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Technical Properties of Cochlear Implants

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Halle Schoen

Proposal

Technical Properties of Cochlear Implants

Goal: Graduate school in Speech-Language Pathology

Stance: Maker

Statement of Purpose

The purpose of this project is to inform patients and speech-language pathologists/audiologists on the technical properties of cochlear implants. I will be researching different sizes and types of cochlear implants, along with multiple manufacturers to better understand how each device works to allow a person to hear, along with how these devices work in the human body. I will be creating a model of a cochlear implant out of modeling clay and other tools to help explain the pieces and parts that make up this device and how they are integrated into a person's auditory system. I will also type a research paper to back up my findings. The steps I need to take include researching background on the makeup of a cochlear implant, along with research on all it takes to power these devices and ultimately allow for an individual to hear. Once I gain knowledge in the parts that form this device, I will then be able to better sculpt my model of the cochlear implant and explain how each part works with different areas of the human auditory system.

Statement of Significance

This project is significant and important because over the last few years, cochlear implants have seen a number of advancements in development for individuals who are profoundly deaf. I am completing this project because I feel it is necessary for both users and speech-language pathologists/audiologists to know the aspects of the technical properties so they can fully understand how cochlear implants work and the mechanics that go into them to allow profoundly deaf individuals to hear. I also feel it is important that users and clinicians both understand what is happening behaviorally in the patient’s body when they have surgery to receive a cochlear implant. For individuals contemplating receiving a cochlear implant or having their children get a cochlear implant, it is important that they know what the device consists of and how it works when pondering the possibility to surgically implant this device into their cochlea.

Zeng (2008) reported that through advancements in this device, there have been a great number of children who were born deaf (prelinguistic), and children who become deaf after birth (post linguistic) who have achieved speech recognition abilities. The biggest area of restriction on young children when it comes to receiving a cochlear implant and having success in achieving normal speech perception, speech production, and expressive and receptive language levels is the amount of information that can be given to the auditory nervous system. There is a small number of electrodes that can be sent into the cochlea with a limited range of stimulation, so research and strategies to overcome this issue are constant. I plan to research this area of study to find out more on how much the human cochlea can take, and how this works to allow an individual to hear.

In order to stimulate the cochlea through this device, adequate amounts of electrical energy are needed to fully achieve loudness. (Clark 2020) states that the top priority in the receiver and stimulator design of a cochlear implant is safety. Because there is electrical stimulation involved in allowing someone to hear with a cochlear implant, it is important to note that overstimulation and unbalanced stimulation delivered to the cochlea can be very harmful. In seeing that these technical findings are crucial in proper development of the cochlear implant, I feel this research is important for speech-language pathologist/audiologists to be familiar with as they encounter patients with these devices.

Literature Review

Technical Properties of Cochlear Implants

This literature review explains some current information on the technical properties of cochlear implants.

In order to understand the technical properties of a cochlear implant, it is important to first be familiar with this device and how it works. ASHA's working group on cochlear implants explained that this is an electronic device containing a current source and an electrode array that are surgically implanted into a person's cochlea. Electrical currents are sent from this device to stimulate auditory nerve fibers of the inner ear. The auditory nerve is known as the hearing nerve. These implants can be used to help treat profound, bilateral, sensorineural hearing loss. There has been a great amount of gains in word recognition among users throughout the years due to technological developments of these implants. A significant amount of research has been conducted to improve the design and technical function of the cochlear implant throughout the years (Working Group on Cochlear Implants, 2003).

Stöver & Lenarz (2009) explain that Cochlear implants are known to be technically sophisticated. Manufacturing a cochlear implant faces mechanical and biological challenges. When it comes to mechanical needs, an electrode array must be flexible and resistant to breakage, but it also must durable enough to withstand external forces. When it comes to biological challenges, bacteria can easily spread to the cochlea because of the placement of the implant in the human auditory system. The implant is placed in the area of middle ear mucous and perilymph of the cochlea. This can be dangerous if bacteria were to spread to the inner ear as there would be a possibility of developing meningitis. Long term stability and function is extremely important in this device. Materials used must be biocompatible to one's body, efficient, and use non-damaging electrical stimulation of the auditory nerve on a sustained basis. The outer casing of the implant must be stable and fluid tight to enclose the electronics. The bent shape is designed to reduce the distance between the electrode and the neuronal cells in the modiolus which leads to focused stimulation. It is important to ensure the cochleostomy is well-sealed to prevent sheath of connective tissue forming around the array. In order to properly work, transfer from the electrode array to the auditory nerve must facilitate a hearing sensation. To do this, many manufacturers use platinum contacts when producing electrodes.

Now that there is a better understanding of what a cochlear implant is and some of the technical requirements needed to make the device work, it is important to understand how exactly this device can stimulate someone’s hearing sensation. Victory (2020) explains that there are two main portions of a cochlear implant: the external and the internal portions. The external portion of this product contains a microphone, speech processor, and transmitter. The internal portion of the device contains the receiver. Each part of this device plays an important role in making hearing possible for the user. The external portion of the cochlear implant sits behind the ear picking up sound with a microphone. The microphone sends sound to the speech processor. These are both enclosed in casing that looks like a hearing aid. A wire connects both the microphone and processor to the transmitter which sits on the outer part of the skull on the temporal bone. This sound is then processed and transmitted to the internal portion of the implant which contains the receiver. There is a thin wire and electrodes connected to this portion that leads to the individual’s cochlea. This wire sends signals to the cochlear nerve which then sends sound information into the brain to create a hearing sensation.

In a study conducted by Shannon, Cruz, & Galvin (2011), it was found that high levels of electrical stimulation are not necessarily needed for better speech recognition and hearing outcomes. There have been many studies throughout the years that have shown decent speech understanding in quiet environments that do not have much background noise. Through lots of technological improvements in these devices, many manufacturers have begun adding electrodes in an attempt to convey more important features of speech. This is an attempt to make higher stimulation rates to better improve speech recognition abilities. It has been found that low/moderate stimulation rates provide enough cues for speech recognition in quieter environments where listening is relatively easy for an individual and higher rate of stimulation are advantageous in conditions that listening can be more difficult. This can be in different environments where there is a lot of noise or different speech conversations going on at once. This study concluded that there are not many advantages when it came to higher rates of stimulation. Higher stimulation rates did not seem to benefit the cochlear implant performance other than times with lots of background noise. For speech recognition, lower stimulation levels are all that is needed to see positive outcomes.

Zeng (2008) states that stimulation safety is the main focus when designing the receiver and stimulator design for a cochlear implant. It is important to note that overstimulation or unbalanced stimulation would be very harmful for an individual receiving an implant. It is nearly impossible to create complete product safety when it comes to implanting this device into a human’s inner ear. Zeng explains that safety of this product can be broken up into four categories including: the materials used and their biocompatibility, sterilization to alleviate infection, mechanical design of the device, and energy exposure limits. There are potential for both short- and long-term issues when it comes to safety problems that are in correlation with these categories, but overall there usually are not many complications that come along with this surgery and the healing process that follows.

Shargorodsky (2020) explains that during surgery, a cut is made behind the ear with a microscope and bone drill to open the mastoid bone. Once the facial nerves are spotted, openings will be created between them to reach the cochlea. The cochlea is now opened, and the implant electrodes are inserted. The receiver is placed and secured in a pocket under the skin behind the ear and that portion is then stitched back up. The pocket keeps the receiver in place and allows for it to stay in close contact to the skin. This makes it possible for electrical information to be sent to throughout this device.

An article from John Hopkins Medicine explains that after surgery, the individual will be stitched up behind the ear. The receiver can be felt behind the ear as there is a small bump under the skin. The outer portion of the cochlear implant will not be placed for one to four weeks after the surgery is completed. This allows time for the portion of the head that has been cut open to heal before the external piece is placed. This surgery is known to be on the safer side as smaller surgical cuts are being made. Some risks that come along with the surgery include difficulty with the wound healing, skin beginning to breakdown over the portion of the device that is implanted under the skin, and infections that may occur near where the device has been implanted into the skin or the inner ear. There are some complications that could occur after surgery that are not as common, yet still a concern for safety. These include temporary vertigo, infection and leakage of the fluid that surrounds the brain, and failure of the device to properly work ("Cochlear Implant Surgery").

Following surgery, most patients are able to go home the day of their procedure. Pain medications and antibiotics are provided to prevent any infections. Once the outer portion of the implant is placed on the back of the ear, the device is ready to be used. The individual will now work with audiologists and speech-language pathologists to process sounds using their new device. Results of a cochlear implant can vary depending on the person. Some individuals are able to completely communicate, but in some cases a person might only be able to recognize sounds. Results will take time and will depend on different things such as what the condition of the individual's auditory nerve was prior to surgery, usage of the device, the amount of time the individual was deaf before receiving the implant, and how the surgery went ("Cochlear Implant Surgery").

Product Description

Technical Properties of Cochlear Implants

This paper provides a description of my work on creating a model of an ear with a cochlear implant. This model shows the main components of the ear and external portion of the cochlear implant. These are involved in the process of implantation and overall hearing sensation for an individual undergoing surgery to receive a cochlear implant. I have labeled these different parts on my model to ensure that viewers have a good understanding of the components involved in this process. I demonstrated the different portions of the ear (outer, middle, and inner), the main parts of the inner ear that are stimulated to create hearing sensation, along with the main pieces of the actual device.

Uploaded to Blackboard are pictures of various angles of my model that show all of the pieces and parts that make up the implant and the ear in general. I highlighted these parts of the ear and implant based on the knowledge I gained from my literature review. This knowledge allowed for me to have a better understanding of how hearing is stimulated and what all goes into allowing this to happen in an individual with profound hearing loss. Victory (2020) explains that the external portion of the implant is made up of the microphone, speech processor, and transmitter. These three pieces are featured on my model as sound is picked up by the microphone and sent to the speech processer. A wire then connects the speech processor to the transmitter for sound to be processed and transmitted into the internal portion of the ear/implant. Here is where the receiver sits right inside of the temporal bone with a wire leading to the individual's cochlea. This wire sends sound information to the cochlear nerve which is then sent to the brain to allow for hearing sensation for an individual with a cochlear implant.

Final Summary and Conclusion

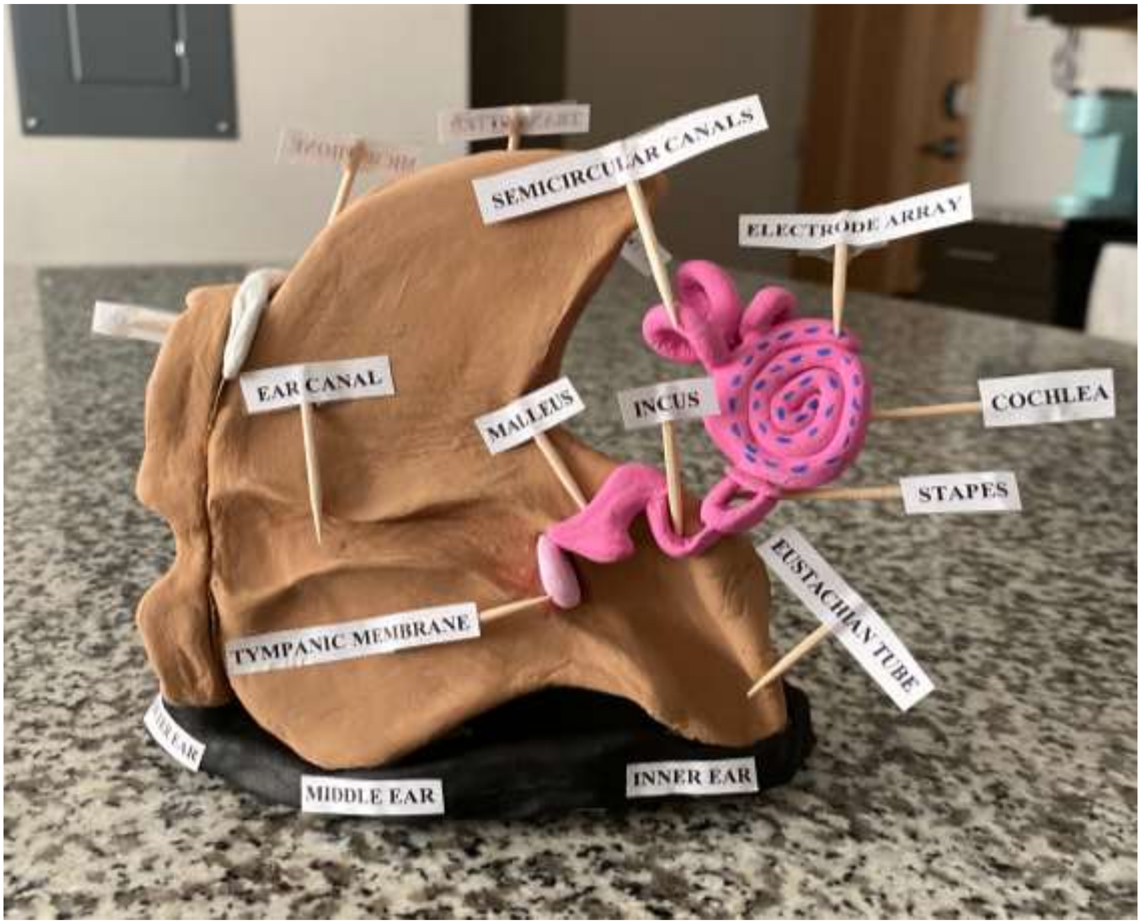
Technical Properties of Cochlear Implants

The purpose of this project was to inform patients and speech-language pathologists/audiologists on the technical properties of cochlear implants. To do this I researched different sizes and types of cochlear implants, along with multiple manufacturers to better understand how each device works to allow an individual to hear. This research was also helpful in giving me a better understanding of how a cochlear implant works in the human body, and all of the pieces and parts that make up this device. I created a cochlear implant model that showed the outer, middle, and inner ear systems to represent all the different areas of the auditory system that play a role in allowing for hearing to be stimulated in an individual with an implant. The main components of the implant were also identified on this model to overall show how the device picks up sound and transfers it to the human brain.

From my literature reading, I gained an abundance of knowledge on how a cochlear implant works, the technical properties that allow for hearing to be stimulated, safety of the implant, the procedure, and post procedure recovery. The article by Victory (2020) explains that there are two main parts of a cochlear implant: the external and internal portions. The external portion contains a microphone, speech processor, and transmitter. I constructed my cochlear implant model to identify all of these components. Sound is picked up by the microphone and sent to the processor. A wire connects the processor to the transmitter where sound is processed and transmitted to the internal portion of the implant. There is a thin wire and electrodes connected to the internal receiver that leads to the individual’s cochlea to stimulate a hearing sensation. I learned in an article from Zeng (2008) that stimulation safety is the main focus when designing the receiver and stimulator design for the implant as overstimulation or unbalanced stimulation is very harmful for an individual. Zeng also points out that there are usually very few complications that come along with the surgery and healing process to follow. Shargorodsky (2020) explains that there is a cut made behind the ear to open the mastoid bone. The cochlea is opened, and implant electrodes are inserted. The receiver is placed and secured in a pocket under the skin right behind the ear to allow for it to stay in close contact with the skin. This makes it possible for electrical stimulation to be sent throughout the device. The external portion of the implant is placed on one to four weeks after surgery to allow time for this portion of the head to heal.

The knowledge that I generated will overall help me in my future career as a speech-language pathologist to better understand how an individual with a cochlear implant is hearing and how this may affect their speech in various ways throughout their everyday lives. This also gives me a better understanding of how to set goals for these individuals to reach their full potential in speech. Having a better understanding of the technical properties of a cochlear implant will help me to better assist these individuals in their speech and language therapy to overall give them better outcomes.

In conclusion, my research conducted on the technical properties of cochlear implants was very effective and useful for my future. I gained a great amount of knowledge on how these devices work to stimulate hearing sensation for individuals who have profound hearing loss. This also allowed me to learn about the different components that make up these devices and the safety behind them, as well as how the procedure is conducted and how an individual heals post-surgery. The model I created helped to give a better understanding of the components of an implant and portions of the ear that are involved in making it possible for hearing to be stimulated. This project was significant and important as throughout the years, cochlear implants have seen a number of advancements in development. It is necessary for both users and speech users and speech-language pathologists/audiologists to know the aspects of the technical properties to fully understand how cochlear implants work and the mechanics that go into them to allow profoundly deaf individuals to hear. It is also important for clinicians to understand what is happening behaviorally in a patient's body when they have surgery to receive the cochlear implant. I feel that overall this project helped me to gain this knowledge and would help users and clinicians to have a better understanding of the properties of this device.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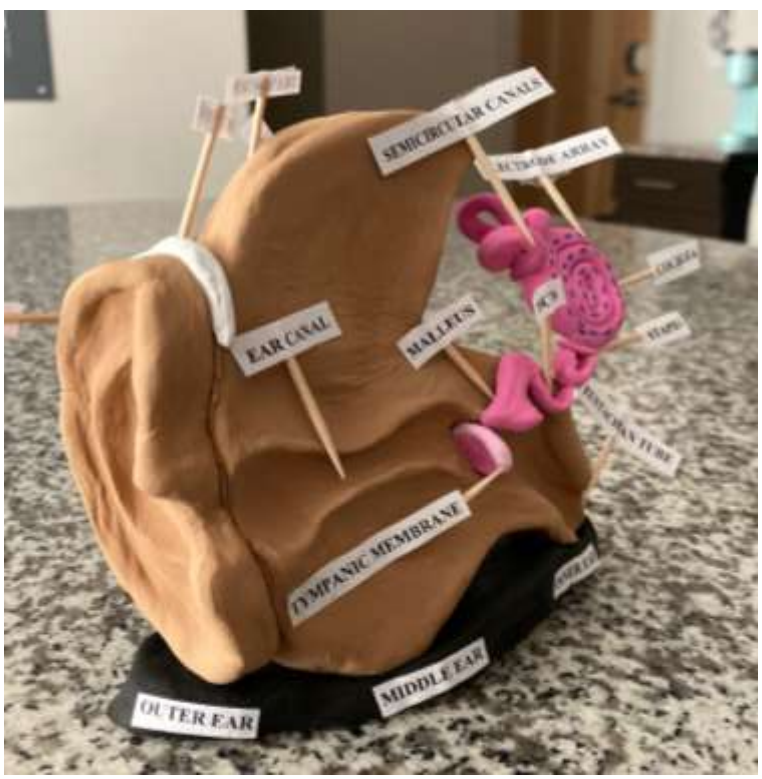
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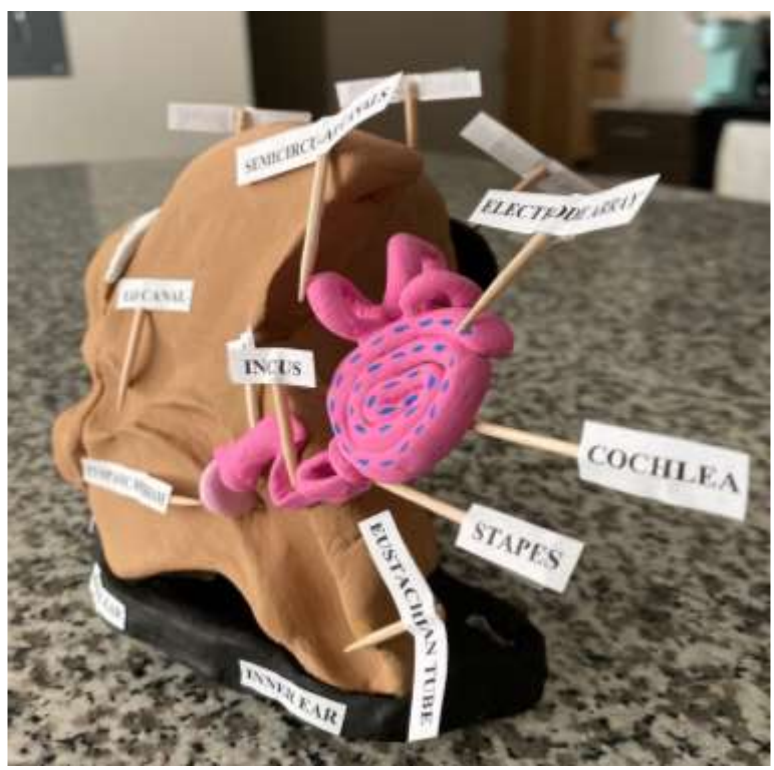
INCUS
COCHLEA
STAPES
EUSTACHIAN TUBE
INNER EAR


TRANSMITTER
EXTERNAL MAGNET
MICROPHONE
PROCESSOR

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