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Facial nerve baroparesis during airflight: a case report and literature review

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Abstract

Background. Facial nerve baroparesis is a rare phenomenon which has been reported during flight. It is thought to occur due to ischaemic neuropraxia on the facial nerve as middle-ear pressure increases in the presence of Eustachian tube dysfunction and force is transmitted through a dehiscent facial nerve canal.
Method. This study presents an aviation-associated, right-sided facial nerve palsy as well as presenting the results of a systematic review that was performed on the available literature using Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. Full-text articles from Medline, PubMed and Embase were used, as well as associated reference lists. This study systematically reviews the literature to discuss presentation, investigations performed and an approach to management of this rare condition.
Results. This study identified 23 cases in the literature (including the case presented in this study) of facial nerve baroparesis.
Conclusion. Facial nerve baroparesis is a mostly temporary rare phenomenon that can be managed effectively with ventilation tube insertion. In the event of long-standing facial nerve palsy after descent of the aircraft, urgent myringotomy should be performed to prevent permanent facial nerve damage.

Introduction

Facial nerve baroparesis is a rare phenomenon that has been reported in both divers and aviators.[1] It is hypothesised to occur as a result of increased pressure on the tympanic segment of the facial nerve through a dehiscence of the horizontal part of the facial canal. The excessive pressure differential between ambient and middle-ear pressure is believed to result in hypoxia and neuropraxia through compression of the vasa nervorum.[1] The generally reported experience is a period of facial weakness occurring during flight and resolving after three minutes to several hours.[2] However, one case has been reported in which the subject took over two months to recover.[3] It may be associated with symptoms such as facial pain, facial numbness, ear discomfort, a sensation of pressure and tinnitus.[4] We present a case report of an aviation-associated right-sided facial nerve palsy lasting 10 minutes on 3 separate flights. The presentation, management and probable pathophysiological mechanisms of facial baroparesis are also discussed, and a literature review of the currently available literature regarding flight-induced facial nerve baroparesis is presented.

Case report

A 43-year-old male presented to our otolaryngology clinic with 3 episodes of aviation induced facial nerve baroparesis. The patient was travelling between the Australian states of Victoria and Queensland and during the flight developed right-sided facial weakness that lasted for 10 minutes and then subsequently resolved. This then happened two weeks later on a similar distance flight between the same states in Australia. The patient frequently flies for work and had never experienced facial palsy previously. He was initially referred to a cardiologist for investigations for assumed cerebral vascular episodes; however, extensive investigations were all normal.

The patient reported no hearing loss, no pain and no tinnitus. He had no significant past medical history and no previous surgical procedures. He reported smoking 20 cigarettes a day for many years. No abnormality was found on clinical examination, including neurotological examination and upper airway nasoendoscopy. The patient was reviewed one month later following audiological assessment, and a high-resolution temporal bone computed tomography (CT) scan was performed. Pure tone audiometry showed a mild right conductive hearing loss at 250, 500 and 8000 Hz. Tympanometry showed negative pressure in the right middle ear. High resolution CT scanning suggested a tympanic facial nerve canal dehiscence. A ventilation tube was subsequently inserted into the right tympanic membrane under local anaesthesia. Upon myringotomy, the patient was found to have a glue ear. The patient had flown multiple times without recurrent symptoms whilst the grommet was in situ. Eight months later, after grommet extrusion, the patient suffered a third episode of transient facial nerve

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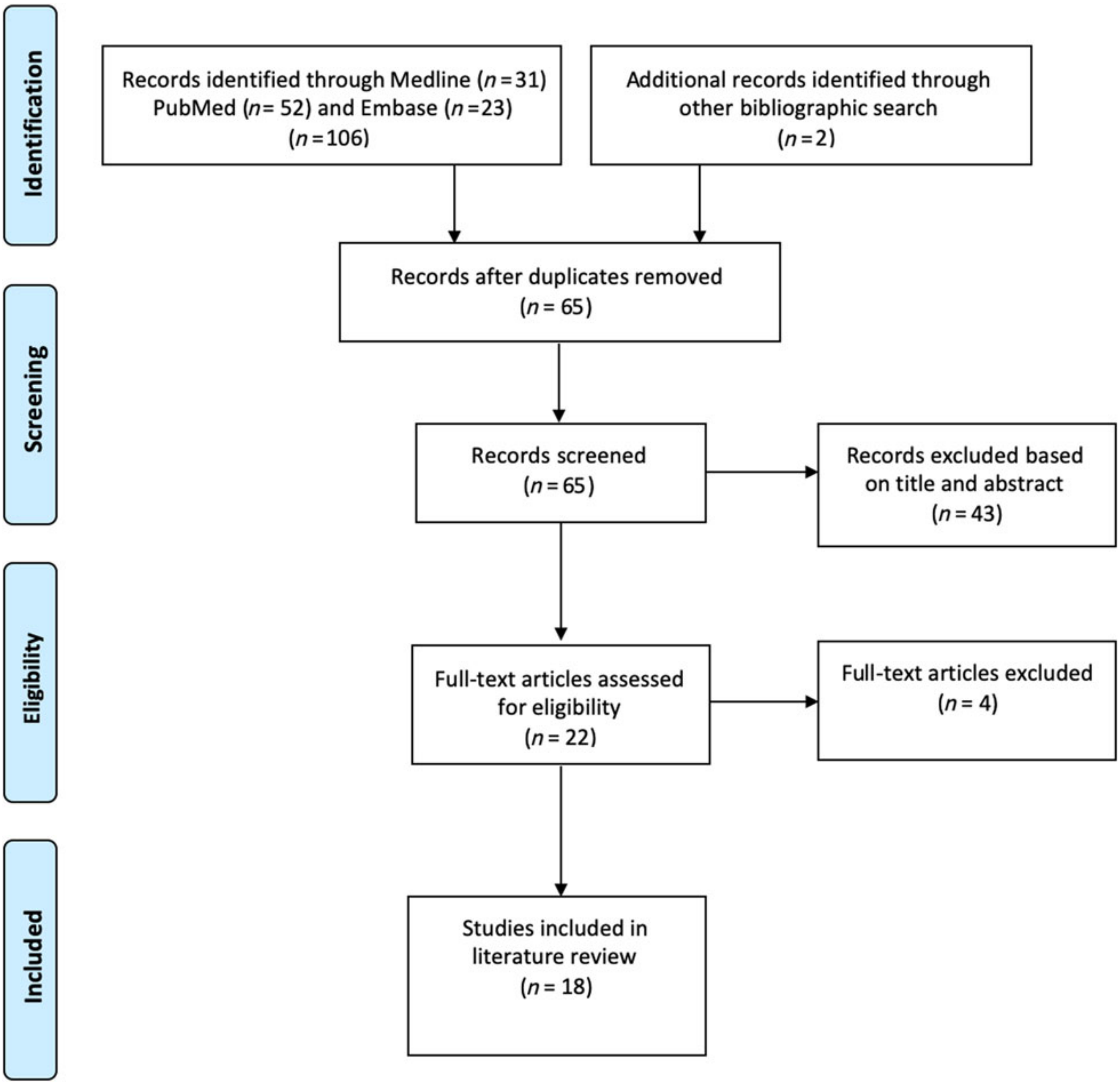

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses ('PRISMA') flow diagram.

palsy whilst flying with a respiratory tract infection. Over the years, he subsequently had significant recurrent otologic symptoms from airflight that required grommet insertion, but no further facial palsies.

Informed patient in the consent was sought and granted by the case we report in this article.

Materials and methods

The search was conducted using PubMed, Ovid Medline and Embase databases from establishment until January 2020. Abstracts were identified using terms relating to facial palsy ('barotrauma facialis', 'baroparesis facialis', 'facial nerve palsy', 'facial nerve paralysis' and 'alternobaric facial palsy') and flight ('flight', 'ascent', 'aviation' and 'high altitude'). Papers that described cases not associated with altitude and animal studies were excluded. There were no language or publication year restrictions imposed. The search strategy performed in January 2020 resulted in 106 articles, resulting in 22 articles that underwent full-text evaluation and 18 studies that fulfilled inclusion criteria for analysis (Figure 1).

Results

Twenty-three cases (including our own) of aviation-induced facial nerve baroparesis are reported in the literature (Table 1). The median age at diagnosis was 36 years, and the age span was 20–62 years (age data is missing in one case). Of the 23 cases, 16 were male. Twelve cases experienced symptoms on the left, nine on the right, one case had bilateral symptoms in separate instances and one case did not report which side was affected. Six patients described a single episode[4–9] and 17 patients described multiple episodes.[2,3,5,10–19]

Episodes ranged from 5 minutes to 4.5 hours in duration. One patient had a known history of facial nerve schwannoma and had previously undergone a facial nerve decompression and incomplete tumour resection two years prior to his first episode of facial nerve baroparesis.[11] Another patient had an iatrogenic facial nerve injury with a baseline House–Brackmann V function.[3] Three patients had suffered an upper respiratory tract infection in the weeks preceding their facial nerve baroparesis.[4,6]

Symptoms experienced by patients included facial weakness (23 patients, 100 per cent), aural fullness (13 patients, 56.5 per

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Table 1. Documented cases of barotraumatic facial nerve palsy in aviation or on ascent to high altitudes

Author (Year)	Country	Age	Sex	Side	Incidences (*n*)	Imaging investigation	Treatment	Outcome
Bennet & Liske,[2] (1967)	USA	30	M	R	3	Skull & sinus X-rays	None	Normalisation
Bennet & Liske,[2] (1967)	USA	40	M	L/R	2	Skull & sinus X-rays	None	Normalisation
Anonymous,[19] (1978)	USA	29	M	L	3	Not stated	None	Normalisation
Silverstein,[18] (1986)	USA	Not stated	F	L	5	Not stated	Grommet insertion	Normalisation
Woodhead,[17] (1988)	USA	50	M	L	Multiple	CT	Grommet insertion, nasal septum submucous resection & inferior turbinate trimming	Normalisation
Motamed *et al.*,[16] (2000)	USA	38	M	Not stated	6	Not stated	Grommet insertion	Normalisation
Berghaus,[9] (2001)	Germany	20	F	L	1	CT	None	Normalisation
Grossman *et al.*,[8] (2004)	USA	24	M	R	1	MRI	None	Normalisation
Ardehali *et al.*,[4] (2009)	Pakistan	34	F	R	1	CT	Oral prednisolone	Minimal sensory hearing loss
Rutten & Kunst,[3] (2010)	The Netherlands	58	M	R	4	MRI	Xylometazoline nasal spray	Normalisation
Ah-See *et al.*,[15] (2012)	UK	23	F	L	2	CT & MRI	None	Normalisation
Ah-See *et al.*,[15] (2012)	UK	62	M	L	2	CT & MRI	Grommet insertion	Normalisation
Ah-See *et al.*,[15] (2012)	UK	27	M	R	Multiple	CT	Grommet insertion	Normalisation
Wimmer & Ali,[14] (2016)	Japan	26	F	R	2	CT	None	Normalisation
Vivekananda & Omer,[13] (2017)	UK	51	M	R	2	MRI	None	Normalisation
Cada *et al.*,[12] (2017)	Czech Republic	25	F	L	Multiple	CT & MRI	Grommet offered but declined by patient	Further episodes
White & Shackleton,[7] (2018)	UK	31	M	R	1	No imaging performed	None	Normalisation
Krywko *et al.*,[6] (2018)	USA	55	M	L	1	CT & MRI	None	Normalisation
Kung *et al.*,[11] (2018)*	USA	35	M	L	7	CT & MRI	Revision facial nerve decompression	Normalisation
Cumming *et al.*,[5] (2019)	Australia	47	M	L	6	CT	Nasal decongestant spray	Normalisation
Cumming *et al.*,[5] (2019)		58	M	L	1	CT	Nasal decongestant spray	Normalisation
Cheng & Kaylie,[10] (2019)	USA	37	F	L	Multiple	CT	Eustachian tube balloon dilatation	Normalisation
Alwan & Gordan, this report (2019)	Australia	43	M	R	3	CT	Grommet insertion	Normalisation

*Patient initially presented with a facial nerve schwannoma and underwent nerve decompression and subtotal tumour resection. M = male; F = female; R = right; L = left; CT = computed tomography; MRI = magnetic resonance imaging cent), otalgia (10 patients, 43.4 per cent) and hearing loss (4 patients, 17.3 per cent). Two patients experienced vertigo during their episodes, and one patient described residual facial pain which persisted for several hours. Nine patients were investigated with CT alone,[4,5,9,10,14,15] three with magnetic resonance imaging (MRI) alone,[3,8,13] and five patients had both MRI and CT.[6,11,12,15] Two patients were investigated with skull and maxillary sinus X-rays.[2] One patient did not undergo imaging investigation[7] and imaging was not reported in three cases.[16,18,19] Five patients had radiological evidence of facial canal dehiscence.[5,14,15]

In 10 of the reported cases, patients were observed, and the facial nerve baroparesis did not recur after the initial 1 to 3 episodes (this was deemed likely because of an upper respiratory tract infection or other self-limiting cause of Eustachian tube dysfunction). One patient who experienced prolonged symptoms before seeking medical attention was treated with oral prednisolone, and whilst facial motor function was restored to normality, the patient suffered a mild sensorineural hearing loss. Five patients were treated with grommet insertion alone,[15,16,18] one was treated with grommet insertion coupled with nasal septum submucous resection and inferior turbinate trimming,[17] three patients were managed with nasal decongestant spray prior to flying[3,5] and one patient was treated with Eustachian tube balloon dilatation.[10] The patient with previously known facial nerve schwannoma underwent a revision facial nerve decompression with subsequent normalisation of symptoms.[11] One patient was offered grommet insertion but declined treatment.[12]

Discussion

The atmospheric pressure at sea level is 760 mmHg. As an aircraft ascends, the atmospheric pressure decreases, and the gas in the middle ear expands in accordance with Boyles' law. In modern commercial aircraft, the cabins are pressurised to the equivalent of 1500–2500 m.[20,21] This creates a potential pressure gradient across the tympanic membrane which is normally equalised by passive opening of the Eustachian tube, venting the pressure through the nasopharynx.[22]

Impaired function of the Eustachian tube may lead to failure of pressure equalisation. This may be caused by conditions which narrow the lumen by oedema, increase the viscosity of the mucous in the lumen or impair the normal opening of the Eustachian tube.[23,24] Acute rhinitis, nasal septum deviation or other upper airway pathology may be associated with Eustachian tube dysfunction[17] and a previous report of five cases noted facial baroparesis in divers who descended whilst afflicted with a viral upper respiratory tract infection and presumably had impaired Eustachian tube function.[25] Although congenital and traumatic malformations of the nasal skeleton and malocclusion of the teeth and jaw are also recognised to impair Eustachian tube function,[24] it is not clear whether these lead to a predisposition to barotrauma.[15]

The failure to vent air pressure from the middle ear to the nasopharynx during ascent results in an excessive middle-ear pressure, which may then be transmitted to the facial nerve. The most widely accepted hypothesis in the literature for facial baroparesis is ischaemic neuropraxia, based on the quick onset and resolution of facial baroparesis.[1] It is theorised that excessive pressure is transmitted through a dehiscence in the facial nerve canal, decreasing the blood flow of the vasa nervorum of the facial nerve. This consequently results in neuropraxia. In cats, facial nerve neuropraxia was induced by applying pressure to an unexposed part of the facial nerve.[26] Subsequently in a guinea pig animal model, it was demonstrated that increasing middle-ear pressures did result in reduced blood flow in the vasa nervorum of the facial nerve.[27] The reported incidence of facial nerve canal dehiscence in humans varies greatly. In anatomical autopsy cases, a dehiscence is shown in 19.7–57 per cent of all human temporal bones.[28–30] However, it must be noted that some cases reported no apparent facial nerve canal dehiscence on CT scan.[15] The sensitivity and specificity of CT scan detection of facial canal dehiscence is reported at 66–80 per cent and 84–98 per cent, respectively.[31,32] A potential explanation for facial baroparesis in patients without a dehiscent tympanic facial canal is the transmission of elevated middle-ear pressure through the fenestra of the chorda tympani;[3] however, this hypothesis is less widely acknowledged.

- Facial nerve baroparesis in aviation is a rare phenomenon
- Most patients present with self-limiting facial weakness
- It is thought to occur as a result of ischaemic neuropraxia in the setting of Eustachian tube dysfunction and a dehiscent facial nerve canal
- The most common imaging modalities utilised in diagnosis are computed tomography and magnetic resonance imaging
- Treatment varies from conservative treatment to nasal decongestant sprays and grommet insertion
- Most cases report no further episodes of facial nerve palsy following treatment

Altitude change of the aircraft, opening of the Eustachian tube, myringotomy or an increase in the perfusion pressure of the vasa nervorum will re-establish the nerve's circulation and restore normal nerve function.[3] If a prolonged period of nerve ischaemia ensues however, then demyelination and interruption of the facial nerve axons may occur, causing degeneration.[1] If pressure interferes with the blood supply of the facial nerve for a sufficiently long time, the nerve may be destroyed and converted to a fibrous cord, with no chance of recovery.[1] In cats, the cut-off for irreversible damage was demonstrated to be approximately 3.5 hours.[26]

Only 23 subjects (including our case) with aviation induced facial nerve baroparesis are reported in the literature (Table 1). However, it has been suggested that this condition may be under-reported and sometimes misdiagnosed.[1,15] In 22 of the reported 23 cases, facial nerve baroparesis resolved spontaneously either during flight or during descent of the flight. As such, these cases do not need immediate medical attention as they are transient in character; however, they may be mistaken for cerebrovascular transient ischaemic attacks or other neurological events. Treatment was therefore aimed at preventing recurrence. All except one of the cases reported normalisation as their outcome.

Several treatments have been recommended for facial nerve baroparesis. Patients should be advised to attempt self-equalisation techniques during the flight in an attempt to open up their Eustachian tubes and relieve middle-ear pressure. Prophylactic and therapeutic use of nasal decongestants to prevent or treat middle-ear barotrauma have been recommended and were used in three of the reported cases to good effect.[3,5] Oral antihistamines have likewise been recommended in patients with allergies for the prevention of barotrauma.[21] In selected cases of recurrent facial nerve baroparesis, ventilation tube insertion would seem to be beneficial. There were no further episodes of facial nerve palsy in cases treated with ventilation tube insertion.[18,33] The senior author's experience supports this, with the patient developing no further facial palsies whilst the ventilation tube was in situ.

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In the case of persistent facial nerve dysfunction after descent, urgent myringotomy with ventilation tube insertion is indicated to prevent irreversible damage to the facial nerve. Oral steroids have been recommended in cases in which persistent facial paralysis and hearing loss occur.[4]

Conclusion

Facial baroparesis is a rare, mostly temporary paresis of the VIIth cranial nerve, which occurs in both aviation and diving. In this paper, we discussed cases associated with flying only and have added 1 case to the 19 cases already in the literature. While the most widely accepted aetiology is ischaemic neuropraxia, other hypotheses have been suggested. Reported cases usually describe facial paresis, which lasts from a few minutes to several hours; however, one case reported a paresis gradually resolving over two and a half months. Treatment modalities suggested include self-equalisation techniques, nasal decongestants, oral antihistamines, oral steroids and ventilation tube insertion. In the event of long-standing facial nerve palsy after descent of the aircraft, urgent myringotomy should be performed to prevent permanent facial nerve damage. Our literature review demonstrated no current evidence-based management protocol for this condition, and more cases are needed in order to increase our understanding and management of this rare condition.

Competing interests. None declared

References

1 Molvaer OI, Eidsvik S. Facial baroparesis: a review. *Undersea Biomed Res* 1987;**14**:277–95
2 Bennett DR, Liske E. Transient facial paralysis during ascent to altitude. *Neurology* 1967;**17**:194–8
3 Rutten H, Kunst H. Facial nerve palsy in aviation facial baroparesis. *J Int Adv Otol* 2010;**6**:277–81
4 Ardehali MM, Yazdani N, Heidarali M. Transient facial nerve baroparesis: case report. *Pak J Biol Sci* 2009;**12**:476–9
5 Cumming B, Matchett I, Meller C, Saxby A. High altitude alternobaric facial palsy: case series and systematic review of the literature. *Otol Neurotol* 2019;**40**:1378–85
6 Krywko DM, Clare DT, Orabi M. Facial baroparesis mimicking stroke. *Clin Pract Cases Emerg Med* 2018;**2**:136–8
7 White R, Shackleton D. Plane palsy: a case of transient facial weakness during an aircraft flight. *BMJ Case Rep* 2018:bcr2018224593
8 Grossman A, Ulanovski D, Barenboim E, Azaria B, Goldstein L. Facial nerve palsy aboard a commercial aircraft. *Aviat Space Environ Med* 2004;**75**:1075–6
9 Berghaus A. Transient facial nerve paralysis during flight [in German]. *HNO* 2001;**49**:927–9
10 Cheng TZ, Kaylie DM. Recurrent and progressive facial baroparesis on flying relieved by Eustachian tube dilation. *Ann Otol Rhinol Laryngol* 2019;**128**:778–81
11 Kung RW, Roche JP, Gantz BJ. Postoperative facial baroparesis while flying: a rare complication of decompressing a facial nerve schwannoma. *JAMA Otolaryngol Head Neck Surg* 2018;**144**:457–9
12 Cada Z, Hruba´ S, Jerabek J, Cerny R, Kluh J, Balatkova Z *et al*. Peripheral facial paresis linked to air travel. *Ceska Slovenska Neurol Neurochir* 2017;**80**:724–5
13 Vivekananda U, Omer S. Transient facial weakness whilst on a flight. *J Neurol Sci* 2017;**375**:299–300
14 Wimmer MS, Ali TY. Transient unilateral facial nerve baroparesis with vertigo on ascent in the F-16CM. *Aerosp Med Hum Perform* 2016;**87**:141–3
15 Ah-See KL, Shakeel M, Maini SK, Hussain SS. Facial paralysis during air travel: case series and literature review. *J Laryngol Otol* 2012;**126**:1063–5
16 Motamed M, Pau H, Daudia A, Narula A. Recurrent facial nerve palsy on flying. *J Laryngol Otol* 2000;**114**:704–5
17 Woodhead CJ. Recurrent facial palsy at high altitude. *J Laryngol Otol* 1988;**102**:718–9
18 Silverstein H. Facial paralysis associated with air flight. *Am J Otol* 1986;**7**:394–5
19 Anonymous. The collected letters of the international correspondence society of ophthalmologists and otolaryngologists. New Orleans; Report No. 1978;24
20 D'Andrea CMJ, Frederik S. Peripheral facial paralysis of dysbaric origin [in French]. *Presse Med* 2008;**37**:643–7
21 Mirza S, Richardson H. Otic barotrauma from air travel. *J Laryngol Otol* 2005;**119**:366–70
22 Brown TP. Middle ear symptoms while flying. Ways to prevent a severe outcome. *Postgrad Med* 1994;**96**:135–7, 141–2
23 Whelan TR. Facial nerve palsy associated with underwater barotrauma. *Postgrad Med J* 1990;**66**:465–6
24 King PF. The Eustachian tube and its significance in flight. *J Laryngol Otol* 1979;**93**:659–78
25 Eidsvik S, Molvaer OI. Facial baroparesis: a report of five cases. *Undersea Biomed Res* 1985;**12**:459–63
26 Roffman GD, Babin RW, Ryu JH. The effect of blood pressure on compression-induced facial nerve neuropraxia in the cat. *Otolaryngol Head Neck Surg* 1981;**89**:629–37
27 Nagai H, Nakashima T, Suzuki T, Yanagita N. Effect of increased middle ear pressure on blood flow to the middle ear, inner ear and facial nerve in guinea pigs. *Acta Otolaryngol* 1996;**116**:439–42
28 Moreano EH, Paparella MM, Zelterman D, Goycoolea MV. Prevalence of carotid canal dehiscence in the human middle ear: a report of 1000 temporal bones. *Laryngoscope* 1994;**104**:612–18
29 Baxter A. Dehiscence of the fallopian canal. An anatomical study. *J Laryngol Otol* 1971;**85**:587–94
30 Kida K. Developmental studies on the petrous part of the human temporal bone--special references to the morphogenesis of the facial nerve canal [in Japanese]. *Hokkaido Igaku Zasshi* 1996;**71**:205–16
31 Keskin S, Çetin H, Töre HG. The correlation of temporal bone CT with surgery findings in evaluation of chronic inflammatory diseases of the middle ear. *Eur J Gen Med* 2011;**8**:24–30
32 Fuse T, Tada Y, Aoyagi M, Sugai Y. CT detection of facial canal dehiscence and semicircular canal fistula: comparison with surgical findings. *J Comput Assist Tomogr* 1996;**20**:221–4
33 Westerman ST, Fine MB, Gilbert L. Aerotitis: cause, prevention, and treatment. *J Am Osteopath Assoc* 1990;**90**:926–8

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