

Prosthetics

Yesterday, Today and Tomorrow

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November 2025

What are Prosthetics?

- Prosthetics
 - Replace missing parts of body such as limbs, digits or other body parts
- Orthotics
 - Support and enhance the functioning of existing body parts

Historical Prosthetics - Limbs

- Earliest known is an artificial big toe on an Egyptian mummy c.950 – 710 BC
- Simple arm, hand, leg or foot replacements were not uncommon for those that could afford them in the middle ages.
- Generally made from iron, steel, copper, wood and leather but were basically visual and had little functionality
- More functional prosthetics started to appear from 1500s onwards incorporating articulated knee and foot joints
- Lightweight materials e.g. aluminium alloy used in early 20th century

19th & 20th Century Prosthetics - Limbs

- American Civil War, Crimean War & WW1 resulted in a great number of limb loss injuries consequently leading to development of more advanced prosthetics.
- Articulation of knee, ankle and foot.
- Contoured suction socket

Current Prosthetics - Limbs & Digits



Current Prosthetics - Limbs & Digits

- Modern materials have transformed comfort, functionality and appearance of limb prosthetics
- Passive and Body powered devices utilise body movements to activate limb movement
- Myoelectric devices controlled by electrical signals from muscle contraction use battery powered motors to activate grip & movement
- Hybrid prosthetics combine body-powered and myoelectric features
- Neural interfaces directly with the nervous system

Myoelectric Devices

- <https://1drv.ms/u/c/1b0dd44420f8ed97/IQAxgHxquJMFTJiCbyK7dQ4oAdg3igVff07LmWBPu4KnrS0?e=ZmJDVvk>
- <https://1drv.ms/u/c/1b0dd44420f8ed97/IQDhle52eInWTq2GDRd9xDXYAaAlMwEAj3fMy1WrFVJKu7U?e=dZFbnB>

Future Prosthetics - Limbs & Digits

- Development of neural interface technology providing intuitive operation and sensory feedback
- Development of artificial nerve systems
- Continued development of advanced materials
- Use of AI to enable prosthetic devices to 'learn' use patterns and preferences
- Tissue engineering and nerve regeneration to complement prosthetic solutions with biological restoration

Vision - Historical Prosthetics & Orthotics

- Earliest prosthetic 2900-2800BC in Persia gold covered bitumen
- In socket gold or glass 16th – 18th century in Venice
- 19th & early 20th century in Germany
- During & after 2WW polymethyl methacrylate & other plastics
- Only cosmetic

Current Prosthetics - Vision

- Whole eye prosthetics currently still only cosmetic
- Developments in polymer chemistry provide integrated (porous) implants with musculature and vascular attachment to the body tissue enabling controlled eye movement

Prosthetic Eye Parts

- Intraocular lens replacement (cataract surgery) now routine
- Cornea replacement in the main are currently achieved by transplant of donor organs
- Prosthetic cornea are available and are evolving but are expensive, typically \$35,000 in US
- Retina replacement much more challenging
- Transplant procedures not successful
- Artificial retinal devices currently being trialled and shown to be possible but degree of sight restoration very rudimentary

Future Prosthetics - Vision

- Most current advances are in surgical, transplant and genetic procedures for cornea and retina replacement
- Artificial retinas are in the future but developments are promising
- Principal problems appear to be linking device to optic nerve and rejection

Historical Prosthetics - Dental & Jaw

- Earliest known dentures are Etruscan 700BC using human or animal teeth
- Wooden dentures made in Japan early 16th century
- First porcelain dentures approx. 1770

Current Prosthetics - Dental & Jaw

- Dentures (Removable)
 - The most common prosthetic in use world wide
 - Heat cured acrylic polymer devices
- Fixed Tooth replacements e.g. Crowns, Bridges and Implants
 - Readily provided in dental surgeries
 - Reasonably affordable
- Oral & Maxillofacial Surgery
 - Replacement of bone structures with advanced materials e.g. titanium

Future Prosthetics - Dental & Jaw

- 3D CT scans and MRI scans provide highly accurate 3D pictures of inside a patients head & neck.
- Allows precise planning of operation, preparation of prosthetic devices and provide 'head-up displays' during operations
- Use of robotic and remote surgical procedures

Historical Prosthetics – Hearing Ear Trumpets



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Could be awkward to use at social gatherings



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Hearing Aids - Electronic

- Receive sound and transmit amplified sound to ear channel
- First devices early 1950s
- Not particularly discrete or comfortable to wear
- Limited range of correction of hearing loss – broad spectrum amplification

Current Orthotics & Prosthetics - Hearing

- Wearable Orthotic devices
 - Discrete and comfortable
 - Robust
 - Tailored to individual aural requirements
- Implanted Prosthetic Devices
 - Cochlear Implants (CI) and Auditory Brainstem Implants (ABI)
 - Provide hearing for cases of profound deafness
 - Bypasses damaged inner ear structure
 - First CI device trialled in late 1960s

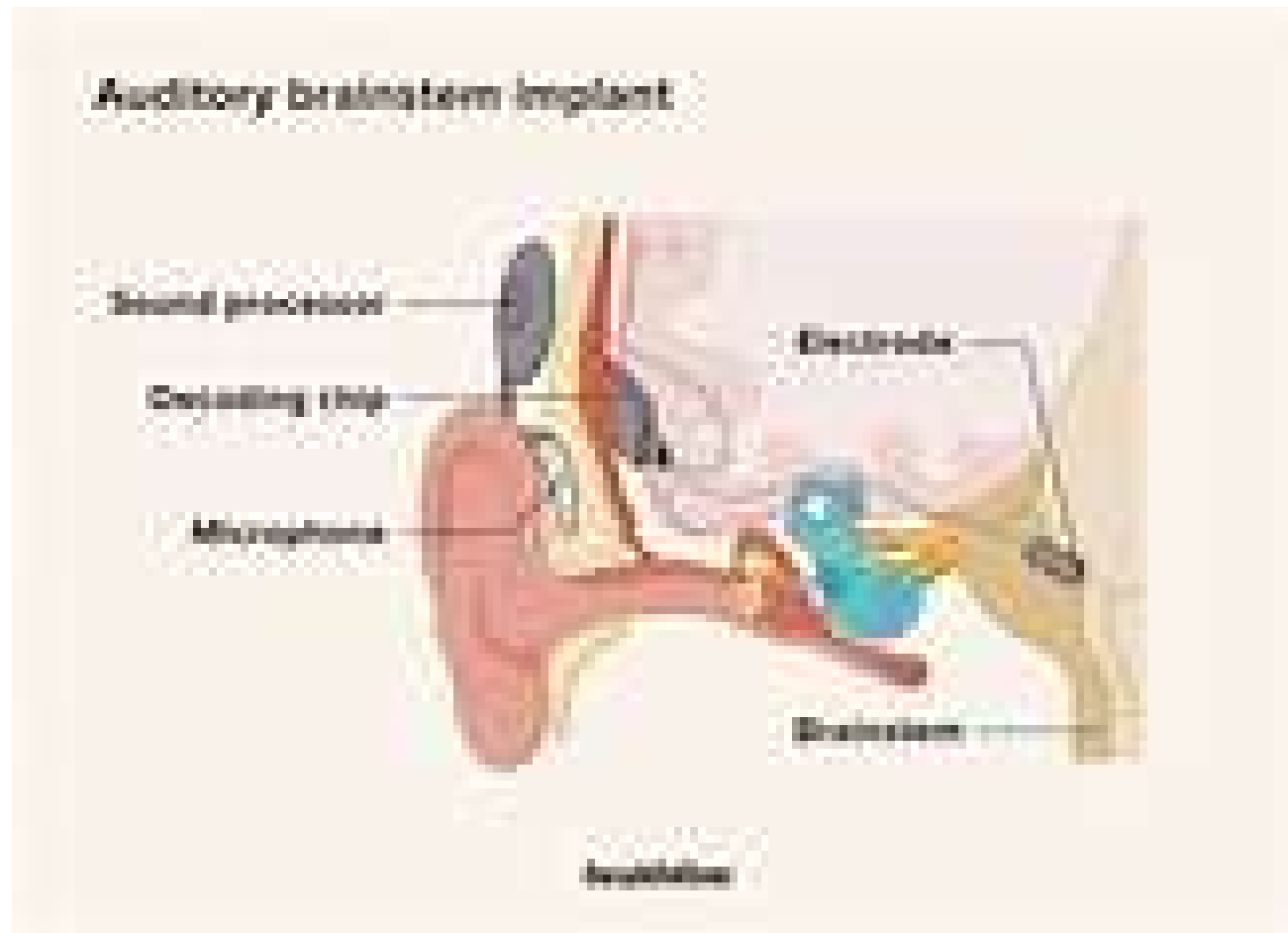
Hearing Prosthetics

- [Cochlear implants](#) are for individuals with hearing loss where the cochlear nerve is still functional. These devices bypass damaged parts of the inner ear and directly stimulate the cochlear nerve to provide auditory signals to the brain.
- [Auditory brainstem implants](#) are used for patients who cannot benefit from cochlear implants due to the absence or damage of the cochlear nerve. ABIs bypass the cochlear nerve entirely and directly stimulate the brainstem to create auditory sensations.

Cochlear implants



Auditory brainstem implants



Future Prosthetics - Hearing

- Incorporation of AI technology into hearing aids to improve personalisation of devices to match hearing loss profiles
- Improvements in CI and ABI devices and surgical 'installation' techniques to provide broad band hearing restoration