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Veria Operation Updated

I. The Trans-Canal Wall Cochlear Implantation

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Key Words

Cochlear implantation · Non-mastoidectomy technique · Trans-canal wall approach

Abstract

The Veria operation is a non-mastoidectomy technique for cochlear implantation. It uses the transcanal approach to the middle ear and the cochlea. The steps of the procedure are: (1) endaural approach, that offers a wide accessibility to the middle ear structures; (2) inspection of the middle ear anatomy; (3) straightening of the postero-superior bony canal wall, which is usually concave; (4) performing the cochleostomy through the outer ear canal; (5) drilling of the suprameatal hollow, which is used for the accommodation of the electrode excess; (6) drilling of the trans-wall direct tunnel, which is the pathway for the active electrode; (7) alignment of the direct tunnel to the cochleostomy; (8) extension of the incision and preparing of the flaps; (9) creating of the bed and fixing the device; (10) insertion of the electrodes; (11) manipulating the excess of the active electrode, and (12) closing. For this technique, two special instruments have been developed: a special perforator used for the drilling of the direct tunnel for the active electrode, making it completely safe, and a safety electrode forceps used to manipulate the active electrode during insertion. The direct tunnel can be enlarged superiorly permitting insertion of two electrodes, in cases where a double electrode array implant has to be used. The method is an efficient tool for handling all cochlear implant cases, including difficult ones such as revision cases, malformations, cochlear ossifications and poor mastoid development. It is safe without complications in over a hundred cases and easy to learn.

Introduction

Surgery for cochlear implants has undergone several modifications since the beginning of cochlear implantations [1–3]. Nowadays, still the most frequently used technique worldwide, the so-called ‘classic’ technique, uses a mastoidectomy and a posterior tympanotomy approach to the middle ear and the cochlea, with several options, regarding soft tissue handling. Even though this classic technique has been very efficient for the vast majority of the cases, we feel that in certain cases there were some disadvantages: (a) limited accessibility to the cochlea and

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related structures with a certain danger to the facial nerve and (b) unnecessary resection of healthy bone. In order to overcome these problems, we developed a new surgical technique. In 1995, after having completed a temporal bone study and trial, we started using a non-mastoidectomy technique for cochlear implantation. We used the endaural approach to the middle ear, through which we could inspect the anatomy of the middle ear structures and perform the cochleostomy. For the active electrode we drilled a groove on the superior-posterior bony canal wall. In the middle of this groove we preserved the cortex of the canal wall for about 5 mm, making a bony bridge. We realized that the groove could be safely converted to a closed tunnel, drilled very superficially under the cortex of the superior-posterior bony canal wall after having inspected the middle ear anatomy. That was confirmed in a temporal bone trial and a CT scan study and the technique was presented as the 'Veria operation' [4]. This involved using the transcanal approach to the middle ear and the cochlea and a direct tunnel drilled through the posterior bony canal wall to the middle ear. This tunnel was used as the pathway for the active electrode, which was then absolutely protected from being in contact with canal skin. For the safe drilling of the tunnel we developed a special drilling device, which permitted us to control very accurately the depth and the direction of the drilling. In 1999, we made some modifications of the technique and we introduced also a special safety electrode forceps for the manipulation of the electrode array in the middle ear. This updated technique we are describing in this paper.

Steps of the Operation

Step 1: Endaural Approach

We favor the endaural incision (fig. 1), but the postauricular incision can be used as well. The endaural approach offers a wide visibility and accessibility to the middle ear structures. The incision is extended supero-posteriorly around the auricle sufficiently enough to expose the temporal line and the mastoid cortex where the *suprameatal hollow* (step 5) is to be drilled.

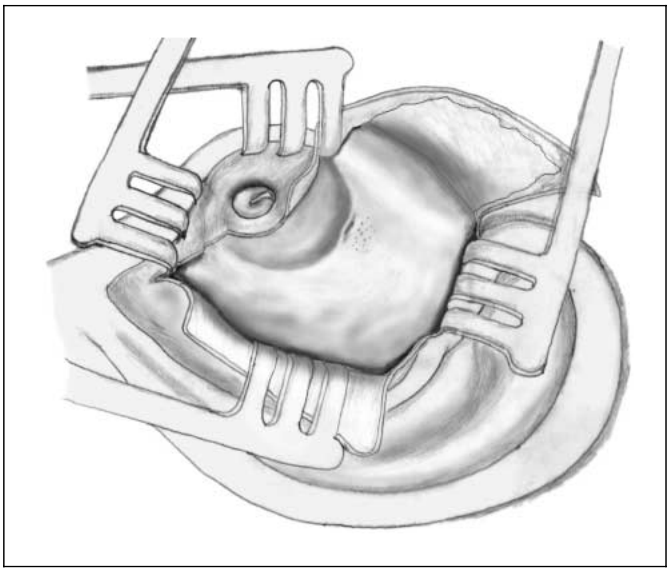

Fig. 1. Endaural approach using the endaural incision.

Step 2: Inspection of the Middle Ear Anatomy

The tympanomeatal flap is created and the middle ear cavity exposed (fig. 2). We prefer to make the circular incision of the canal skin quite deep, 5 mm from the annulus, creating a small thin tympanomeatal flap, which then can be rolled over the anterior part of the tympanic membrane, leaving the canal completely free of any tissue. By a small atticotomy the incudo-stapedial joint and the facial canal are exposed and inspected to rule out any irregularities. The round window niche and basal turn of the cochlea are safely identified. Contrary to the limited exposure through the posterior tympanotomy, the wide exposure of the endaural approach makes the identification of the basal turn of the cochlea safe and prevents any surgical

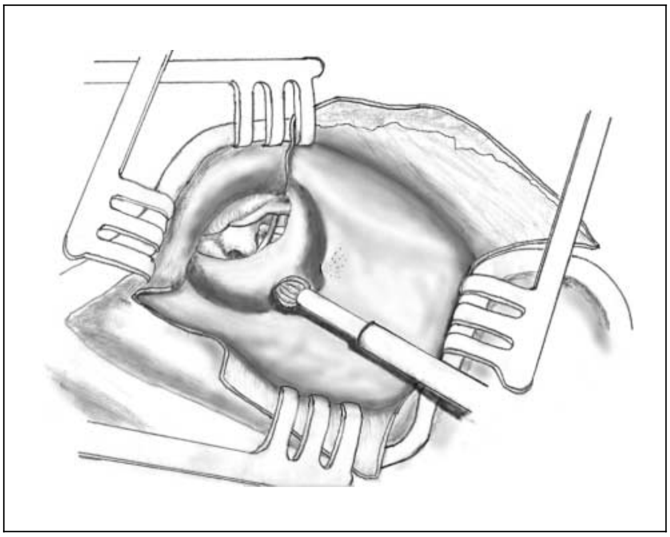

Fig. 2. Tympanomeatal flap is rolled anteriorly, the middle ear structures are exposed by a small atticotomy and the posterior canal wall is straightened by drilling the outer canal rim supero-posteriorly.

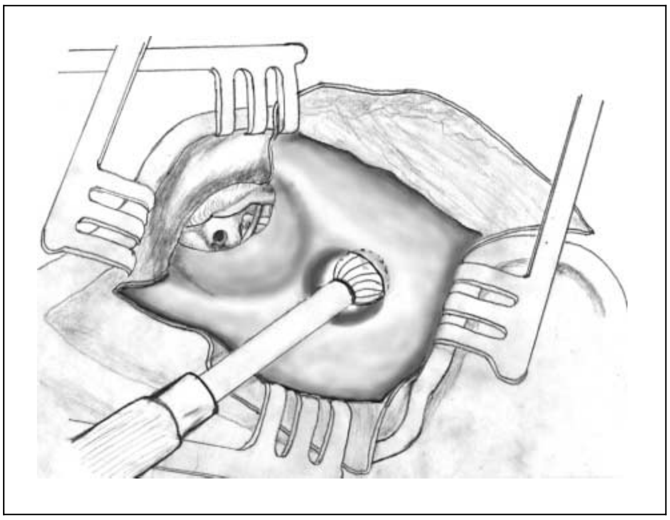

Fig. 3. Drilling the suprameatal hollow. Care must be taken to leave an around-the-rim overhang.

failure with malpositioned electrode or incomplete surgery, where the cochlea was not properly identified. We have seen and revised successfully a considerable number of such cases, using the endaural approach.

Step 3: Straightening of the Posterior Bony Canal Wall

In most of the cases the supero-posterior bony canal wall presents a concavity. By drilling out the outer rim of the bony canal posteriorly and superiorly (fig. 2), together with the suprameatal spine of Henle if necessary, a straightening of the wall is achieved, which is very important. It facilitates very much the drilling of the *direct tunnel* (step 6) by use of the special perforator.

Step 4: Cochleostomy

We perform the cochleostomy through the canal with a 1-mm diamond burr, drilling exactly over the anterior rim of the round window niche, creating a 1.2-mm opening of the scala tympani. After the opening has been created, the outer posterior rim is drilled out and then by drilling from inside out, the inner anterior rim is removed. In this way the created tunnel of the cochleostomy has an oblique direction from postero-superior to antero-inferior, facilitating the insertion of the electrode into the scala tympani without pressing on the modiolus.

Highlights for the cochleostomy are: (1) Drilling is done in a smooth circular motion of the burr, trying rather to skeletonize (blue-lining) the scala tympani before entering it, than perforating it directly by direct drilling. (2) Care is taken so that an outflow of perilymph is possible (patient's head down). The flow of the perilymph prevents the entering into the scala tympani of: bone dust (may cause ossification), air bubbles (affects the impedance of the electrodes making early fitting difficult) and also prevents contamination. (3) After opening the scala tympani the trimming of the rim is done by inside-out drilling. (4) The cochleostomy is temporarily sealed with a piece of gel-foam soaked in antibiotic to be re-opened just before insertion of the electrode.

The timing of the cochleostomy may change according to the preference of the surgeon and may be kept as a final stage before insertion. The reasons for which we prefer to do it early are: (1) It is a useful landmark during drilling of the direct tunnel. (2) In handling questionable cases, regarding patency of the cochlea, there is early identification of the difficulty, permitting proper planning of the procedure. (3) In cases where the choice is quitting the procedure, the surgical trauma and time would be minimal.

Step 5: Drilling the Suprameatal Hollow

Using a 3-mm cutting burr, we drill a round hollow 5 mm wide and the same depth (fig. 3), starting above the cribriform area and drilling up to the temporal line, adjacent to the supero-posterior rim of the bony canal wall, leaving only a thin bony layer between the canal and the hollow. We take care to drill in such a way to leave a considerable overhang in the cortical rim of the hollow (see fig. 3). This suprameatal hollow has been designed to accommodate any final excess of the active electrode, which is rolled in the hollow and kept in place spontaneously under the overhang rim by springing. Besides, it was proved to be useful in other aspects: (1) it facilitates the drilling of the *direct tunnel* by shortening the distance to be drilled and by allowing better control of the perforator and (2) it ensures the continuous irrigation if it is saline filled during drilling.

Step 6: Drilling the Trans-Wall Direct Tunnel

This is the most critical step of the procedure because it makes the difference from the classic technique, replacing the mastoidectomy and the posterior tympanotomy. For the creation of the direct tunnel we use the thickness of the supero-posterior bony canal wall itself (trans-wall), by drilling very accurately within it by use of the special perforator (fig. 4). This is a simple device which contains a 1.6-mm cutting burr paired with a straight guide. The tip of the guide is very close to the burr allowing the drilling to be less than 0.5 mm under the surface of the bone. Apart from controlling very accurately the depth of the drilling, the guide also permits a very efficient control of the direction of the drilling, since it is always visible in the canal, showing every moment the position and the direction of the drilling burr, which is hidden into the bone.

The drilling of the direct tunnel starts at the uppermost point of the bottom of the *suprameatal hollow* adjacent to the supero-posterior bony wall of the canal (fig. 5). The hollow is saline filled and the drilling is done in a push-pull movement of the drill to allow continuous irrigation of the tip of the drilling burr. For the direction of the drilling we follow a straight line from the point of the start towards the cochleostomy. If the point of exit of the chorda tympani is above this line we then drill higher to this point to avoid damage of the nerve.

When the burr enters the middle ear the direct tunnel has been completed and the perforator is removed from inside out with the drill running. Using a 1.5-mm suction tip on a syringe, any bone dust is washed out from the tunnel and the middle ear, and besides the potency of the tunnel is controlled. By observing the distance of the suction tip from the facial canal and the ossicles, one can realize the safety of the procedure.

The direct tunnel is sufficiently large for any electrode array, but it can be further enlarged if necessary, by drilling sidewise superiorly with the perforator. Thus it was possible, in several ossified cochlea cases, to use the double array implant, passing two electrode arrays through the direct tunnel.

Highlights of the drilling of the direct tunnel are:

(1) *Direction:* from the uppermost point of the supero-posterior canal wall to the cochleostomy. This oblique direction is very important for two reasons: (a) to create a tunnel almost parallel to the long process of the incus, approaching the basal turn of the cochlea at a very closed angle, almost the same as with the posterior tympanotomy but with a much wider view, and (b) it moves the line of the drilling higher from the point of exit of the chorda tympani increasing safety for this nerve.

(2) *Depth of drilling:* most superficially, preserving <0.5 mm of thickness of the cortex. This is achieved by the special perforator and makes the cover of the canal eggshell thick, which is almost transparent, through that we can observe the tunnel and any instrument inserted in it. This superficial drilling combined with the width of the tunnel (1.6 mm) makes the total depth of the drilling 2 mm maximum, meaning that the tunnel is drilled through the thickness of the canal. This is very important for the safety of the facial nerve, since there has never been reported any irregularity where the nerve is growing into the canal wall.

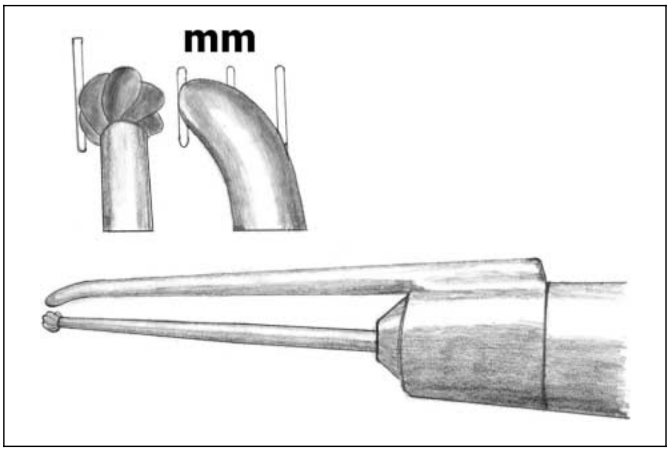

Fig. 4. Special perforator: the guide allows only very superficial drilling (<0.5 mm) and accurate control of the direction of the drilling.

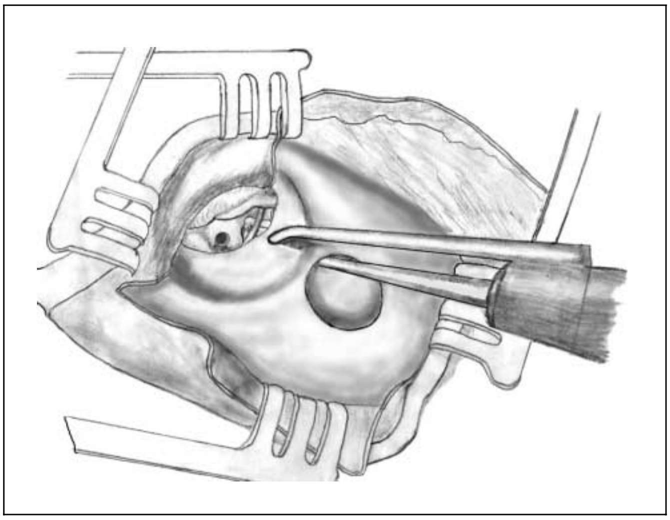

Fig. 5. Drilling the direct tunnel. Start at the uppermost point of the supero-posterior canal wall and drill towards the point of the cochleostomy. Using the special perforator the depth and the direction of the drilling are accurately controlled.

(3) In case there is any dehiscence of the bony cover of the tunnel, this can be closed with bone dust.

(4) The existence of a sufficient space for a safe drilling of the direct tunnel could always be predicted preoperatively on the HRCT scans. This, in combination with the inspection of the middle ear and facial nerve anatomy during operation, could rule out any facial nerve irregularities, preventing the application of this technique in such cases. In our series we did not come across any such cases.

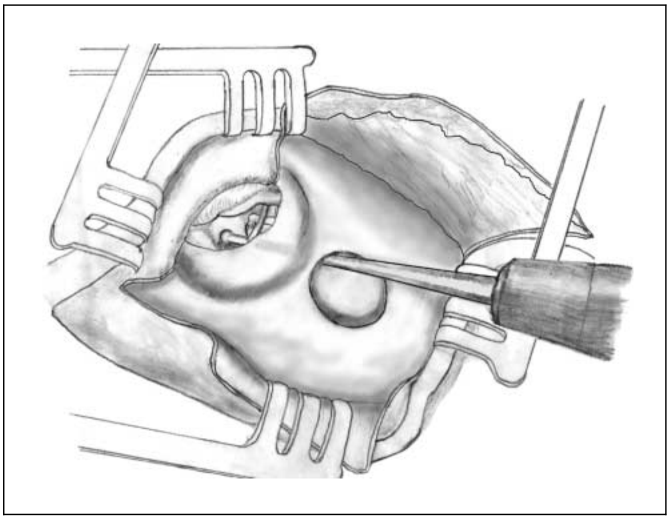

Fig. 6. Alignment of the tunnel to the cochleostomy. Notice that the rod of the burr is visible into the direct tunnel, through the eggshell thin bone covering the tunnel.

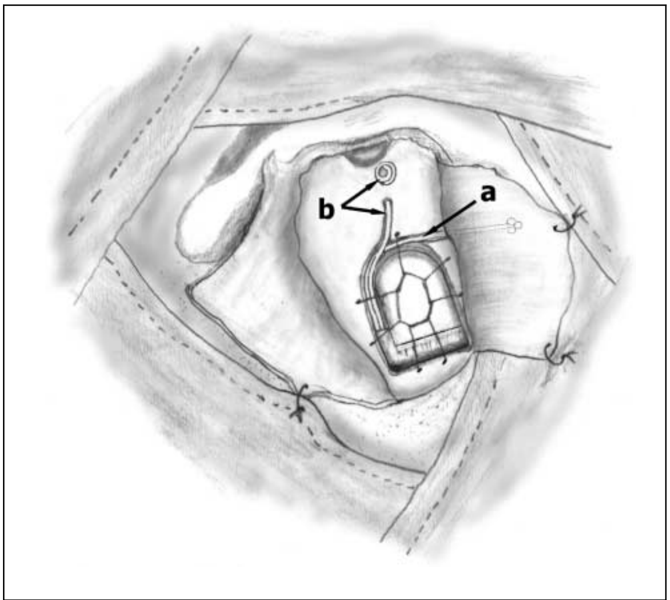

Fig. 7. The device is fixed in place, the reference electrode (a) is placed subperiosteally under the temporal muscle and the active electrode (b) runs in the connecting grove and is inserted into the suprameatal hollow. From there it is advanced into the direct tunnel and the cochleostomy.

Step 7: Alignment of the Tunnel to the Cochleostomy

This step is optional but when done it facilitates the insertion of the electrode into the scala tympani. It is performed by the use of a special 1.2-mm diamond burr with a conically thinned rod so that the 1.6-mm point of it lies at a distance of 30 mm from the tip (fig. 6). This burr is inserted running into the direct tunnel with a push-pull movement and polishes the tunnel. After that it is directed to the cochleostomy in an attempt to be inserted into it. Some final polishing of the cochleostomy is sometimes necessary to achieve this.

Step 8: Extension of the Incision and Preparing of the Flaps

The skin incision is extended supero-posteriorly on a curved line without cutting the fascial layer. The skin with the auricle is elevated inferiorly creating the *inferiorly based skin flap*. A lower incision of the fascial layer close to the tip of the mastoid permits the elevation of the fascia-muscle-periosteum superiorly creating the *superiorly based flap.*

Step 9: Creating the Bed and Fixing Device

The drilling of the device bed is done using the special template at a distance from the canal to leave sufficient space for the speech processor. A grove is drilled from the lower point of the bed towards the suprameatal hollow. At the very last few millimeters the grove becomes a closed tunnel. In this connecting grove and tunnel will run the active electrode of the device, entering the suprameatal hollow and from there into the direct tunnel, to be inserted into the cochleostomy. The device is fixed in place with 3-0 Vicryl tie-down suture, passed through several holes drilled around the implant bed. Any other way of fixation may be used (fig. 7).

Step 10: Insertion of the Electrodes

After fixing the device in place, the reference electrode is placed subperiosteally under the temporal muscle. The active electrode is passed through the connecting tunnel into the suprameatal hollow and advanced into the direct tunnel. By pushing from within the suprameatal hollow the electrode is advanced in the direct tunnel and from there it is inserted straight into the cochleostomy and the basal turn of the cochlea. The electrode is manipulated very gently, initially with the fingers and then using the special claw and the specially designed safety electrode forceps (fig. 8), which can be used in cases where manipulation of the electrode within the middle ear is required. The cochleostomy is sealed with a piece of connective tissue pushed around the electrode into the cochleostomy and with tissue glue.

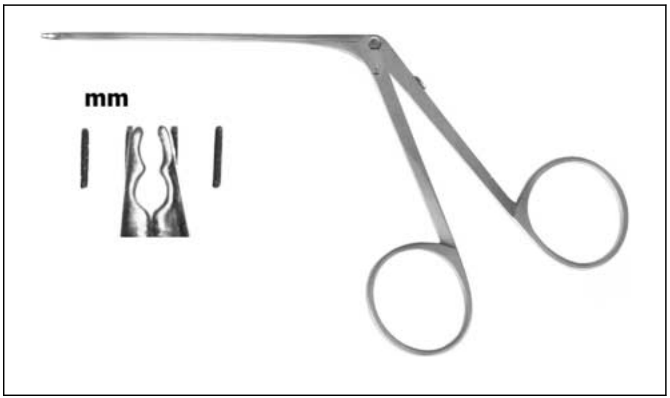

Fig. 8. The special electrode forceps is a left curved crocodile (for the right-handed) with atraumatically closing jaws, with two keeping points, one with 0.6 and 0.9 mm, to manipulate the apical and the basal part of the electrode. It can be used in both ears, with the jaws fitted always on the electrode in the posterior middle ear space.

Step 11: Manipulating the Excess of the Electrode

After the insertion of the electrode into the cochlea has been completed, its excess is pulled out of the suprameatal hollow so that the first part after the device lies into the connecting grove. The excess then is rolled very gently with a soft anatomical forceps and pushed under the overhang into the hollow. It stays there spontaneously fixed by springing (fig. 9).

Step 12: Closing

First the tympanomeatal flap is put back in place very precisely and the inner part of the canal is packed with gel-foam soaked in antibiotic. Then the superiorly based fascia-muscle-periosteal flap is sutured in place with a few stitches of 3-0 Vicryl. The inferiorly based skin-and-auricle flap is then put back in place and sutured in two layers, subcutaneous with 3-0 Vicryl and skin with running suture of 4-0 Prolene. The outer posterior flap of the canal skin is put in place precisely and the canal is then fully packed with gel-foam. The cavum conchae is packed with an absorbing cotton pad and the head is properly bandaged.

Postoperative Situation

The postoperative situation in the temporal bone is demonstrated in figure 10a–d. The electrode is running in the direct tunnel, which is very superficial (a). The electrode excess is nicely accommodated in the suprameatal hollow (b). The facial canal is at a safe distance from the direct tunnel (c). The deep electrode insertion of a Med-El electrode is clearly demonstrated, with the first contact at

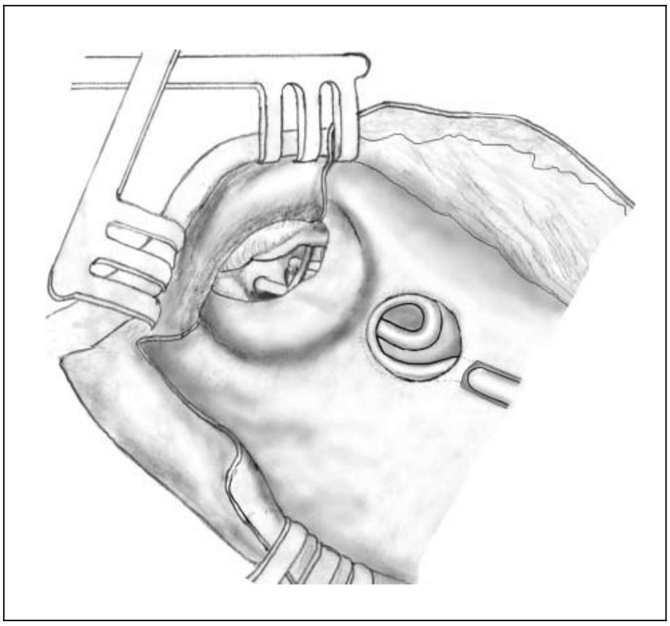

Fig. 9. The active electrode from the suprameatal hollow is advanced to the direct tunnel and inserted into the cochleostomy and the basal turn of the cochlea. The excess of the electrode is accommodated in the suprameatal hollow by rolling and pushing in there. It stays in place spontaneously by springing.

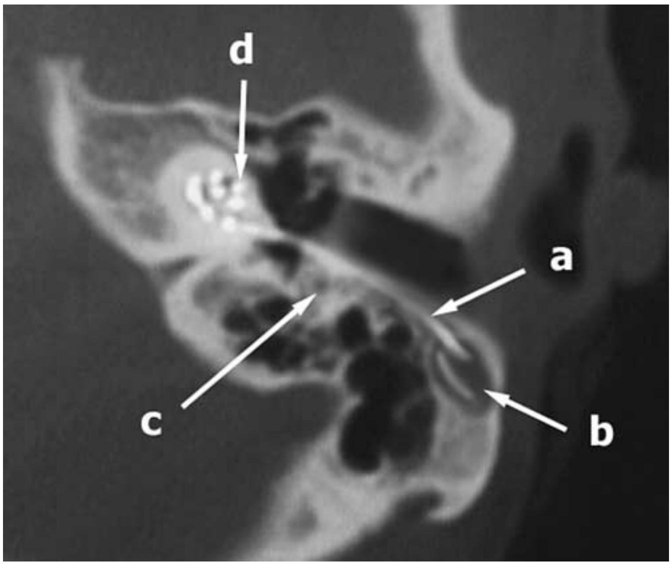

Fig. 10. The postoperative situation on a CT scan image: a the electrode cable runs in the direct tunnel, which is very superficial; b the suprameatal hollow accommodates the excess of the electrode; c the facial canal is far from the tunnel, and d real deep insertion with a Med-El electrode. The first contact approaches the apex. Notice the undisturbed middle ear and mastoid air cell system anatomy and function.

the apex (d). The middle ear, the additus and mastoid aircell system are absolutely unaffected from the surgery and they maintain their normal anatomy and function. Not any resection of healthy bone was necessary. No scar tissue and no foreign body material lies in the mastoid. Normal growth of the temporal and mastoid bone is not affected in small children. The clinical experience and results are discussed in Part II of this issue.

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