



The extended iClIP-Piston in Stapedotomy: Use of the lever arm



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Abstract

Introduction: Since the start of modern stapes surgery in 1958 by Shea an Air Bone Gap (ABG) of 5 to 10 dB is considered an excellent result. No prosthesis could provide an ABG of 0 dB in the majority of patients so far. **Objectives:** We are developing an extended Stapes Prosthesis "iPiston" that reaches beyond the long process of the incus and articulates in a ball-joint connection. The direction of the piston is more posterior-inferior than the usual direction from the long process of the incus directly down to the stapes footplate. **Results:** Clinical experience with iPiston is still limited. We find a closure of ABG of 5 to 0 dB in most cases. This paper will also present the background and the idea behind iPiston. However, due to the additional freedom of movement in rotation depth insertion into the vestibule may be more difficult to judge by the surgeon. **Discussion & Conclusion:** We have not finished the final shape of iPiston. **Keywords:** Stapedotomy, stapes prosthesis, air bone gap, improved hearing, otosclerosis, middle ear surgery, lever arm.

Introduction

Traditionally stapes prostheses have been fixed onto the long process of the incus thus shortening the lever arm when compared to the natural position of the human stapes. The question then arises, whether a prolongation of the lever arm extending over the lenticular process might provide better hearing with less air-bone gap.



Figure 1
CiIP Piston in Classical attachment

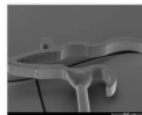


Figure 2
Laser-cut CiIP Piston

Methods and Materials

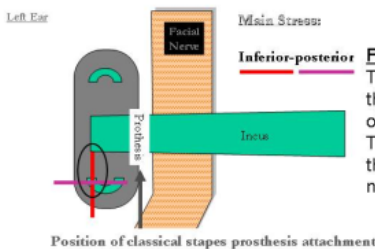
Anatomical basis:



Fig. 4. Superior and inferior crural arches of stapes superstructure.

Figure 3

The human stapes is formed as a hollow double arch: Inferior arch is stronger and the posterior crus is stronger. More force acting on the inferior-posterior quadrant of the stapes.



Position of classical stapes prosthesis attachment

Figure 4

The main stress is located in the inferior-posterior aspect of the stapes superstructure. The classical attachment of the stapes prostheses does not follow this aspect.

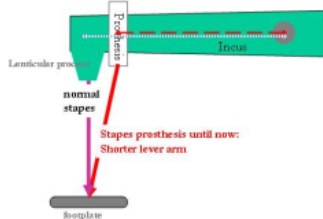


Figure 5

The human stapes is articulated to the lenticular process of the incus. The classical attachment of the stapes prostheses implies a shorter lever arm.

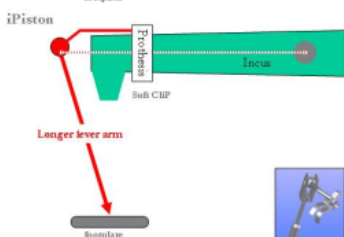


Figure 6

The iPiston extends further than the lenticular process of the incus in order to extend the lever arm.

Figure 7

iPiston: Soft Clip attachment, angulated extension, ball-joint connection to the piston.



Results

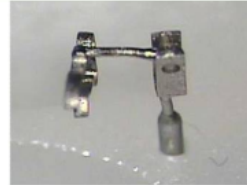


Figure 8
iPiston from anterior.



Figure 9
iPiston from posterior



Figure 10
View through external auditory canal. iPiston in a left temporal bone.



Figure 11
View through posterior tympanotomy. iPiston in a left temporal bone.



Figure 12
Soft Clip Piston in a right ear: Conventional position



Figure 13
iPiston: Extension towards promontory. Increase of lever arm

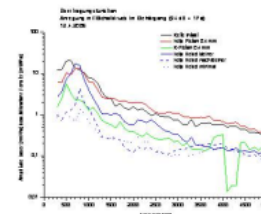


Figure 14

Laser Doppler Measurements:
black = normal chain
green = standard piston placement
red = iPiston

Discussion / Conclusions

Theoretically the extended lever arm of the iPiston Prosthesis will provide higher amplitudes in vibration. Practically this increased movements might lead also to luxation of the piston out of the vestibule. Furthermore the attachment of the Soft Clip on the long process of the incus allows various positions due to the possibility of rotation. This additional variant might lead to further relative movements of the prosthesis at the time of surgery. The exact position of the piston end inside the vestibule might therefore vary. The added freedom of movement due to the ball-joint connection permits various rotational positions for the clip attachment to the incus. Further work will be needed to avoid this variability and to help the surgeon in a precise placement of the iPiston. Clinical experience is too limited to be reported. A possible solution might be a reduction of the posterior angle and extension. Another possibility is a fixed angled prosthesis without a ball-joint. This will restrict these additional movements but will also limit its freedom in placement in the middle ear.

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