Hydraulic Insertion of CI Electrode Arrays Achieving Very Slow, Continuous Insertion Velocities

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Introduction

A crucial element of cochlear implant soft surgery for hearing preservation is the velocity at which the electrode array is inserted. It has been previously described that insertion forces and subsequently intracochlear trauma can be reduced with lower insertion velocities.

However, it is also recognized that there is a human limitation as to how slow an electrode array (EA) can be manually inserted. While several investigations have performed automated EA insertions in laboratory settings, such technologies have not been widely transferred to clinical settings. Therefore, our research group developed a novel insertion tool called Cochlea Hydro Drive (CHD), which is characterized by its simplicity given that it uses a standard syringe as hydraulic actuator to deliver an EA into a cochlea model.

The present investigation sought to evaluate the use of the CHD in achieving EA insertions into a cochlea model with continuous velocities lower than humanly feasible (0.9mm/s).

Methods

A prototype for the CHD, previously designed and built at our Institution, was used to perform insertions of an EA into an artificial scala tympani model. The prototype design can be attached to a surgical retractor (Fig. 2), serve as the EA carrier, and mobilize in response to a standard infusion pump (Fig. 3).

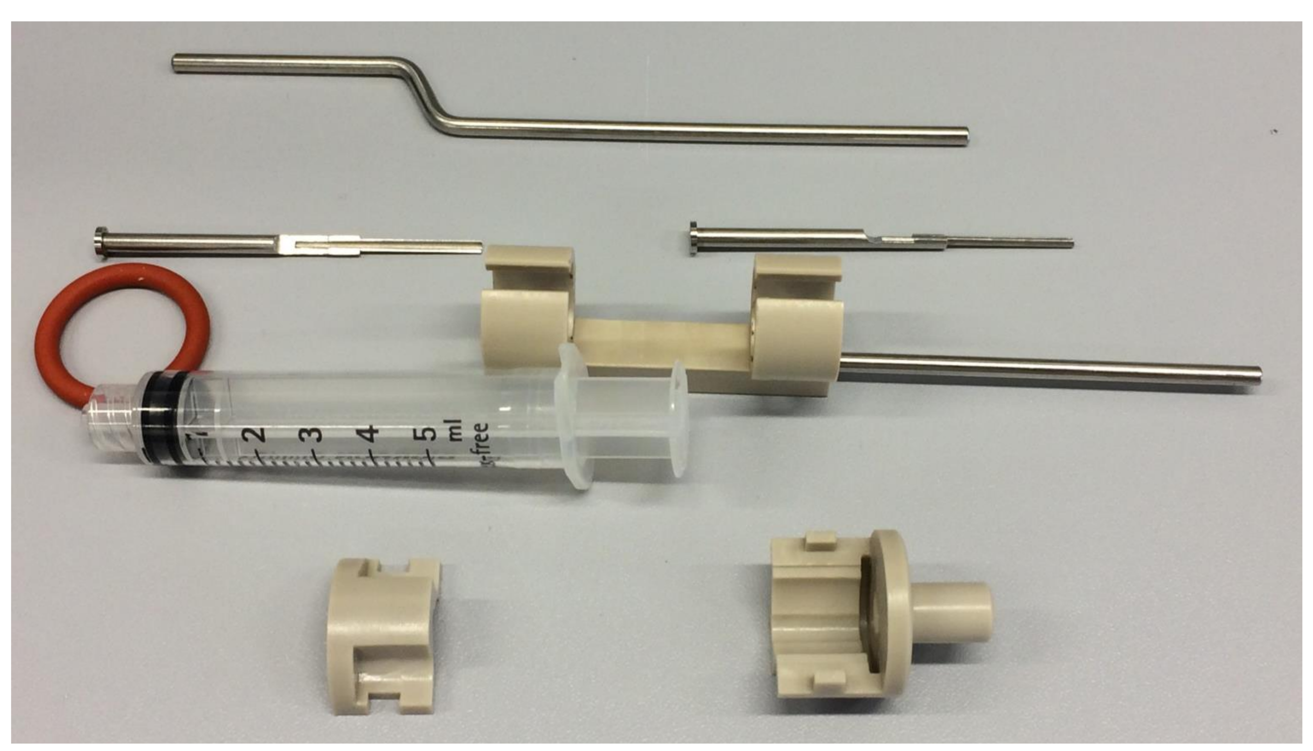

Fig. 1: A prototype for the Cochlea Hydro Drive (CHD).

Methods (cont.)

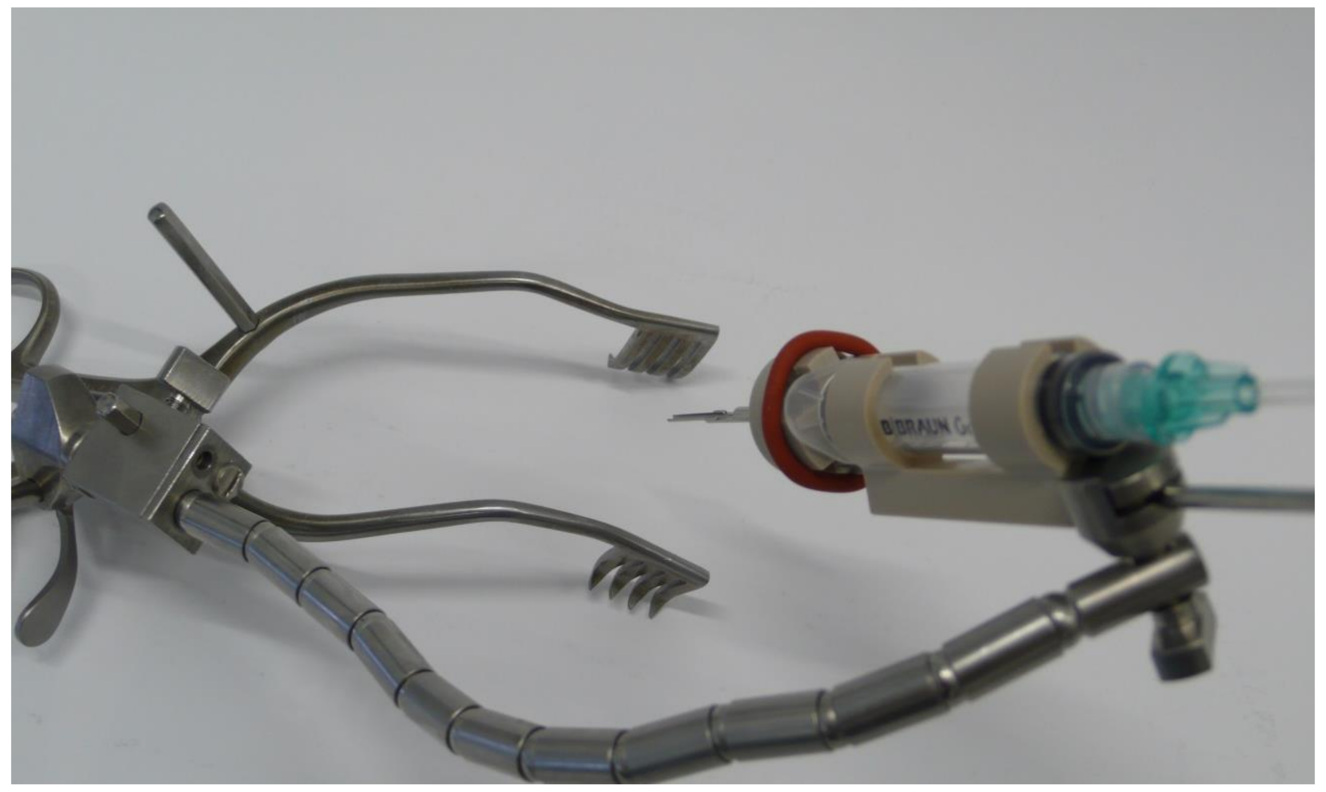

Fig. 2: CHD attached to a surgical retractor with a flexible arm.

The infusion pump was programmed in order to feed the EA at a velocity of 0.4mm/s. A silicon dummy served as the EA to be inserted into an artificial scala tympani model.

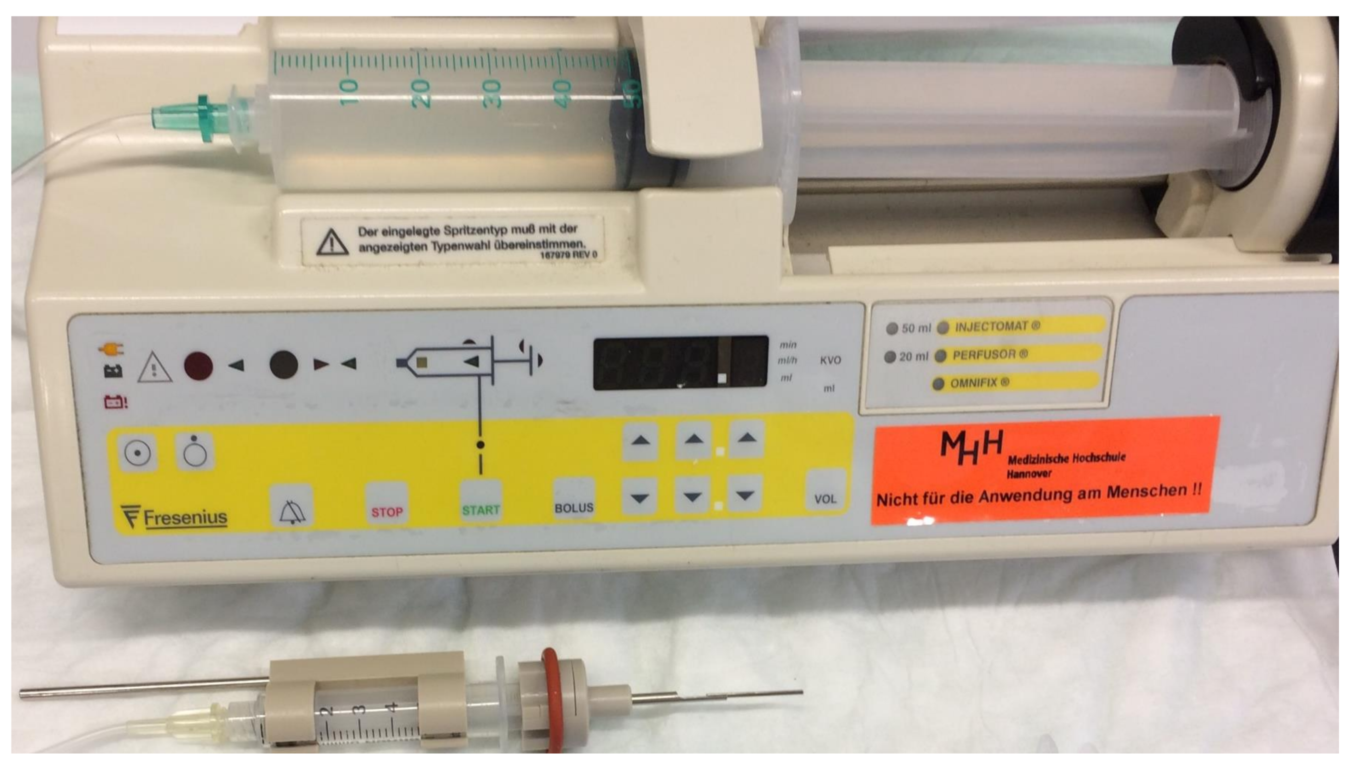

Fig. 3: The tip of the CHD moves thanks to hydraulic actuation – different rates can be programmed using the infusion pump.

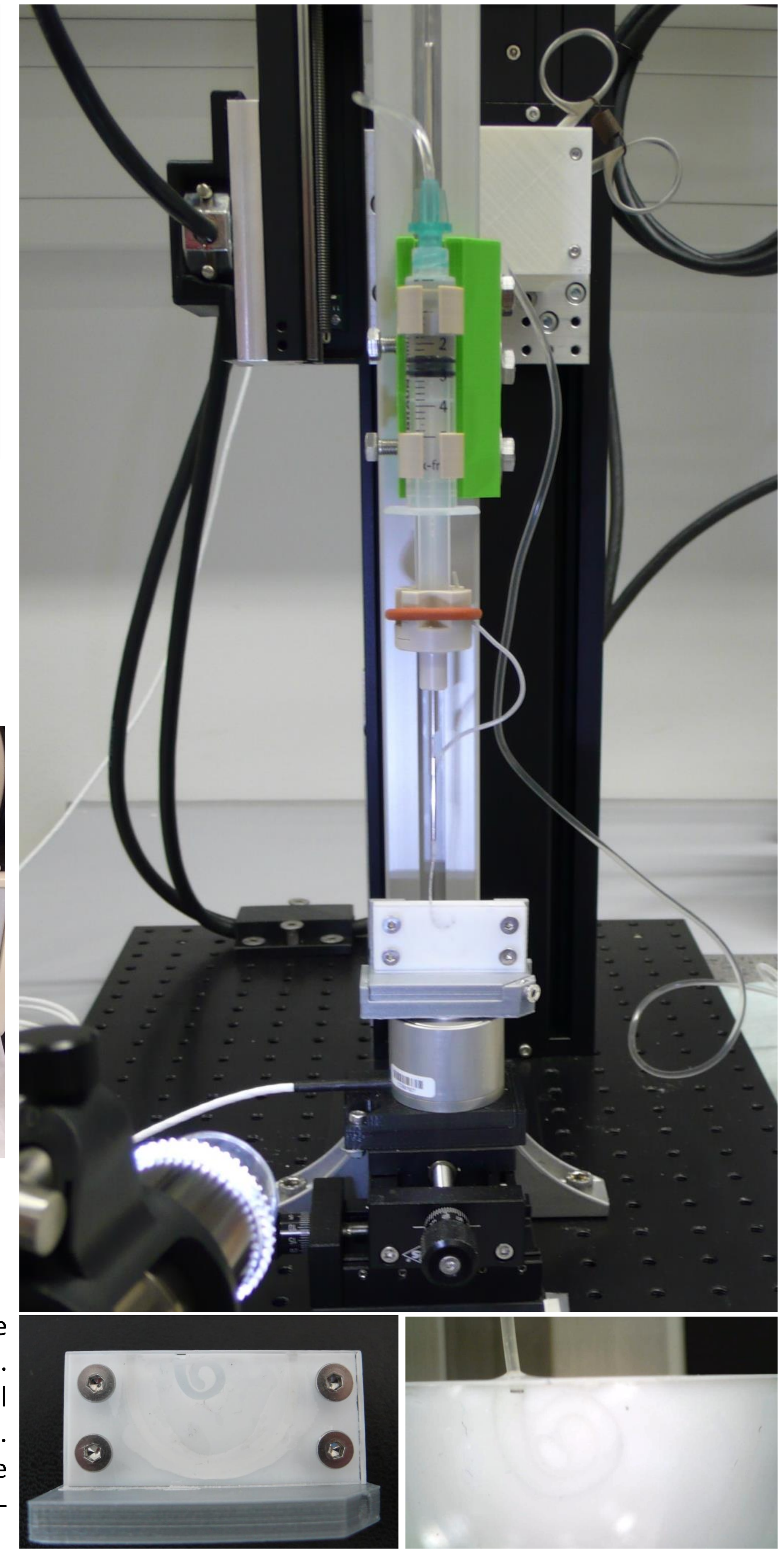

Fig. 4: (A) Test bench for the hydraulic insertions. (B) Close-up of the artificial scala tympani model. (C) EA inserted into the artificial scala tympani model-

Results

Ten insertion trials were successfully completed at the predetermined insertion velocity of 0.4mm/s with the use of the CHD. Five additional testing trials were performed to test if the insertion could be voluntarily aborted and this showed a delay of approximately less than 0.5 seconds (= 0.2mm using 0.4mm/s as insertion velocity) from the moment the infusion was stopped to the moment the EA ceased movement.

Conclusion

The CHD can reliably deliver and insert an EA at velocities lower than humanly feasible and could be a relevant tool to optimize some of the technical aspects of soft surgery in the future, as it eliminates human tremor during insertion and allows for very low, continuous insertion velocities.

In addition, the simple design of the device promises an easy translation into clinical practice.

Further testing of different slow and ultra-slow insertion velocities is needed and ongoing.

Comment: Since the original abstract submission we have published results from this work:

Rau, T.S., Zuniga, M.G., Salcher, R. *et al.* A simple tool to automate the insertion process in cochlear implant surgery. *Int J CARS* **15,** 1931–1939 (2020).https://doi.org/10.1007/s11548-020-02243-7

Please visit: https://link.springer.com/article/10.1007/s11548-020-02243-7

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