post-surgery

Table 2. Percentage (%) of ears with hearing loss and Eustachian tube dysfunction

	Pre- Surgery	Post-surgery			
		1 week	6 weeks	3 months	6 months
<u>Hearing loss</u>					
<b>Conductive</b>	6.8	10.8	2.7	4.2	4.2
<b>Mixed</b>	1.4	1.4	1.4	1.4	1.4
<b>Sensorineural</b>	10.8	10.8	8.1	8.3	5.6
<b>Total</b>	<b>18.9</b>	<b>23.0</b>	<b>12.2</b>	<b>13.9</b>	<b>11.1</b>
<b>Eustachian tube dysfunction</b>	58.1	62.5	61.5	58.0	60.3
<b>Total N</b>	74	74	74	70	70

Note: Totals do not always match, due to missing data in one or more categories.

Table 3. Phi coefficients describing the relationship of existence of pre-operative measured loss to subjective complaints of aural symptoms.

	Pre- surgery	Post-operation			
		1 week	6 weeks	3 months	6 months
<b>Perceived loss</b>	.29*	.16	.29*	.39**	-.07
<b>Tinnitus</b>	.27*	.51***	.35***	-.02	-.01
<b>Fullness</b>	.35***	-.02	.45***	-.05	.02
<b>Otalgia</b>	.11	-.04	.00	.06	.25

\*  $p < .05$

\*\*  $p < .01$

\*\*\*  $p < .005$



Table 4. Total percentages (%) of ears reporting aural symptoms of perceived hearing loss, tinnitus, fullness and otalgia.

	Pre-	Post-surgery			
	surgery	1 week	6 weeks	3 months	6 months
<b>Any aural symptoms</b>	24.3	40.3	32.4	21.9	22.2
<b>Hearing problems</b>	12.3	18.9	10.8	5.5	2.8
<b>Tinnitus</b>	24.7	22.2	24.3	23.3	15.3
<b>Fullness</b>	6.8	22.2	8.1	1.4	7.0
<b>Otalgia</b>	10.8	12.5	14.9	2.8	11.3

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