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OTOLOGY

Endoscopic vs microscopic facial nerve decompression for traumatic facial nerve palsy: a randomized controlled trial

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Abstract

Purpose To explore a minimally invasive trans-canal endoscopic facial nerve decompression for traumatic facial nerve palsy and compare it with microscopic facial nerve decompression.

Methods 35 and 38 patients underwent endoscopic and microscopic facial nerve decompression, respectively, for traumatic facial nerve palsy. Onset of symptoms, type of temporal bone fracture, day of surgical intervention following trauma, ossicular chain status and nature of insult to facial nerve were observed. Time period for recovery (House Brackmann grade ≤ 3), long term recovery rates, pre- and post-operative hearing status, surgical time and post-operative pain were compared between groups.

Results Maximum patients in endoscopic and microscopic groups (77.1% and 76.3%, respectively) had acute onset of symptoms. 57.1% (20/35) had longitudinal, 17.1% (6/35) had transverse and 25.7% (9/35) had mixed fractures in endoscopic group. In the microscopic group, 57.9% (22/38) had longitudinal, 18.4% (7/38) had transverse and 23.7% (9/38) had mixed fractures. The mean (± S.D.) post-operative air–bone gap in endoscopic and microscopic group were 16.47 ± 4.5 dB and 19.4 ± 5.2 dB, respectively, which was statistically significant. The mean (± S.D.) time period for recovery of endoscopic and microscopic groups were 14.4 ± 5 days and 22.5 ± 7 days, respectively (p value < 0.05). The difference in post-operative pain between the two groups was also statistically significant. The difference in long term recovery rates was not statistically significant ($p > 0.05$).

Conclusions Endoscopic facial nerve decompression results in early recovery, less post-operative pain and better post-operative air–bone gap closure when compared to conventional microscopic technique.

Keywords Facial paralysis · Temporal bone · Decompression · Surgical · Endoscopy

Introduction

Traumatic temporal bone fractures often present with facial nerve paralysis. Temporal bone fractures have been classified as longitudinal, transverse and mixed type, in which facial nerve involvement is seen in upto 15–20% of longitudinal fractures and upto 50% of transverse fractures [1, 2].

Through most of its intra-temporal course, facial nerve is covered by bony fallopian canal, which makes it more prone to injury in an event of trauma. Impingement of bone fragment, intraneural haematoma or oedema, contusion, perineural fibrosis or rarely transection are some of the insults that can occur to the nerve. Due to associated injuries, many such patients require ICU admission and emergency management before accurate diagnosis and grading of facial nerve palsy can be done. This sometimes delays referral to otolaryngologist and its subsequent treatment.

Though, the role and timing of surgical intervention is a matter of debate and lacks an internationally accepted management protocol specific for traumatic facial nerve palsy, yet, in light of definite radiological and electrophysiological evidence, such patients should be offered the surgical option at the earnest [3].

Peri-geniculate area is one of the most common sites affected in traumatic facial nerve paralysis [4, 5]. Conventionally, peri-geniculate facial nerve injuries have been

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addressed by microscopic techniques of facial nerve decompression. With the advent of oto-endoscopy and its growing applications and acceptance, a vast majority of ear pathologies from external ear to as far as the lateral skull base are now being treated endoscopically. The endoscope provides a superior visualization of the perigeniculate area, which can easily and effectively be addressed endoscopically. In this study, we aim to explore a minimally invasive trans-canal endoscopic facial nerve decompression for traumatic facial nerve palsy.

Materials and methods

Patient selection and inclusion/exclusion criteria

Eighty patients, diagnosed as having traumatic facial nerve palsy, presenting to our institution between January 2018 and June 2021, were enrolled in this prospective randomized controlled trial. All patients underwent routine pre-operative investigations, topo-diagnostic tests for facial nerve function (Schirmer's test and stapedial reflex in our cases), High Resolution Computed Tomography (HRCT) Scan of temporo-mastoid region (0.6 mm cuts) with 3D reconstruction, Electroneuronography (ENoG), Pure Tone Audiometry, tympanometry and Speech Discrimination Score (SDS) percentage.

The inclusion criteria were:

- House Brackmann Grade 5, 6
- Radiological evidence of fracture line traversing the region of facial nerve
- ≥ 90% degeneration on ENoG
- Time of presentation within 21 days of injury
- Injury involving facial nerve proximal to vertical segment

Patients having injuries involving vertical segment of facial nerve, narrow external auditory canal, CSF otorrhea and other intra-cranial complications, though treated, were excluded from this study.

Two patients were lost to follow up, three cases were found to have vertical segment involvement intra-operatively and two patients failed to achieve recovery of House–Brackmann Score < 3 even at 1 year. Hence, these were excluded from further statistical analysis.

The patients were randomly assigned into two groups—one undergoing endoscopic transcanal technique and the other by microscopic transcanal technique. The randomization sequence was generated by table of random numbers and allocation was concealed using sealed opaque envelopes. To maintain uniformity, all the surgeries were done by the same team of surgeons.

35 patients underwent endoscopic surgery and 38 patients underwent microscopic surgery.

All patients were blinded to the mode of surgery during pre-operative and early post-operative period. All patients were followed up for 1 year.

Written informed consent and Institutional Ethics Committee approval were obtained.

According to site of injury to the nerve and trajectory of fracture line, Endoscopic facial nerve decompression has been classified by the authors into three types:

- Type A: Geniculate ganglion + Tympanic segment + Greater superficial petrosal nerve
- Type B: Tympanic segment + Second genu
- Type C: Labyrinthine segment + Geniculate ganglion + Greater superficial petrosal nerve (Fig. 1)

Steps of surgery

All cases were done under general anaesthesia with local infiltration of 2% Lignocaine and Adrenaline (1:1,00,000). Slow intravenous tranexamic acid bolus (10 mg/kg) half an hour before the start of surgery followed by infusion (5 mg/kg/h) was administered [6]. Fracture line in the external auditory canal was palpated with ball point probe and the incision line was modified accordingly. The horizontal limb of the incision was placed at a distance of about 5–6 mm from the annulus with the help of a circular knife. The inferior limb was positioned at 6 o' clock position, starting 1 mm away from the inferior annulus and joining the lower border of the horizontal limb. The horizontal incision was extended further antero-superiorly up to the level of Eustachian tube.

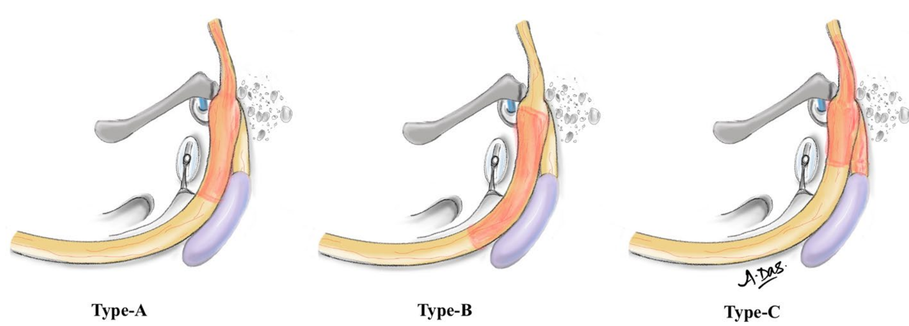

Fig. 1 Types of endoscopic facial nerve decompression. Type A: Geniculate ganglion + Tympanic segment + Greater superficial petrosal nerve; Type B: Tympanic segment + Second genu; Type C: Labyrinthine segment + Geniculate ganglion + Greater superficial petrosal nerve

Tympano-meatal flap was elevated and was then tucked inferiorly in the hypotympanum. Middle ear was inspected and the diagnosis was confirmed. An (endoscopic) transcanal atticotomy was performed. Ossicular chain was exposed. Incudo-stapedial and incudo-malleolar joints were dislocated (if found intact) and incus was delivered out. Malleus head was amputated to expose the epitympanum and access the perigeniculate region of facial nerve. Sharp dissection was performed to remove any granulation tissue/polypoidal mucosa/organized fibrous tissue from the facial nerve. Fractured fragments of bony fallopian canal impinging on the nerve were dis-impacted. In endoscopic technique, the type of decompression was chosen according to the site-based classification devised by the authors. Egg–shell bone was carefully lifted off the nerve sheath. Spectra A and B modes of SPIES endoscopy unit by Karl Storz™ were used to precisely visualise the affected nerve segment. Facial nerve sheath was then incised sharply. A strip of temporalis fascia was placed over the decompressed nerve to protect it from the subsequent ossicular reconstruction assembly. Ossicular chain reconstruction (OCR) with Teflon Partial Ossicular Replacement Prosthesis (PORP) was performed. Temporalis fascia graft was placed by underlay technique. Gelfoam was used to pack the middle ear and external auditory canal.

For the microscopic approach, trans-canal route was utilized. Complete atticotomy (inside–out mastoidectomy) was done for access, followed by the necessary steps, as warranted, based on the injured segment, were taken.

Study parameters and result analysis

The parameters studied were:

Pre-operative

- Onset of symptoms (sudden or insidious)
- Type of temporal bone fracture (longitudinal, transverse or mixed)
- Day of surgical intervention following trauma
- Pre-operative air–bone gap

Intra-operative

- Nature of insult (oedema/haematoma/bone chip impaction)
- Ossicular chain status
- Type of decompression (Type A/B/C) (endoscopic group)
- Surgical time

Post-operative

- Time period for recovery (defined as HB grade ≤ 3)
- Post-operative air–bone gap (at 4 weeks)
- Post-operative pain (in Numerical Rating Scale)
- Long term recovery rates (HB grade at 1 year)

Photographic documentation of improvement of facial nerve function was done by an observer who was blinded to the surgical approach, every day after 72 h till recovery to HB grade ≤ 3 was noted. Thereafter, the patients were followed up every 3 months till 1 year.

For statistical analysis, data were analysed by SPSS (version24.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Data have been summarized as mean and standard deviation for numerical variables and count and percentages for categorical variables. Paired t test was used for paired samples. Unpaired proportions were compared by Chi-square test, Fischer's exact test or Mann Whitney U test, as appropriate. $p \leq 0.05$ was considered as statistically significant.

Results

Demographic data

A total of 73 patients were analysed. The mean age of patients was 32.32 ± 4 years in endoscopic group and 32.68 ± 8 years in microscopic group. The male to female ratio was 3:1 in both groups.

Onset of symptoms

77.1% (27/35) patients in the endoscopic group and 76.3% (29/38) patients in the microscopic group had acute onset of symptoms.

Type of temporal bone fracture

57.1% (20/35) had longitudinal, 17.1% (6/35) had transverse and 25.7% (9/35) had mixed fractures in endoscopic group. In the microscopic group, 57.9% (22/38) had longitudinal, 18.4% (7/38) had transverse and 23.7% (9/38) had mixed type of temporal bone fracture.

Day of surgical intervention following trauma

The mean($\pm$ S.D.) day of surgical intervention following trauma in endoscopic group was 15.4 ± 5 days, while that in microscopic group was 15.5 ± 4 days (p value > 0.05).

Nature of injury

In the endoscopic group, 65.7% (23/35) patients were found to have bone fragment impaction with haematoma, 17.1% (6/35) had bone fragment impaction with haematoma with partial transection of nerve, whereas 17.1% (6/35) had only bone fragment impaction. In microscopic group, 57.9% (22/38) patients had bone fragment impaction with haematoma, 21.1% (8/38) had only bone fragment impaction, 5.3% (2/38) had only haematoma, while 15.8% (6/38) had bone fragment impaction with haematoma with partial transection of nerve.

Ossicular chain status

20% (7/35) patients suffered incudo(I)–stapedial(S) joint dislocation; 20% (7/35) patients had I–M joint dislocation; 37.1% (13/35) had I–S joint and incudo(I)–malleolar(M) joint dislocation and 8.6% (3/35) had I–S, I–M joint dislocation and lenticular process fracture in the endoscopic group. In the microscopic group, 21.1% (8/38) patients suffered I–S joint dislocation; 18.4% (7/38) had I–M joint dislocation; 42.1% (16/38) had I–S and I–M joint dislocation and 5.3% (2/38) had I–S, I–M joint dislocation and lenticular process fracture. No statistically significant difference was found between the two groups.

Pre-operative air–bone gap

The mean (± S.D.) pre-operative air–bone gap in endoscopic and microscopic group were 29.6 ± 6.3 dB and 29.5 ± 5.9 dB, respectively. No statistically significant difference was found between the two groups.

Post-operative air–bone gap

The mean (± S.D.) post-operative air–bone gap in endoscopic and microscopic group were 16.47 ± 4.5 dB and 19.4 ± 5.2 dB, respectively. A statistically significant difference was found between the two groups (p value < 0.05) (Fig. 2).

Type of decompression in endoscopic group

57.2% (20/35) patients underwent Type A decompression, 31.4% (11/35) had Type B and 11.4% (4/35) patients had Type C decompression in endoscopic facial nerve decompression.

Surgical time (in minutes)

The mean (± S.D.) surgical time in endoscopic group was 164.5 ± 13.2 min and that in case of microscopic group was 165.6 ± 18.1 min. There was no statistically significant difference between the two groups (p value > 0.05).

Timeperiod for recovery (HB grade ≤ 3)

The mean (± S.D.) day of recovery in case of endoscopic facial nerve decompression was 14.4 ± 5 days, while that in case of microscopic facial nerve decompression was 22.5 ± 7 days. The difference was found to be statistically significant (p value < 0.05). The average recovery period for the endoscopic and microscopic facial nerve decompression (FND) was 2 weeks and 4 weeks, respectively. At week 2, there was a significant recovery of endoscopic FND patients relative to microscopic FND patients. Post operative days of recovery in endoscopic FND had started from week 1 and reached its significance level at day 14 (week 2) (Fig. 3).

Post-operative pain (in Numerical Rating Scale)

The median (range) post-operative pain score in endoscopic group was 4 (2–7) and that in microscopic group was 6 (5–8). The difference between the two groups was found to be statistically significant (p value < 0.05).

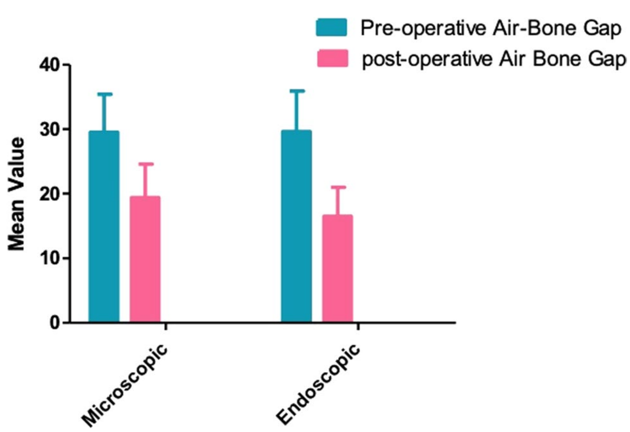

Fig. 2 Mean pre- and post-operative air–bone gap in endoscopic and microscopic groups

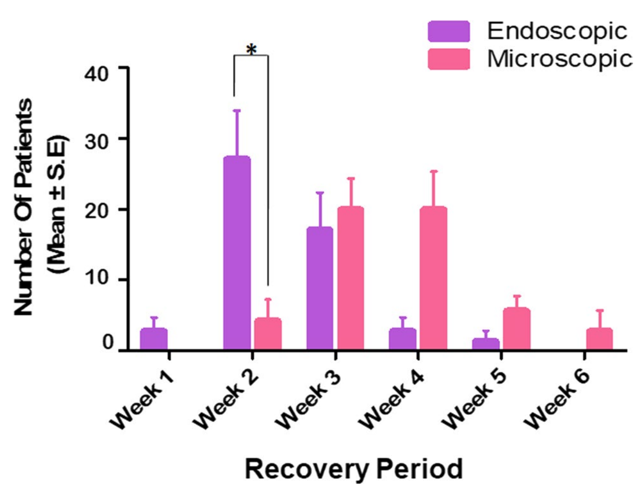

Fig. 3 Days for recovery to House–Brackmann (H–B) Grade ≤ 3 post-operatively. *Significance denoted by $p < 0.05$

Long term recovery (at 1 year)

In Endoscopic group, 82.9% (29/35) patients had H–B Grade I recovery, 11.4% (4/35) had Grade II and 5.7%(2/35) had recovery till Grade III. Whereas in Microscopic group, 73.7%(28/38) patients had Grade I recovery, 18.4% (7/38) patients had Grade II recovery and 7.9% (3/38) had Grade III. The difference in both groups for H–B Grade I recovery was not statistically significant (*p* value > 0.05) (Table 1).

Discussion

Injury to the facial nerve in temporal bone fractures results in prominent cosmetic disfigurement that has a negative effect on the quality of life of the affected patients. There is inability to close eyelids which might subsequently lead to conjunctivitis or keratitis, visible facial asymmetry, problems with mastication, articulation and salivation, as well as tear secretion. All this adds to psychological and social distress to the patient. Therefore, timely diagnosis and intervention is crucial. Early surgical decompression of the nerve leads to better and rapid recovery of the nerve function. Hato et al. as well as Xie et al. have documented that ideal timing for surgery should be within 2 weeks and within 2 months at the latest, to obtain good outcomes [3, 7].

The facial nerve makes a tortuous course through the temporal bone, making it prone to getting afflicted in temporal bone trauma. The lengths of the labyrinthine, tympanic and mastoid segments as described in literature are 3–5 mm, 10–12 mm and 13–15 mm, respectively [8, 9]. Conventional microscopic facial nerve decompression techniques have propagated that the nerve should be decompressed *one centimetre* proximal and distal to the injured segment [10]. Taking into account the total length of the intra-temporal facial nerve, it is evident that decompression of one centimetre proximal and distal to the injured segment entails extensive handling of *normal* nerve segments. Injury to the normal segment of the nerve, while decompression of the injured nerve may delay or compromise the

Table 1 Summary of results

Serial no.	Parameter	Endoscopic group	Microscopic group	*p* value
1	Mean(± S.D.) age	32.32 (± 4) years	32.68 (± 8) years	N.A
2	Sex	M:F = 3:1(27:8)	M:F = 3:1(28:10)	N.A
Pre-operative				
3	Onset of symptoms	77.1% (27/35) acute 22.8% (8/35) insidious	76.3% (29/38) acute 23.7% (9/38) insidious	N.A
4	Type of temporal bone fracture	57.1% (20/35) longitudinal 17.1% (6/35) transverse 25.7% (9/35) mixed	57.9% (22/38) longitudinal 18.4% (7/38) transverse 23.7% (9/38) mixed	N.A
5	Day of surgical intervention (Mean ± S.D.)	15.4 ± 5 days	15.5 ± 4 days	> 0.05
6	Pre-operative air–bone gap (Mean ± S.D in dB)	29.6 ± 6.3 dB	29.5 ± 5.9 dB	> 0.05
Intra-operative				
7	Nature of facial nerve injury	65.7% (23/35) BFI + H 17.1% (6/35) BFI + H + Ptc 17.1% (6/35) BFI	57.9% (22/38) BFI + H 15.8% (6/38) BFI + H + Ptc 21.1%% (8/38) BFI 5.3% (2/38) H	N.A
8	Ossicular chain status	20% (7/35) ISJ # 20% (7/35) IMJ # 37.1% (13/35) ISJ + IMJ # 8.6% (3/35) ISJ + IMJ + LtP #	21.1% (8/38) ISJ # 18.4% (7/38) IMJ # 42.1% (16/38) ISJ + IMJ # 5.3% (2/38) ISJ + IMJ + LtP #	> 0.05
9	Surgical time (Mean ± S.D in min)	164.5 ± 13.2 min	165.6 ± 18.1 min	> 0.05
Post-operative				
10	Post-operative air–bone gap (Mean ± S.D in dB)	16.47 ± 4.5 dB	19.4 ± 5.2 dB	**< 0.05**
11	Day of recovery (Mean ± S.D)	14.4 ± 5 days	22.5 ± 7 days	**< 0.05**
12	Median Post-operative pain (NRS)	4 (2–7)	6 (5–8)	**< 0.05**
13	Long-term recovery (at 1 year)	82.9%—H–B Grade I 11.4%—H–B Grade II 5.7%—H–B Grade III	73.7%—H–B Grade I 18.4%—H–B Grade II 7.9%—H–B Grade III	> 0.05 (for H–B Grade I)

Bold value indicates statistically significant values

BFI bone fragment impaction, *H* haematoma, *PtC* partial transection, *ISJ* incudo-stapedial joint, *IMJ* Incudo-malleolar joint, *LtP* Lenticular Process of incus, *NRS* Numerical Rating Scale, *H–B* House–Brackmann Score final post-operative outcome [12]. In contrast, in endoscopic facial nerve decompression, owing to better visualization of the injured segment, only the selected injured segment and a small part of adjoining nerve is decompressed. The authors have described a systematic protocol for documenting the type of endoscopic facial nerve decompression which was lacking in literature, as per the authors' knowledge. In microscopic facial nerve decompression, the oedema, while decompressing the excess segment of the nerve shall require additional time to subside, which is probably the reason of delayed recovery in microscopic facial nerve decompression, as evident in our study.

Ossicular chain injury during facial nerve decompression has been described as the most common complication of the surgery in its conventional form [12]. However, a more close-up view of the working area during endoscopic decompression avoids this devastating complication. Moreover, it has been documented in literature that endoscopic ossicular chain reconstruction has comparable outcomes with microscopic technique in terms of post-operative air–bone gap closure [13, 14].

Intra-operative confirmation of diagnosis can be easily made with a simple tympanotomy aided with zero-degree and angled endoscopes. Canal step deformity, which often obscures further view and the need for a complete atticotomy/mastoidectomy can be bypassed in the initial stage of the surgery to confirm the diagnosis using endoscopes. In contrast, all the bone coming in the line of view of the microscope has to be drilled away to attain optimal access (Fig. 4).

Spectra A and B are virtual optical chromo-endoscopy modes of Karl Storz™ SPIES unit. This technology has been used in intra-operative diagnosis of neoplasms of upper aero-digestive tract and bladder [15, 16]. Our study has used it to better diagnose pathology in the affected segments of the nerve, such as devascularization, intra-neural haematoma and overlying granulation tissue or clots. It not only helps in understanding the pathology, but also differentiation of normal and affected nerve segment, thereby helping surgeons pinpoint the exact site for decompression. As per authors' knowledge, this technology has never been used before in cases of traumatic facial nerve palsy. This is an additional advantage that can be utilized during endoscopic facial nerve decompression (Fig. 5).

Endoscopic facial nerve decompression has a steep learning curve. Single-handed manipulation of the delicate nerve and adjoining ossicles can be challenging for beginners and may result in adverse post-operative outcomes. Direct exposure of the nerve to warm light source of the endoscope for long duration may cause possible thermal damage. To avoid such injury, use of cooler light such as Light Emitting Diode (LED) and intermittent copious irrigation are necessary [16].

There are certain limitations of our study that need to be highlighted. Limited sample size in both groups, variable timing of surgery following trauma due to delayed presentation to ENT surgeon are some of them. Larger multi-centric studies are necessary to further elucidate the pros and cons of endoscopic facial nerve decompression over conventional techniques.

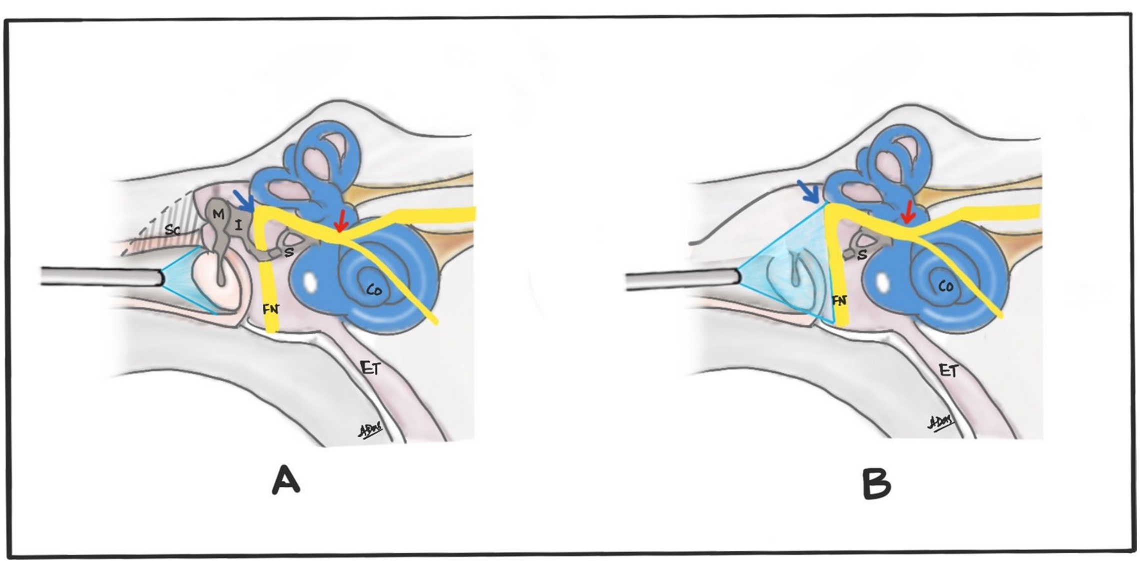

Fig. 4 Principle of endoscopic facial nerve decompression. **A** Coronal section showing minimal bone removal required for access. **B** Enhanced bird's eye view of facial nerve obtained from Endoscope after limited atticotomy and incus removal. *Sc* scutum, *m* malleus, *i* incus, *s* stapes, *Co* cochlea, *fn* facial nerve, *et* eustachian tube, *red arrow* second genu, *blue arrow* first genu

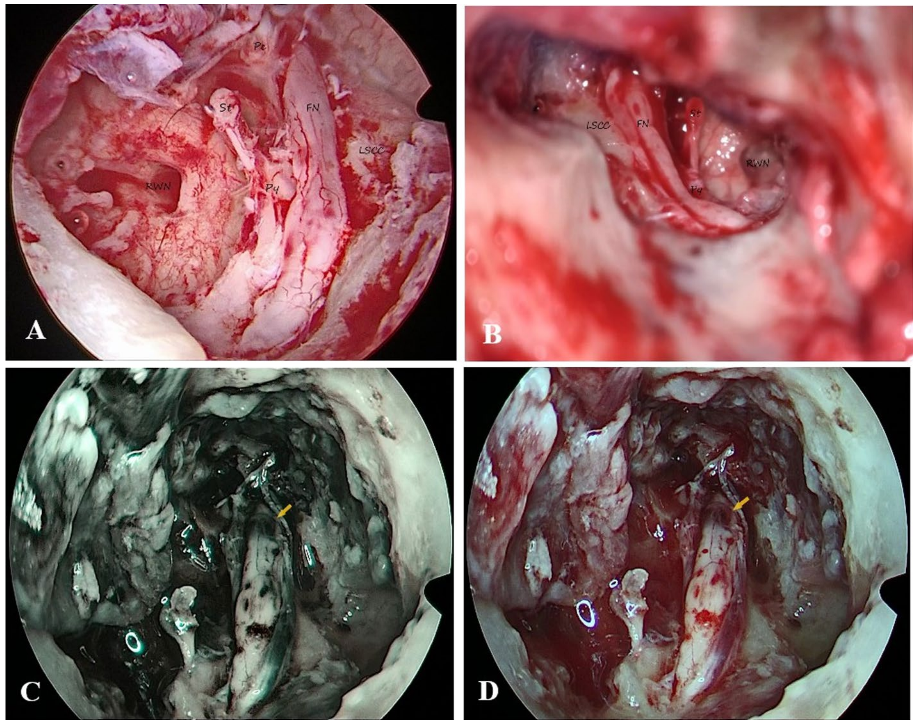

Fig. 5 Facial nerve decompression. **a** Endoscopic trans-canal technique; **b** microscopic trans-canal technique; **c** visualization of nerve injury with SPECTRA-A mode; **d** visualization of nerve injury with SPECTRA-B mode; arrow pointing toward intra-neural haematoma; *rwn* round window niche, *pc* processus cochleariformis, *py* processus pyramidalis, *st* stapes, *fn* facial nerve, *lscc* lateral semicircular canal

Conclusion

Endoscopic facial nerve decompression results in early recovery, less post-operative pain and better post-operative air–bone gap closure when compared to conventional microscopic techniques.

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Data availability The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of interest The authors declares that they have no conflict of interest.

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