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REVIEW ARTICLE

Iatrogenic injury of the chorda tympani: a systematic review

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Abstract

Objective: To review the currently available literature on iatrogenic injury of the adult chorda tympani.

Design: Systematic literature review.

Method Five electronic databases and one search engine were used to access available English language literature on the chorda tympani, focusing on iatrogenic injury.

Results: The chorda tympani is most often injured during middle-ear surgery, after which at least 15–22 per cent of patients experience symptoms, mostly changes in taste and dryness of the mouth. Numerous factors influence whether injury to the chorda tympani causes symptoms, including the extent of injury, type of surgery, age of the patient, anatomical variables and subjective adaptation. Although most patients experience gradual symptomatic recovery, complaints can be persistent and troublesome.

Conclusion: Care should be taken to preserve the chorda tympani during middle-ear surgery, and to warn patients pre-operatively about this potential complication. This is particularly important if surgery is bilateral.

Key words: Ear, Middle; Chorda Tympani Nerve; Otologic Surgical Procedures; Complications; Gustation

Introduction

Iatrogenic damage to the chorda tympani is a well recognised complication of middle-ear surgery.[1] The overall reported prevalence of related symptoms after such surgery is between 15 and 22 per cent,[2,3] although chorda tympani injury occurs more often. The consequences of injury are variable, prognosis is difficult to predict, and prevention is sometimes controversial.

This article follows on from a systematic review of the clinical anatomy of the chorda tympani (see below), and aims to summarise our current knowledge about iatrogenic injury to the chorda tympani and the implications for clinical practice.

Search strategy

A systematic literature review was undertaken using the electronic databases Medline, Embase, PubMed, Web of Science, and Cochrane Library and the search engine Google Scholar. English language and human studies were selected using the search term 'chorda tympani' and its subheadings, focusing on articles relevant to iatrogenic injury. Secondary references were retrieved from primary sources, and animal data included where relevant.

Results

These are best considered as a series of clinical questions, as follows.

Where and when does chorda tympani injury occur?

The lengthy course of the chorda tympani exposes it to the risk of injury in a variety of surgical procedures (Table I), most commonly during middle-ear surgery. The frequency of injury is difficult to determine and depends on the surgical procedure and technique, underlying pathology, and method and timing of detection. In one study of 107 patients undergoing middle-ear surgery for chronic otitis media, the chorda tympani was inadvertently divided in 20 (19 per cent) cases.[4]

How is the chorda tympani injured?

The chorda tympani may be injured by a variety of mechanisms including transection, stretching, ischaemia, thermal injury, excessive handling and desiccation. Nerve transection may be accidental or deliberate. Stretching is a common mechanism,[19] such as when raising a tympano-meatal flap during myringoplasty.[10] Animal studies have shown that the

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TABLE I
IATROGENIC CAUSES OF CHORDA TYMPANI* DAMAGE

Facial nerve
Middle cranial fossa surgery involving internal auditory meatus
Translabyrinthine approaches to cerebellopontine angle
Chorda tympani
Cochlear implantation[4–6]
Mastoid surgery[2,7,8]
Middle-ear surgery (e.g. cholesteatoma, tumours)[8,9]
Ossiculoplasty
Stapedectomy[7,10]
Stapedotomy[11,12]
Tympanoplasty & myringoplasty[2,10]
Tympanotomy[2]
Subannular tube placement
Surgery for ear canal widening (e.g. removal of surfers' exostoses)
Temporomandibular joint surgery
Lingual nerve
Orthognathic surgery
– Mandibular sagittal split osteotomy[13]
Dental surgery
– Inferior alveolar nerve block[14–16]
– Lower 3rd molar extraction[17]
Salivary gland surgery
– Submandibular gland & duct surgery
– Sublingual gland interventions

*The nerve and/or its fibres.

intraneural microcirculation is interrupted when nerves are stretched by 15 per cent or more of their resting length.[20] Various authors have reported thermal injury from bone drilling[10] or diathermy, and drying from the microscope heat or overhead lights[1,7] or from prolonged exposure without moistening.[3,21]

What are the effects of chorda tympani injury?

The classic features of chorda tympani injury are loss or alteration of taste with or without dryness of the mouth, both of which are related to the main functions of the nerve. In one study of 140 middle-ear operations, 15 per cent of patients reported post-operative taste disturbances: 71 per cent had altered taste, 29 per cent had loss of taste, and 19 per cent had concomitant dryness of the mouth.[2] Several authors have also described somatosensory symptoms such as numbness and tingling[7,11,19,22–26] and post-operative touch-evoked dysgeusia,[27] following chorda tympani damage.

Injury to the chorda tympani does not necessarily cause symptoms. Some patients are asymptomatic, whilst others can have transient or permanent symptoms.[1–3] Numerous factors influence which of these three outcomes occurs, the most important being whether the chorda tympani has been sectioned or is grossly intact.[2,3,10,19,22,28–30] Others include the type of surgery,[2,31] the age of the patient,[30,32] whether the injury is unilateral or bilateral,[7,33] and the underlying disease.[1,2,9,32,34]

Anatomical variables are also likely to affect the outcome, i.e.: the extent to which inhibition of other taste nerves is released after chorda tympani injury;[33,35,36] the extent of regeneration of the ipsilateral chorda tympani;[19,37] and the degree of reinnervation by the chorda tympani or glossopharyngeal nerve.[22,29,38] In addition, there is a variable subjective adjustment to taste impairment.[22,29]

Specific symptoms, and their prevalence and prognosis, will now be discussed.

Taste

Changes in taste can be categorised as dysgeusia, a 'perversion of the sense of taste' or, less commonly, as ageusia, a 'lack or impairment of the sense of taste'.[10] Chorda tympani injury most often causes dysgeusia, which typically manifests as an intermittent metallic taste on the side of the tongue ipsilateral to the injury, but which may be sensed all over the tongue or confined to its tip.[1,7] Loss of appetite may be a consequence.[11] Dysgeusia can also manifest as increased saltiness or decreased sweetness perception,[10,19] or as taste disturbance with specific foods only (particularly tea and coffee).[7] Ageusia affecting the ipsilateral side of the tongue most often occurs after unilateral transection of the chorda tympani,[7] although the patient may find it difficult to accurately localise the taste impairment.[21] The surface of the denervated side of the tongue becomes smooth and pale, with associated atrophy of the fungiform papillae.[7,39,40] Rarely, patients complain that food is only tasted when it reaches the back of the tongue just before swallowing.[7]

In a small sample of 20 patients, Yeo and Loy[10] found that post-operative dysgeusia was associated with a much higher incidence of permanent taste disturbance, compared with ageusia.

Various factors influence the development of gustatory symptoms, as follows.

Nerve transection versus lesser injury. Opinion is divided on whether the chorda tympani should be preserved or cleanly divided if it is injured[10] or mobilised (e.g. whilst obtaining surgical access to the oval window). In the past, most surgeons elected to leave the nerve intact in cases of suspected injury.[41] Of seven studies that have assessed this question, four advocated preservation of the chorda tympani,[3,10,11,24] two advocated section of the nerve,[2,4] and one concluded that there was little difference between these two options.[21] Recent evidence shows that between 16 and 73 per cent of patients report subjective disturbances of taste after ear surgery in which the chorda tympani has been manipulated,[22,31] and that these symptoms persist in 3 to 29 per cent of cases.[3,4] After the chorda tympani has been severed, 10–95 per cent of patients report symptoms,[2,11] which persist in 0–50 per cent.[11,31] This wide range of outcomes is due in part to the distorting effects of small studies on the data, and also to the differing intervals after which symptom persistence is defined; the true incidence is likely to be towards the lower end of these ranges (Tables II and

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TABLE II
SUBJECTIVE GUSTATORY SYMPTOMS AFTER MIDDLE-EAR SURGERY WITH CHORDA TYMPANI PRESERVATION

Study	Pts (*n*), surgery	Post-op symptoms (pts)	
		Transient	Persistent
Berteretche *et al.*[22]	11, Unilateral surgery for otosclerosis-related HL	64%	9% (at 6 mth)
Lloyd *et al.*[4]	24, Cochlear implantation	21%	29%
Gopalan *et al.*[31]	55, Middle-ear surgery	13%	4% (at 6 mth)
Mahendran *et al.*[11]	33, Stapedotomy	39%	12% (at 6 mth)
Saito *et al.*[3]	109, Middle-ear surgery (CT not touched)	3%	0%
Saito *et al.*[3]	149, Middle-ear surgery	26%	3% (at >3 y)
Yeo & Loy[10]	17, Ossicular surgery	47%	12% (period NS)
Moon & Pullen[24]	153, Stapedectomy (CT not damaged)	6%	12% (≥6 mth)

Post-op = post-operative; pts = patients; HL = hearing loss; mth=months; CT = chorda tympani; y = years; NS = not specified

III). Overall, the majority of studies show that section of the chorda tympani is more likely to lead to post-operative gustatory symptoms, and these symptoms are more likely to persist, than if the nerve is preserved. For example, one study of 55 patients recorded a mean symptom duration of 6.7 months in patients in whom the chorda tympani had been sectioned, compared with 3.4 months in patients in whom it had been preserved.[11]

The severity of chorda tympani manipulation also affects the prevalence of symptoms. Mueller *et al.*[25] reported that taste function was impaired in 47 per cent of patients after minor manipulation of the nerve, compared with 56 per cent of patients after major manipulation. Gopalan *et al.*[31] reported similar findings: 7 per cent of patients developed symptoms following handling of the chorda tympani, and 28 per cent after stretching of the nerve. Chorda tympani damage may be so minor as to go unnoticed.[4] Thus, Saito *et al.*[3] found that 2.8 per cent of patients developed symptoms when the chorda tympani had not knowingly been touched.

Type of surgery. The type of middle-ear procedure appears to affect the frequency of chorda tympani damage and therefore the incidence of post-operative taste disturbance.[2] In one study of 140 patients undergoing middle-ear operations,[2] subjective taste disturbance was recorded in 45 per cent after tympanotomy, 11 per cent after myringoplasty and 2 per cent after mastoidectomy. Whilst three-quarters of patients had recovered within one year, the duration of symptoms was longest in the tympanotomy group. In another study of 93 patients, Gopalan *et al.*[31] found chorda tympani related symptoms in 57 per cent after tympanotomy, 6.5 per cent after myringoplasty and 15 per cent after mastoidectomy; again, functional recovery was slower in the tympanotomy group. Both authors commented that the high incidence of gustatory symptoms after tympanotomy may be due to the chorda tympani being previously unaffected by disease in these cases; therefore, a change in function would be more noticeable.

Patient age. Sone *et al.*[30] found that recovery of electrogustometry thresholds six months after middle-ear surgery with preservation of the chorda tympani was significantly more likely in patients aged 20 years or younger, compared with older patients. This is consistent with the observation that electrogustometry thresholds increase with advancing age.[32] This deterioration in taste function with age prompted Terada *et al.*[32] to suggest that less attention needs to be paid to the chorda tympani during middle-ear surgery in patients over the age of 60 years.

Underlying disease. In its path across the tympanic membrane, the chorda tympani may be directly affected by middle-ear diseases such as cholesteatoma or chronic otitis media,[1,5,18] as shown by histological changes in the nerve.[18] In such cases, iatrogenic

TABLE III
SUBJECTIVE GUSTATORY SYMPTOMS AFTER MIDDLE-EAR SURGERY WITH CHORDA TYMPANI TRANSECTION

Study	Pts (*n*), surgery	Post-op symptoms (pts)	
		Transient	Persistent
Lloyd *et al.*[4]	14, Cochlear implantation	57%	29%
Nin *et al.*[19]	32, Unilateral middle-ear surgery	50%	6% (at 2 y)
Gopalan *et al.*[31]	32, Middle-ear surgery	13%	0% (at 6 mth)
Mahendran *et al.*[11]	22, Stapedotomy	45%	50% (at 6 mth)
Saito *et al.*[3]	113, Middle-ear surgery	39%	5% (>3–4 y)
Yeo & Loy[10]	14, Ossicular surgery	36%	43% (period NS)
Moon & Pullen[24]	89, Stapedectomy	18%	26% (≥6 mth)

Pts = patients; y = years; mth = months; NS = not specified

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nerve injury causes less post-operative taste disturbance than that caused (at least short term) by surgery for a non-inflammatory condition (Table IV).[1,2,34] Electrogustometric assessment in patients with a cholesteatoma has shown pre-operative threshold elevations of approximately 45 per cent.[42] Studies in patients with chronic otitis media indicate that inflammation and advancing age have additive detrimental effects on electrogustometry thresholds.[32]

Inhibition of other taste nerves. Damage to the chorda tympani is understood to release inhibiting influences on other taste nerves, which tends to compensate for any taste deficiency.[33,35] Thus, unilateral anaesthesia of the chorda tympani enhances the response to taste stimulation in areas of the tongue innervated by the ipsilateral glossopharyngeal nerve.[33,36] This may be one explanation for why some individuals experience no taste disturbance even after bilateral chorda tympani injury.[19]

Regeneration and reinnervation. Saito *et al.*[37] found evidence of regeneration of the chorda tympani in 42 per cent of 52 patients undergoing reoperative middle-ear surgery 11 to 65 months after chorda tympani transection. Regeneration was present in all five patients who had originally undergone end-to-end nerve repair, but in only 17 of 47 patients (36 per cent) in whom a nerve gap defect had been present; recovery of electrogustometry thresholds occurred in more than 70 per cent of cases with regeneration. Evidence of nerve regeneration was more likely in children; this is in keeping with the higher recovery rates seen in younger patients.[19]

Recovery of taste may be the result of reinnervation of taste buds by the contralateral or ipsilateral chorda tympani or glossopharyngeal nerve. Whilst chorda tympani regeneration has been documented in experimental animals,[43] little is known about its extent in humans.

Subjective adjustment to taste impairment. Patients with a permanent taste disturbance may to a variable extent adapt to this dysfunction over time, and either stop noticing the deficit or stop complaining[22,29] (although one patient still reported symptoms 21 years after chorda tympani transection).[7] This is supported by observations that the recovery of electrogustometry taste threshold is slower than that of subjective taste,[3,19,22,23] and the fact that the chorda tympani supplies only 15 per cent of all taste buds.[22] Recovery is probably also influenced by the extent to which alternative taste pathways, such as the greater superficial petrosal nerve, are recruited.[21]

In most cases of unilateral chorda tympani injury, taste symptoms are not particularly troublesome, particularly in the context of successful middle-ear surgery.[7] This is illustrated by one patient's remark, after successful stapedectomy: 'I would rather hear than taste normally'.[7] It is the small proportion of cases in which symptoms persist or impact on the patient's occupation (e.g. in the case of a professional chef) that cause most distress.[7,19] Symptoms of taste disturbance after bilateral chorda tympani injury are similar to those following unilateral damage, but may be more pronounced.[7]

Salivation

Unilateral chorda tympani injury can reduce basal salivation such that the patient notices a dry mouth. Indeed, transtympanic chorda tympani ablation was previously used to control sialorrhoea in patients with neurological handicap. As with disturbances of taste, outcome is variable and dependent on several factors.

Nerve transection versus lesser injury. Chilla *et al.*[28] found that ipsilateral submandibular gland salivary flow was significantly decreased after chorda tympani injury, but not enough to cause symptoms. When the patients were retested four years later, submandibular

TABLE IV
SUBJECTIVE POST-OPERATIVE GUSTATORY SYMPTOMS BY UNDERLYING PATHOLOGY

Study	Pts (*n*), surgery	Post-op symptoms (pts)	
		CT transected	CT preserved
Clark & O'Malley[1]	45, Middle-ear surgery – 21, Cholesteatoma – 19, Myringoplasty – 5, Stapedectomy	Cholesteatoma 31% Myringoplasty 100% Stapedectomy 100% Symptoms resolved by 6 mth	Cholesteatoma 0% Myringoplasty 75% Stapedectomy 100% Symptoms resolved by 6 mth
Sakagami *et al.*[34]	79, Middle-ear surgery – 20, Non-inflammatory – 35, COM + perf – 28, Cholesteatoma		At 2 wk – Non-inflammatory 65% – COM + perf 37% – Cholesteatoma 71% At 6 mth – Non-inflammatory 25% – COM + perf 6% – Cholesteatoma 7%

Pts = patients; post-op = post-operative; CT = chorda tympani; mth = months; wk = weeks; COM + perf = chronic otitis media with perforation

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salivary flow remained diminished, but only in those whose chorda tympani had been divided.[29]

Unilateral versus bilateral injury. In a large study of 126 patients in whom the chorda tympani was deliberately divided during unilateral middle-ear surgery, 30 per cent reported a dry mouth, which in most was persistent for more than a year.[7] However, symptoms were typically mild. After bilateral transection, dryness of the mouth was marked in 50 per cent of patients, tended to be persistent, and was described as 'very annoying' but not severely distressing.[7]

Two studies have investigated the long term effects of unilateral chorda tympani injury on target salivary glands. The first used ultrasound imaging, and found that the volume of the denervated submandibular gland was significantly smaller, compared with the contralateral gland, one year later.[44] However, this was because the contralateral gland was larger than in healthy controls (i.e. it had hypertrophied), rather than the ipsilateral gland being smaller. In the second study, the ability of the denervated gland to take up, concentrate and secrete radioisotope was significantly reduced.[45] Therefore, it seems that unilateral chorda tympani damage impairs the function of the ipsilateral submandibular salivary gland but does not cause atrophy.[45]

Despite these measurable changes, in most cases of unilateral transection any effect on salivation is subclinical.[10,28] Paradoxically, one study documented a few patients who reported a subjective increase in salivation after unilateral chorda tympani injury.[22] Bilateral chorda tympani transection reduces salivary flow more significantly, but some recovery is possible.[10] Chorda tympani transection was previously used as a treatment for disabling sialorrhoea.[44] However, this procedure became redundant following the realisation that drooling was not so much a problem of hypersalivation but related more to neuromuscular incoordination,[46] and following demonstration of the efficacy of botulinum toxin therapy.[47]

General sensory symptoms

Alterations in general lingual sensation after chorda tympani injury are comparatively uncommon, but include tingling, numbness, burning or a sensation of anaesthesia.[7,11,19,22–26,30] The incidence of these symptoms is very variable, ranging from 3 per cent (in one large study of 126 patients after unilateral chorda tympani transection)[7] to 46 per cent (in other studies).[26] Tongue numbness was specifically recorded in 42 per cent of 67 patients in whom the chorda tympani was preserved during middle-ear surgery, and in 16 per cent of 37 patients in whom it was sectioned; in most cases this symptom resolved within six months.[30]

The pathogenesis of general sensory symptoms has been reviewed elsewhere (see our chorda tympani clinical anatomy review).[48]

Tactile dysgeusia

Chen *et al.*[27] described persistent post-operative dysgeusia evoked by touch in seven patients with chorda tympani injury complicating middle-ear surgery. Application of a cotton-tip to the ventral aspect of the pinna and tragus and the posterolateral aspect of the external auditory canal resulted in dysgeusia limited to the ipsilateral side of the tongue. The authors attributed this phenomenon to aberrant reinnervation of taste fibres within the injured chorda tympani by somatosensory fibres. The gradual onset of tactile dysgeusia (three weeks to eight months) supports this hypothesis. Only one of the patients reported the symptom as 'frequently annoying'.

What steps can be taken to prevent iatrogenic chorda tympani injury?

A good understanding of normal and variant chorda tympani anatomy may help to avoid some instances of iatrogenic injury.

If the chorda tympani is encountered, preservation of the nerve appears preferable to transection, in terms of the frequency and persistence of resultant symptoms. Bull[7] found that, overall, 51 per cent of patients whose chorda tympani had been preserved at stapes surgery had related symptoms, and that these symptoms were still present one year later in 7 per cent. Of the 126 patients whose chorda tympani had been sectioned at stapes surgery, 80 per cent were symptomatic and 32 per cent had persistent complaints.

Avoiding diathermy injury, desiccation and excessive handling of the nerve are general prophylactic measures. Other preventive strategies have been discussed in relation to specific procedures or approaches, namely cochlear implantation,[49,50] stapes surgery[41] and tympanotomy.[7] In the case of bilateral surgery, several authors have recommended pre-operative taste testing, and waiting for the electrogustometry threshold to be restored to normal on the operated side prior to operating on the contralateral ear.[23,25]

Comment

Despite a reasonable body of literature on iatrogenic chorda tympani injury, meaningful comparison between studies is difficult because they differ in their aims, patient characteristics, sample size and methodologies. Some have relied on subjective taste disturbance whilst others have focused on objective measures such as electrogustometry, yet the correlation between these two outcome measures is not good.[10,11] Unsurprisingly, subjective taste disturbance resolves more rapidly than the electrogustometry taste threshold.[3,19,22]

These are not the only reasons why it is difficult to determine the true prevalence of taste symptoms after chorda tympani injury. It is likely that patients do not associate taste with an ear operation,[7] especially if the primary goal of surgery (e.g. improved hearing) has

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been achieved.[1] Therefore, taste disturbance may be under-reported.[5,7] Gopalan *et al.*[31] found nearly half of the symptomatic patients in their study were unaware of their symptoms until asked specifically.

From a medicolegal perspective, it remains debatable whether taste should be tested routinely prior to middle-ear surgery.[51] However, patients should be warned of possible taste disturbance as a complication of surgery. In a survey of British otorhinolaryngology surgeons reported in 2003, nearly half did not routinely discuss chorda tympani injury and taste impairment as a possible complication of myringoplasty or tympanoplasty.[52] This is similar to the proportion of patients advised about this complication of ossiculoplasty, reported five years earlier.[53] Instead, consent tends to focus on the more important otological, intracranial and facial nerve complications.[2]

Conclusion

The diversity of chorda tympani functions, and the range of factors modifying the response to injury, results in a broad and variable spectrum of symptoms following iatrogenic injury. However, complaints are sufficiently common, troublesome and, in some cases, persistent to merit care being taken to preserve the chorda tympani in middle-ear surgery and to warn patients pre-operatively about this potential complication.[2,25] This is particularly important if surgery is bilateral. Chorda tympani transection is more likely to cause sequelae than injury to an intact nerve.

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