will stretch along its length so that the 'wearer' can maintain a full range of movement, but will not stretch circumferentially therefore preventing the blood pooling in one place. Other polymeric implants include artificial ligaments and tendons, lenses to replace those lost through cataracts and silicone based finger joint replacements.

Temporary Implants

If a bone is broken materials are often implanted into the body to hold the ends of the fracture together. These bone plates and the screws used to fasten them to the bone are generally made from stainless steel titanium and they are often removed once the bone has knitted together. In recent years shape memory alloy technology has been employed in bone plates to produce implants which actually pull the two ends of the broken bone together. The plate is attached to the bone in its deformed state and then pouring warm brine over the site invokes the memory of the metal and the plate contracts thus pulling the ends together. Although bone plates allow breaks to be set and held in place their use can mean two uncomfortable surgical procedures for the patient so alternative methods have been sought. Ceramic or polymer foams with a large surface area can be placed between damaged bones where there has been a loss of tissue and new bone is encouraged to grow into the foam. These foams can be designed to dissolve in the body over a period of time.

Whenever surgery is involved there is an open wound to close and there are three methods of doing this. Firstly tape can be used to close small wounds provided the skin is clean and free from grease and hair. This is the most hygienic method as it does not puncture the skin. Secondly staples made from surgical steel which can easily be sterilised can be used. Finally the wound can be stitched together. Stitches were originally made from silk or cotton thread but the multi-fibre nature of these materials was a breeding ground for infection and nowadays single fibre nylon or polypropylene thread is used. In cases where internal stitches are needed (for example after major surgery) dissolvable materials are used. A copolymer (or mixture) of glycolic and lactic acid is used which dissolves slowly over a period of three months. This is completely safe as lactic acid is naturally occurring in the body and one of the by-products produced by glycolic acid breaking down is a strong antibacterial agent.

Tissue Engineering

Tissue engineering is a relatively new field which uses man-made materials to support the growth of new human tissues. Skin is a prime example of tissue engineering. A biocompatible scaffold is woven from a polymeric material such as poly-l-lactic acid, and impregnated with antibacterial agents and nutrients. A culture of human skin cells is introduced and these grow on the scaffold over a period of around a month to form a new sheet of skin which can then be grafted on to the patient from whom the original cells were taken (i.e. patient specific skin can be grown to order outside the body). A great deal of research is going on in this area looking at whether new organ, muscle, nerve and bone tissue can be engineered in a similar way. It is considerably more difficult to construct the scaffold necessary to build these types of tissues as they are generally very complex three dimensional shapes.

For more information

www.hipreplacement.co.uk
www.medicalmultimediagroup.com/pated/joints/hip/hip_replacement.html
www.medicalmultimediagroup.com/pated/joints/knee/knee_replacement.html
Dental Dilemmas A GNVQ resource, CIEC, University of York

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Materials in Medicine

Materials in dentistry

Materials for imlpants

Tissue Engineering

Materials in Medicine

Materials have been used in medicine for many centuries as people tried to help broken bones mend, fasten loose teeth together or stitch open wounds. Any material which interfaces with living tissue can be described as a biomaterial. An early example is a wooden splint bound to the leg to support a broken bone. A pair of spectacles has two biomaterials, the nose piece and the ear rests. During the latter part of the twentieth century biomaterials have found much wider use internally with the development of joint replacements, heart valves and artificial arteries to name just a few examples. Materials have also been used in dentistry for many centuries.

No matter what the application, a biomaterial must fulfil three criteria:

- Biocompatibility. It is important that any material that is put in to the body does not corrode; if it does it must not produce toxic substances. Even so the tissues surrounding the implant will not recognise a piece of metal, polymer or ceramic as part of the body and one common problem is implants working loose due to bone loss in the surrounding area. Out of the thousands of metal alloys available very few can safely be used in the body. Those that can are stainless steel, alloys based on the cobalt chromium system, selected titanium alloys and the shape memory alloy of nickel and aluminium.

- Mechanical properties. It is important that the materials used have sufficient strength and toughness to perform the required task. They must also have good fatigue resistance as the implants will undergo many thousands of cycles in their lifetime. Materials which exhibit suitable properties outside the body may suffer a loss in their properties inside the body due to the aggressive working environment. Testing of biomaterials is often carried out in SBF (simulated body fluid) to establish how they will behave in-service.

- Tribological properties. It is important that the materials used have good wear resistance. Often surfaces of different materials are placed in contact and it is essential that this contact does not result in wear debris. Any small pieces of material produced can be transported around the body leading to inflammation and pain. Extensive testing is carried out prior to implantation to ensure that this situation does not arise. Care must also be taken by the surgeons to ensure that implants are not scratched or otherwise damaged during the operation.

It is relatively difficult to find materials which will fulfil these criteria in dentistry as the mouth is an aggressive environment in which the conditions of temperature and pH are constantly changing. A wide variety of materials are used in medicine from complex metal alloys to common polymers and ceramics which are actually produced in the body. Although these will all perform the function they were designed for they will never develop a full synergy with the body. The next step in biomaterial development is tissue engineering where an individual's own cells are used to create or grow a prosthesis which can then be transplanted.

Materials in Dentistry

One of the earliest recorded uses of materials used in restorative dentistry was found in a tomb at Gizeh, dated around 2500 BC, where teeth were found bound together with gold wire. Gold was probably used as it is soft and could easily be formed into wires. It has the additional benefit of being inert and indeed it is still used today for dental crowns. Ceramic materials such as porcelain and ivory were later added to the dental materials repertoire for the manufacture of dentures. However, although teeth with acceptable appearance could be made they lacked functionality (they had to be removed in order to eat) and ivory was unhygienic. The invention of the metal spring during the industrial revolution allowed the upper and lower false dentures to be connected and held in place within the mouth.

The first fillings were made from lint and lead which were packed in to the cavities in the teeth. This method dates back to the times of Celsus in AD 30 and few advances were made after this until the early 1800s when the first silver amalgam fillings were used. The first balanced dental amalgam was developed in 1890 by Dr G V Black and it was made from powdered tin and silver (with small additions of copper and zinc), mixed with mercury. Over the years the silver was replaced with copper. In recent years polymeric fillings, based on polymethyl methacrylate, have been introduced which can be colour-matched to the teeth. When choosing a material to use for a dental filling is it important to match the thermal expansion of the filling and tooth. If the tooth expands more than the filling, the filling will fall out and if the filling expands more than the tooth, the tooth may crack. This is also an important consideration for replacement teeth in the form of crowns, bridges or dentures.

The latest advances in dentistry have seen the use of strong magnets to hold dentures in place and implanting false teeth into the jaw bone.

Materials in the Body

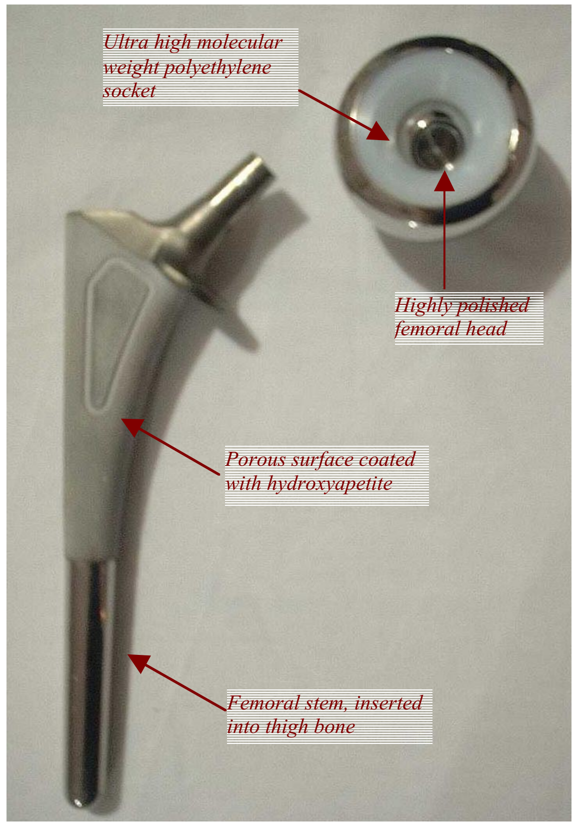
The materials used in the body can be classified in to the two groups as outlined below:

- Permanent implants, such as replacement joints, blood vessels and pacemakers.
- Temporary implants for restorative work, such as bone plates, screws and stitches.

In both cases metals, polymers and ceramics are used, but different properties are required depending on the application.

Permanent implants

As people are living longer the medical world has had to work with other disciplines to develop replacement body parts for those which wear out. A prime example is the hip replacement which was first developed in the UK by Dr John Charnley in 1958.



Degenerative diseases such as osteoartheritis cause the protective cartilage on the inner faces of the ball and socket joint to wear away leading to inflammation and pain. The only way to completely overcome this is by performing a total hip replacement operation. The implant comes in two parts, firstly the acetabular cup or socket section, which is fitted in to the pelvis, and secondly the femoral head and stem, which are fitted into the femur or thigh bone. The components can either be glued in to place using an epoxy-type adhesive or bone cement, or they can have a porous surface covered in hydroxyapatite (a ceramic substance found naturally in bones) which promotes the growth of new bone in to the replacement prosthesis and helps prevent loosening. In order to have a smooth running bearing between the ball and socket surfaces the ball is made from highly polished metal or smooth ceramic and the socket is made from ultra high molecular weight polyethylene (a higher density form of the polythene used for carrier bags). The plastic liner mimics the role of natural cartilage allowing smooth movements to be performed. Knee replacements such as the one on the front of these notes are also made from metal with a polymer 'cartilage' insert.

Not all body part replacements are made from metals. If a vein or artery has collapsed or become blocked it is possible to remove the problem section and replace it with an artificial artery made from knitted polyester. The replacement is designed so that it