Journal of Visualized Experiments

The microscopic transcanal approach in stapes surgery revisited

--Manuscript Draft--

Article Type:	Invited Methods Collection - JoVE Produced Video
Manuscript Number:	JoVE63011R4
Full Title:	The microscopic transcanal approach in stapes surgery revisited
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TITLE:

The Microscopic Transcanal Approach in Stapes Surgery Revisited

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SUMMARY:

This article describes the microscopic transcanal technique for stapes surgery, providing step-by-step surgical instructions for familiarizing surgeons with this approach.

ABSTRACT:

The microscopic transcanal (aka transmeatal) surgical approach was first described in the 60s, offering a minimally invasive means of reaching the external auditory canal, the middle ear, and epitympanon. Such an approach avoids a retroauricular or endaural skin incision; however, working through a narrow space needs angled microsurgical instruments and specific training in otologic surgery. The transcanal approach restricts the working space; however, it offers a binocular microscopic vision into the middle ear without extended skin incisions and thus, reducing post-operative pain and bleeding. In addition, this minimally invasive approach avoids scar tissue complications, hypoesthesia of the auricle, and potential protrusion of the pinna. Despite its numerous advantages, this method is still not routinely performed by otologic surgeons. Since this minimally invasive technique is more challenging, there is a need for extensive training in order for it to be widely adopted by otologic surgeons. This article provides step-by-step surgical instructions for stapes surgery and reports possible indications, pitfalls, and limitations using this microscopic transcanal technique.

INTRODUCTION:

The advent of a binocular operating microscope in otologic surgery in 1951[1] paved the way for a less invasive microscopic transcanal approach. Alternatives were endaural incisions or retroauricular approaches, which are more invasive. The first transcanal stapes surgery was described by Rosen already in 1952[2,3], but at that time, the stapes was mobilized and not removed. In 1956, Shea revolutionized stapes surgery with the use of the first Teflon prosthesis[4]. The transcanal approach proved suitably adapted to this technique since it provided good 3D visualization of the posterior part of the ear canal, tympanic membrane, and middle ear. The indication for a transcanal microscopic method has widened over time, covering a large number of surgical otologic interventions: Tympanotomy[5], tympanoplasty[6-8], ossiculoplasty[9], antrotomy[10], cholesteatoma[11–13], glomus tympanicum[14], labyrinthectomy[15], neurectomy[16,17], intrameatal acoustic neuroma by transpromontory approach[18–20] or even cochlea implantation[21].

This challenging approach requires the use of specialized instrumentation for transcanal surgery (initially described in the 60s)[22] and specific surgical training. It restricts working space but does, however, offer a binocular microscopic vision into the middle ear without the need for an extended skin incision and thus, reduces post-operative pain and bleeding. In addition, this minimally invasive approach avoids scar tissue complications, hypoesthesia of the auricle, and protrusion of the pinna. In this article, we provide step-by-step surgical instructions for stapes surgery and report possible indications, pitfalls, and limitations using this microscopic transcanal technique.

PROTOCOL:

The local review board of the Bern University (Kantonale Ethikkomission Bern) approved the present study, a formal informed consent was not required for this type of retrospective study.

1. Indications

1.1. Use the transcanal approach if the diameter of the ear canal is ≥5.5 mm.

NOTE: The anatomy and shape of the outer ear canal might further limit the working space.

1.2. Assess the canal's diameter by placing a 5 mm diameter ear speculum. Ensure that the speculum sits comfortably in the canal.

1.3. Do not use the transcanal approach in anterior perforations with a non-visible anterior rim.

1.4. Use the inside-out-technique[11] for middle ear pathologies such as cholesteatomas, which reach the epitympanon beyond the semicircular canal.

2. Preparation

2.1. Positioning of the patient: Place the operating table at the lowest position, tilted in a reverse Trendelenburg position (**Figure 1A**) with the angle (α) of the headrest at its maximal reclination (without head hanging).

NOTE: This position is contraindicated in patients with atlantoaxial instability. Finally, rotate the head towards the contralateral side (β, **Figure 1B**).

2.2. Instruments: Use bent instruments to keep the working field open. Hold the instruments correctly with the fingers, thus preventing any blocked vision (**Figure 2** and **Figure 3**).

NOTE: Black-colored instruments reduce light reflections.

2.3. Disinfection and cleaning of the ear canal: Clean the ear canal thoroughly to avoid any intraoperative infection. Disinfect the canal with diluted Povidone Iodine (2.5%–5% due to toxicity).

3. Local anesthesia

3.1. Perform local anesthesia in two steps:

3.1.1. Inject all four quadrants (23 G needle) with Carbostesin 0.25% (50 mg/20 mL) mixed with Adrenalin 1 mg/mL (final concentration 1:200,000 epinephrine).

3.1.2. Inject within the ear canal using a small bent 27 G needle. Be careful when injecting in the anterior-inferior area to avoid facial paresis.

4. Tympanomeatal flap and speculum holder

4.1. Perform a tympanomeatal flap using a u-shape incision with a sickle or a round knife starting at 6’ o clock position (inferio-anterior). Detach the ear canal skin with a Rosen knife until the inferior annulus rim is reached.

4.2. Install the speculum holder (**Figure 4**).

4.3. Insert the largest possible ear speculum. Make sure that the orientation is correct.

NOTE: Letters indicating the size of the speculum should be placed superiorly.

4.4. Complete the tympanomeatal u-shaped flap by cutting the superior-posterior part with the Belucci scissor. Detach the ear canal skin with a Rosen knife until the superior annulus rim is reached.

4.5. This step might cause bleeding.

4.6. Use an absorbable gelatin sponge soaked with adrenaline to stop bleeding.

4.7. Detach the whole flap until the edge of the annulus.

5. Middle ear dissection

5.1. Make sure that facial nerve monitoring is working before entering the middle ear.

NOTE: The patient should have recovered from any neuromuscular block, which can be assessed by neuromuscular monitoring (4 TOF, train of four).

5.2. Enter the middle ear at the posterior-superior part of the annulus since it is easier to detach at this position.

NOTE: Large cholesteatomas or granulation tissue around the middle ear ossicles might hide any anatomical landmark. In this case, inferio-posterior entering of the middle ear might be advised to find other landmarks (CAVE: jugular bulb).

5.3. Dissect and visualize the anatomical middle ear structures. Visualize the chorda tympani, promontory, incudostapedial joint, stapedial tendon, and the facial nerve (tympanic segment).

5.4. Widen the posterior-superior part of the ear canal with a bone curette or a 2 mm rough diamond drill (low speed) if any of the above structures are not sufficiently exposed. Put an absorbable gelatin sponge in the middle ear to prevent the entrance of bone dust into the middle ear.

6. Stapes suprastructure removal

6.1. Disconnect the incudostapedial joint with a small 0.3–0.6 mm hook or a sickle knife and make an anterior movement to prevent breaking of the footplate.

6.2. Test the mobility of all the three ossicles by touching each ossicle with a needle to confirm isolated ankylosis of the stapes.

6.3. Use protection glasses or filters integrated into the microscope.

6.4. Dissect the stapedial tendon with the laser (e.g., diode laser, CO_2-Laser). Test the strength of the laser during this procedure. Use a FOX laser with 2.5–3 W energy in pulse mode (30–50 ms); however, this value depends on the device and its probe.

6.5. Dissect the posterior crus of stapes near the attachment of the footplate ± anterior crus if the footplate is too mobile.

6.6. Remove the stapes suprastructure. Brake the stapes away from the facial nerve towards the promontory if the anterior crus is still intact. Keep the footplate intact.

NOTE: The footplate should not move while breaking the suprastructure. There is a risk of a longitudinal fracture of the footplate during this procedure.

7. Footplate perforation

7.1. Use the FOX laser to carbonize/weaken the footplate (2 W, 30 ms pulse mode) by making a rosette pattern.

7.2. Use a perforator microdrill (skeeter 0.6 mm) to perforate the last shell of the footplate in the posterior third section.

7.3. If the footplate is too thick, use a diamond microdrill to thin out the footplate until a blue shimmering structure is visible (also known as blue lining).

7.4. Do not use the suction in the area of the footplate once the footplate is open.

8. Stapes prosthesis insertion

8.1. Measure the distance between the long process of the incus and the footplate using a measurement instrument with a 4 mm measuring mark. Use a 0.25 mm longer prosthesis than measured.

8.2. Hold the prosthesis hook with a small alligator ear forceps using a predefined angle of orientation (~20°) prior to insertion.

8.3. Crimp the stapes hook on the long process of the incus.

NOTE: The front tine of the crimping instrument moves while the back tine remains stable on the incus.

8.4. Check the movement of the prosthesis by moving the malleus handle.

8.5. Avoid the prosthesis from touching the promontory or the facial nerve.

8.6. Consider using otologic cement if there is an interplay between prosthesis and incus process.

8.7. Avoid over-crimping since there is a risk for incus necrosis in the long term.

8.8. Seal the perforated footplate with small water-soaked absorbable gelatin sponge.

9. Wound closure/dressing

9.1. Reposition the tympanomeatal flap, adapt with silk dressing, and pack with absorbable gelatin sponge soaked with a solution of hydrocortisone 10 mg (1%)/neomycin 3.5 mg/polymyxin B sulfates 10,000 Units.

9.2. Use a 10 cm ribbon gauze soaked with the same solution for ear canal packing.

REPRESENTATIVE RESULTS:

We present here a retrospective cross-sectional analysis (01/2018 to 05/2021) from 66 patients (37 males, 29 females) aged 9–68 years (mean 46.3y, SD ±13.4y), who underwent stapes surgery (48 standard surgeries, 18 revisions, **Table 1** and **Table 2**). All patients were operated by the same surgeon (GM). The instruments were bent and black (**Figure 3**). The mean speculum size was 6.1 mm (range 5–8 mm, n = 51, **Figure 2**) which allowed an adequate visualization of the operating field. Only 1 out 66 cases needed a retroauricular incision (9 years old child with a canal diameter <5 mm). A posterior canaloplasty was necessary for 37 of 66 patients. **Figure 2** illustrate how to hold the bent instruments with the first three fingertips while stabilizing the hand on the speculum or head of the patient with the remaining two fingers. A speculum holder consists of a mobile extension mounted on the operation table (**Figure 4**). Light exposure is limited and needs to be adjusted by the position of the microscope and the angled instruments (**Figure 5**). The ergonometric position of the sitting surgeon and optimized angle of the hands (**Figure 6**) allow a stable microsurgical performance. Fifty-eight patients received a Richards' piston prosthesis, one patient a Matrix Slim Line KURZ prosthesis, and five patients a malleo-vestibulo-pexy (MVP) prosthesis (ball joint prosthesis). The mean size of the prosthesis was 4.4 mm (range 4–5 mm, SD ± 0.2 mm), mean diameter was 0.46 mm (range 0.4–0.6 mm, SD ± 0.08 mm, **Table 1**). The prosthesis was additionally fixed with otologic cement in 33 of 66 cases. The Chorda tympani was preserved in 55 out of 65 cases.

FIGURE AND TABLE LEGENDS:

Figure 1: Positioning of the patient. (**A**) The operation table at the lowest position tilted in the reverse Trendelenburg position. (**B**) The head/body rotation in a side-lying position towards the healthy ear.

Figure 2: How to hold the instruments. The instruments must be held like a pencil; the ring finger should be supported at the edge of the speculum.

Figure 3: Bent instruments for transcanal microscopic approach. The figure illustrates bent instruments such as a hook, a suction, or an ear speculum (from left to right).

Figure 4: Ear speculum holder. The figure illustrates the design of the speculum holder.

Figure 5: Surgical field exposure. The exposure of the surgical field can be influenced by 1) the angle of the microscope light, 2) the angle of the introduced instrument, and 3) the angle of the ear canal/head position.

Figure 6: Positioning of the hands. The wrist of the surgeon should be in (**A**) neutral position and (**B**) not extended.

Table 1: Summary of the study. The table summarizes the patient and operation characteristics

Table 2: Patient and operation characteristics. The table shows individual patient details and operation characteristics.

DISCUSSION:

The current article provides detailed insider information about the transcanal microscopic approach for stapes surgery. We could demonstrate that microsurgery is feasible using a key-hole technique avoiding a retroauricular or endaural incision in the majority of cases.

Some prerequisites, however, have to be met for achieving a successful surgery. The dissectors should be curved. The knives, hooks, and the needle are angled (**Figure 1**) to improve the visualization and light conditions in such a narrow space[22]. In addition, instruments should be black-colored, avoiding any microscopic light reflections. Patient positioning is crucial for the transcanal approach since the ear canal is curved, and the light beam of the microscope must be fully aligned with the longitudinal axis of the canal (**Figure 2**). In addition, it is crucial to hold the instruments correctly (**Figure 3**) and to keep a suitable ergonomic posture of the hands (**Figure 5**) for a successful transcanal surgery.

A speculum holder, as shown in **Figure 3**, allows a two-handed technique and a straight access route to the tympanic membrane/middle ear. The speculum might additionally serve as an instrument guide. Finally, the angle of the fingers/instruments and the angle of the microscope light should be adjusted and optimized. In view of all these parameters, extensive training of transcanal otologic surgery is needed to improve surgical performance.

Alternative approaches include the endaural and retroauricular incision or the endoscopic transcanal approach. The retroauricular incision is advised for inaccessible anterior perforations of the tympanic membrane or subtotal perforations. Such cases, however, might still be accessible through endoscopic approach[23], provided that the ear canal diameter is large enough (>5 mm). The retroauricular approach remains the gold standard if there is a need to open the mastoid cavity. For combined cholesteatoma surgeries (transmeatal and retroauricular transmastoidal approach), we recommend the inside-out technique, which was first described by Roth and Häusler[11]. This technique suggests as a first step a transcanal access to the middle ear identifying all anatomical structures following the extension of the disease (cholesteatoma) by epitympanectomy. As a second step, a retroauricular incision might follow in cases where transmastoidal access is indicated based on the extension of the cholesteatoma. There is a considerable advantage of this two-step approach since there is a non-negligible proportion of patients who will not need a retroauricular incision (second step) based on a limited extension of the disease.

The transcanal endoscopic approach uses the same route of access and is also limited to an ear canal diameter of >5 mm. Similarly, this approach is minimal-invasive and offers a closer wide-angle view of anatomical structures. In addition, an endoscopic approach offers an angled view of 45° or 70°, which is valuable for the removal of cholesteatomas in the retrotympanum[24], the attic region[25] or for anterior perforations[23]. In cholesteatoma surgery, similarly to the abovementioned inside-out technique, a transcanal endoscopic cholesteatoma removal is performed, followed by clearance of the disease from the mastoid as necessary. In this context, novel exclusive endoscopic techniques were recently described using a constant suction bone-drilling technique[26]. Endoscopic surgery, however, is a one-handed technique and challenging in inflamed conditions with associated bleeding. Therefore, the management of bleeding plays a key role in the endoscopic approach to the middle ear[27]. In addition, endoscopy provides a limited depth of field since it does not offer a binocular view. New 3D endoscopes might improve the depth of field[28]; however, such endoscopes have a larger diameter of 4 mm.

Compared to the retroauricular approach, the microscopic transcanal approach is minimal-invasive and has several advantages such as avoidance of retroauricular pain, scar tissue complications, hypoesthesia of the auricle, and protrusion of the ear.

The transcanal approach also has limitations. The main limitation is the diameter of the ear canal, which should be at least 5 mm. Any disease without direct or with limited access through the meatus is not suitable for a transcanal approach alone. The approach can be extended by using an endoscope or a combined transmastoidal access.

The transcanal/transmeatal microscopic approach has been a proven technique for more than 70 years; however, this method is still not routinely performed by otologists despite the advantages of this minimally invasive approach. Since the performance of this minimally invasive technique is more difficult and challenging, there is a need for extensive training in order to promote its use by otologic surgeons. This illustrative teaching video offers one additional tool to familiarize otologists with this surgical technique.

ACKNOWLEDGMENTS:
G.M. is supported by the Swiss National Science Foundation #320030_173081.

DISCLOSURES:
L.A. is a consultant for Stryker ENT. None of the other investigators has any relevant financial interests, activities, relationships, or affiliations that represent a relevant financial conflict of interest with respect to this work.

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Figure 1

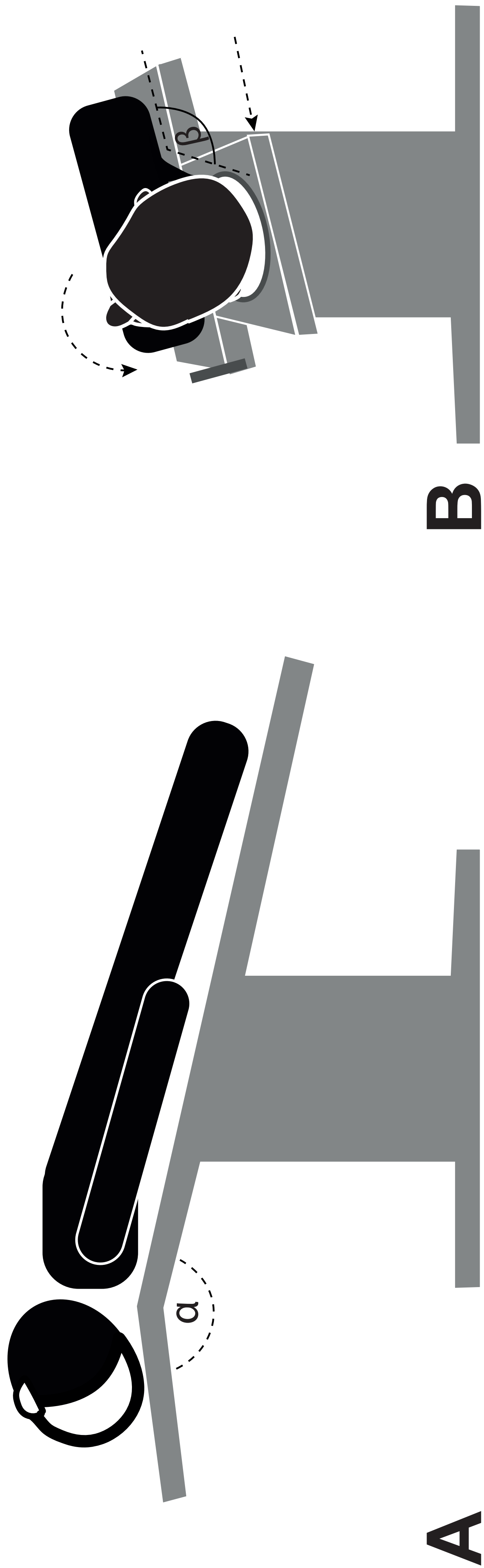
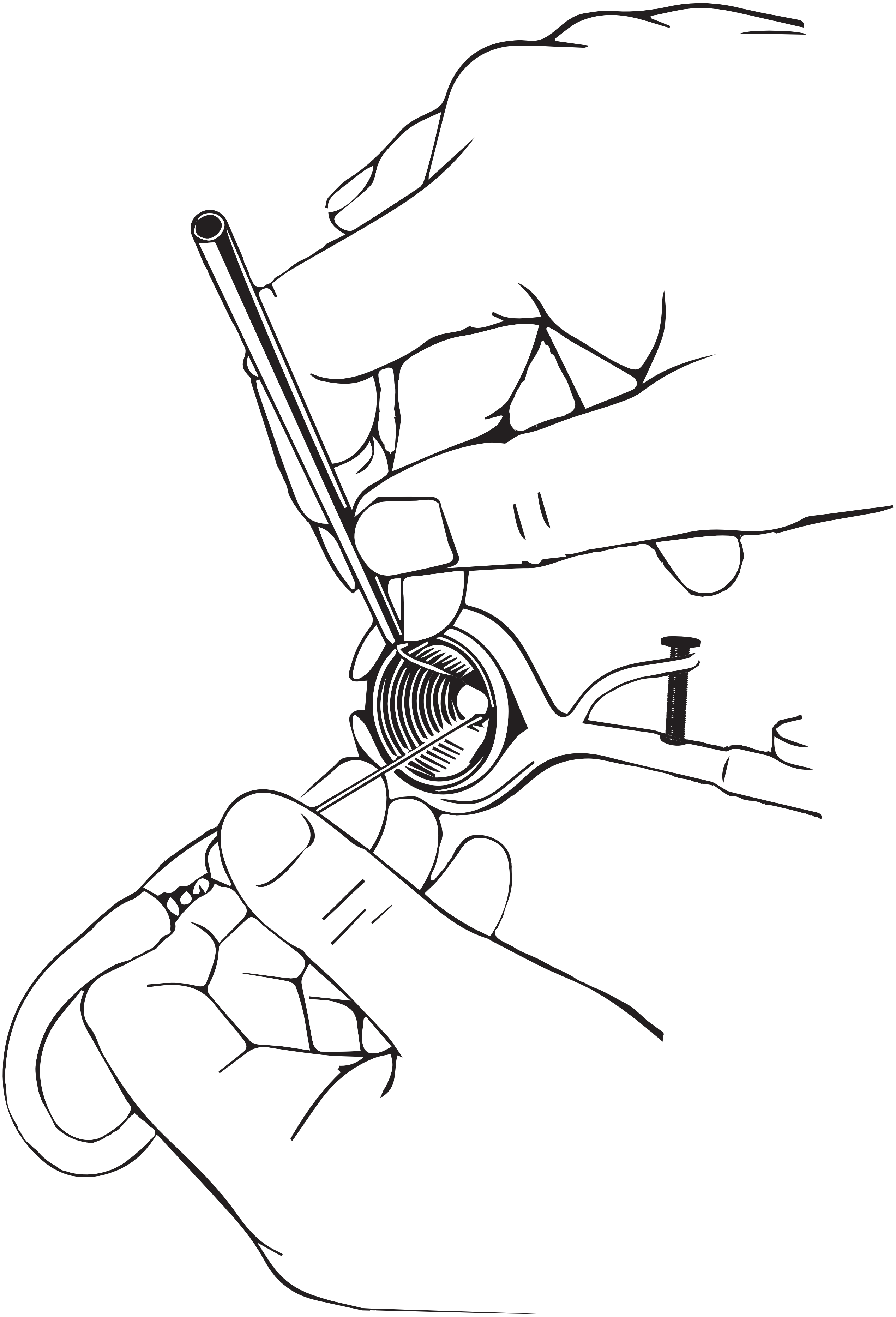


Figure 2



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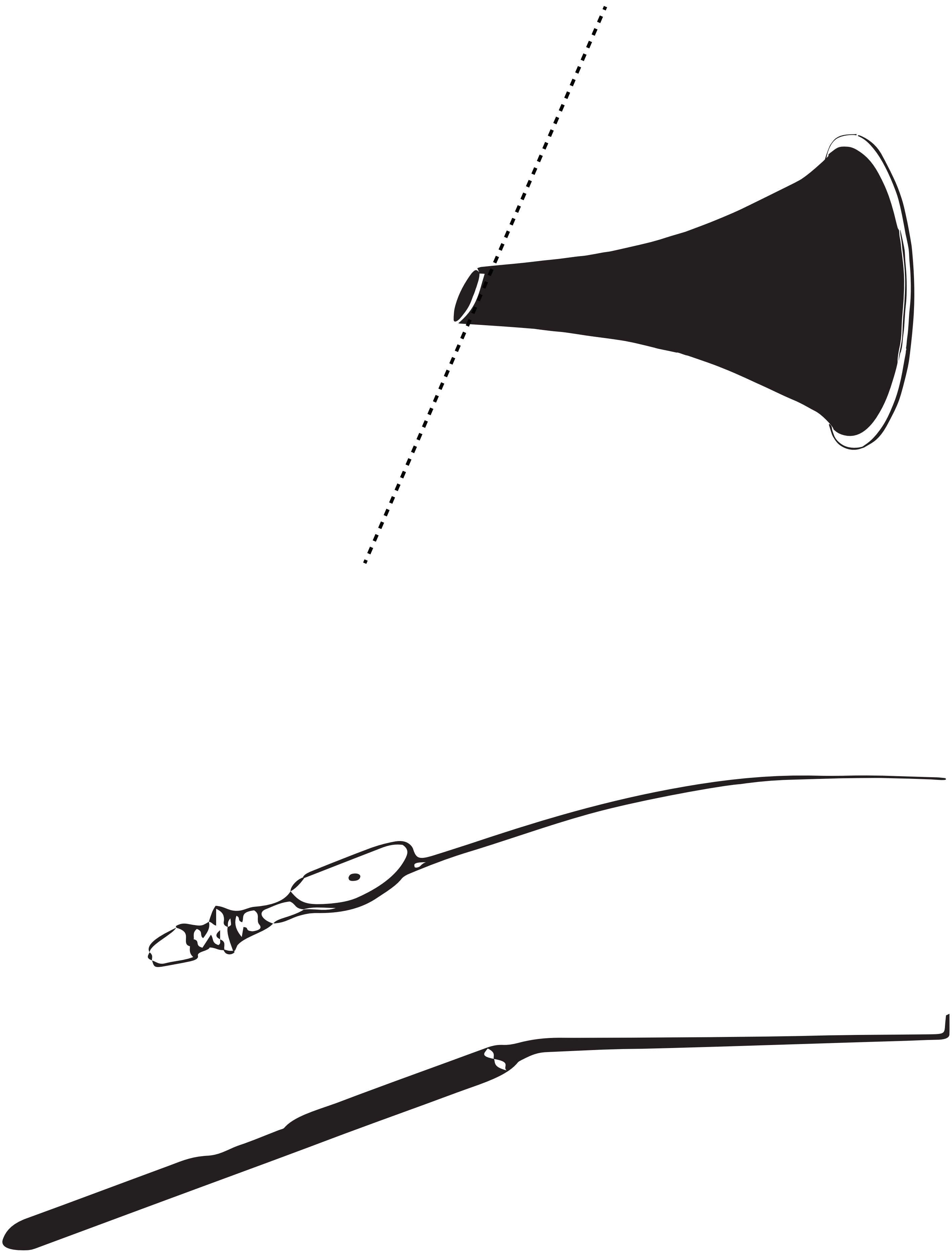

Figure 4

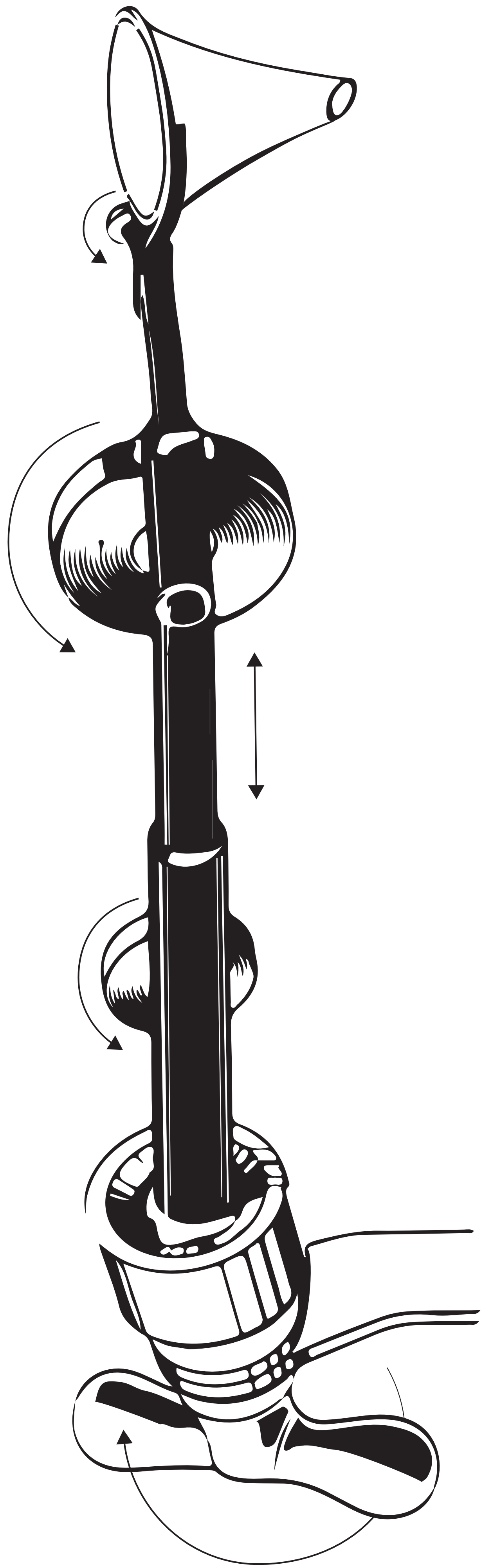

Figure 5

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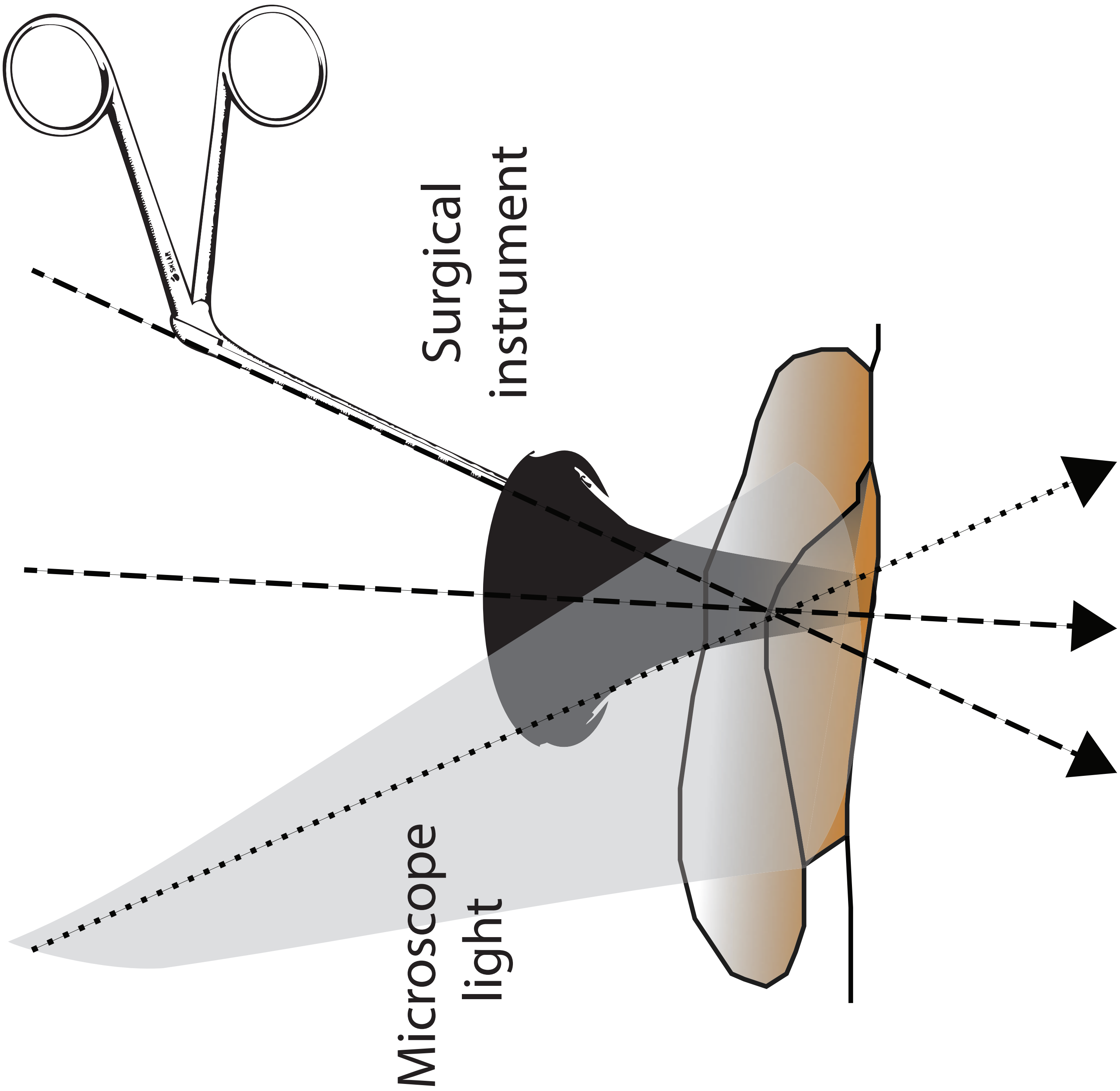

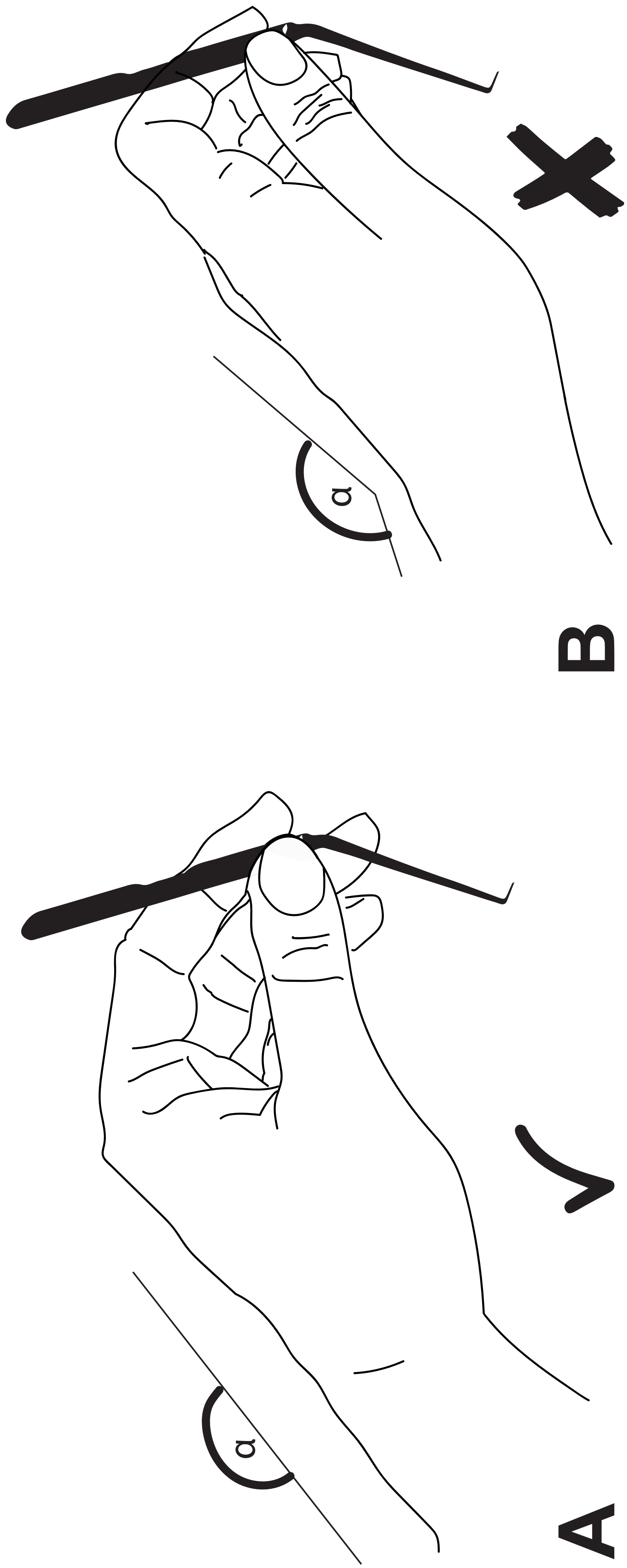
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Table 1 Click here to access/download;Table;table1_summary.xlsx

Summary of the study	
Total number of Patients	66 patients
Males	37 patients
Females	29 patients
Age group	46.3 years ± 13.4 years
Standard Surgeries	48 patients
Revision surgeries	18 patients
Mean speculum size	6.1 mm
Retroauricular incision	1 patient
Posterior canaloplasty	37 patients
Richards piston prosthesis	58 patients
Matrix Slim Line KURZ prosthesis	1 patient
Malleo-vestibulo-pexy (MVP) prosthesis (ba	5 patients
Mean size of prosthesis	4.4 mm ± 0.2 mm
Mean Diameter of Prosthesis	0.46 mm ± 0.08 mm
Fixation with otologic cement	33 patients
Chorda tympani preserved	55 patients

Table 2

ID	Age	Gender	Retro-auricular approach	Speculum Size	Revision	Richards Piston
1	58	male	No	6	No	Yes
2	51	male	No	6.5	Yes	Yes
3	49	male	No	NA	Yes	No
4	57	male	No	NA	No	Yes
5	68	male	No	6	No	Yes
6	60	female	No	5	No	Yes
7	42	female	No	6.5	Yes	Yes
8	52	male	No	6	No	Yes
9	52	male	No	6	No	Yes
10	55	male	No	6	No	Yes
11	36	female	No	7	No	Yes
12	50	female	No	5.5	No	Yes
13	61	male	No	6	No	Yes
14	52	female	No	6	No	Yes
15	42	male	No	6	No	Yes
16	53	male	No	7	No	No
17	48	female	No	6	Yes	Yes
18	60	female	No	5	No	Yes
19	56	male	No	6	No	Yes
20	38	male	No	7	No	Yes
21	43	male	No	NA	No	Yes
22	67	male	No	6	Yes	Yes
23	36	male	No	7	No	Yes
24	62	male	No	7	Yes	No
25	61	male	No	5.5	Yes	No
26	61	female	No	6	Yes	Yes
27	46	female	No	6.5	No	Yes
28	48	female	No	NA	No	Yes
29	26	female	No	8	Yes	No
30	58	female	No	5.5	Yes	No
31	36	male	No	5	No	Yes
32	33	male	No	6	No	Yes
33	9	female	Yes	NA	No	Yes
34	45	female	No	7	Yes	Yes
35	23	male	No	6	No	Yes
36	44	male	No	NA	No	Yes
37	50	female	No	5.5	No	Yes
38	44	male	No	6.5	No	Yes
39	43	male	No	7	No	Yes
40	34	female	No	5.5	No	Yes
41	44	female	No	6.5	Yes	Yes
42	44	female	No	6	Yes	Yes
43	37	male	No	5.5	No	Yes
44	64	male	No	NA	Yes	Yes
45	22	female	No	5.5	Yes	Yes
46	21	female	No	7	Yes	Yes
47	27	female	No	5.5	No	Yes
48	12	female	No	5.5	No	Yes
49	46	female	No	6	Yes	Yes
50	49	female	No	NA	No	Yes
51	51	female	No	5.5	No	Yes
52	44	female	No	5.5	No	Yes
53	51	male	No		No	Yes

54	49	male	No	5.5	No	Yes
55	68	male	No	8	No	Yes
56	40	male	No	NA	No	Yes
57	59	male	No	NA	Yes	No
58	17	female	No	5	No	Yes
59	38	male	No	NA	No	Yes
60	53	male	No	NA	No	Yes
61	35	male	No	NA	No	No
62	61	male	No	8	No	Yes
63	43	female	No	NA	No	Yes
64	55	female	No	7	No	Yes
65	53	male	No	6	No	Yes
66	62	male	No	6	No	Yes

Comments	Length	Diameter	Otologic cement used	Chorda preserved	Canaloplasty performed
	4.75	0.5	Yes	Yes	Yes
	4.5	0.5	Yes	Yes	No
Stapes prosthesis removal, superior canal dehiscence syndrome	NA	NA	No	NA	No
	4.5	0.4	No	Yes	Yes
	4.25	0.6	No	Yes	Yes
	4.24	0.4	No	Yes	No
	4.75	0.5	Yes	No	No
	4.5	0.5	No	Yes	Yes
	4.25	0.5	Yes	Yes	Yes
	4.25	0.5	No	Yes	Yes
	4	0.5	Yes	Yes	Yes
	4.25	0.5	No	Yes	Yes
	4.5	0.4	No	No	Yes
	4.5	0.5	Yes	Yes	Yes
	4.25	0	Yes	Yes	Yes
Matrix Slim Line KURZ prosthesis	4.25	0.5	Yes	Yes	Yes
	4.75	0.4	Yes	No	No
	4.25	4	Yes	Yes	Yes
	4.5	0.4	Yes	Yes	No
	4.5	0.5	No	Yes	Yes
	4.5	0.5	No	Yes	No
	4.5	0.4	Yes	Yes	Yes
	4.25	0.4	Yes	Yes	Yes
Malleovestibulopexy (MVP)	6.5	0.4	No	No	No
Malleovestibulopexy (MVP)	6	0.4	No	No	No
	4.25	0.5	Yes	Yes	No
	4	0.4	Yes	Yes	Yes
	4.5	0.5	No	Yes	No
Malleovestibulopexy (MVP)	6	0.4	Yes	No	No
Malleovestibulopexy (MVP)	6	0.4	No	Yes	No
	4.25	0.5	Yes	Yes	Yes
	4.5	0.5	No	Yes	Yes
	4.25	0.5	Yes	No	No
	4.5	0.5	No	Yes	Yes
	4.5	0.4	Yes	Yes	Yes
	4.25	0.5	No	No	No
	4.5	0.5	Yes	Yes	Yes
	4.5	0.5	No	Yes	Yes
	4.75	0.5	No	Yes	Yes
	4.25	0.5	Yes	Yes	Yes
	4.75	0.4	Yes	Yes	No
	4.25	0.5	Yes	Yes	Yes
	4.25	0.5	No	Yes	No
	4.25	0.5	No	Yes	No
	4.5	0.5	Yes	Yes	No
	4.5	0.5	Yes	Yes	No
	4.5	0.4	Yes	Yes	Yes
	5	0.4	Yes	Yes	Yes
	4.5	0.6	Yes	Yes	No
	4.5	0.4	No	No	No
	4.5	0.4	No	Yes	Yes
	4.5	0.5	Yes	Yes	Yes
	4.5	0.5	No	Yes	No

	4	0.5	No	Yes	Yes
	4.5	0.5	No	Yes	Yes
	4.25	0.5	No	Yes	No
Malleovestibulopexy (MVP)	5	0.5	No	Yes	No
	4.25	0.4	No	Yes	Yes
	4.5	0.4	No	No	No
	4.25	0.5	No	Yes	No
	4.5	0.4	Yes	Yes	No
	4.5	0.5	No	Yes	Yes
	4.25	0.5	Yes	Yes	No
	4.25	0.4	Yes	Yes	Yes
	4.5	0.5	No	Yes	Yes
	4.75	0.5	Yes	Yes	Yes

We thank the Editors and Reviewers for their insightful and helpful critiques and suggestions. We added a new table 1 as suggested. We enclose a ‘tracked’ version (red font) in our submission. We hope that our responses prove satisfactory and look forward to working with you.