IMPLANT FAILURE

Thesis
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In
Orthopaedic Surgery

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بسم الله الرحمن الرحيم

To My Father

Prof. Dr. Abdel-Alim Metwally

ACKNOWLEDGEMENT

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Yaser Abdel Alim

INTRODUCTION

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Prior to the 20th Century, sporadic attempts were made at internal fixation of fractures, but because of poor understanding of metallurgy and poor aseptic techniques, uniform success was not achieved.

The great wars of the last century have provided much of the impetus for improvement in the care of trauma.

In 1870, during the Franco-Purssian war, Louiz Ollier introduced a technique of complete immobilization of a limb in a plaster of paris cast. While Robert Jones of England re-introduced the use of the splint, devised by ***Thomas.***

In ***1924, Zierold*** published a study on the reactions of tissues, including, skulls, tibiae and ribs of dogs to a variety of metals. Iron and steel, the most widely employed materials at that time, were noted to dissolve rapidly and to provoke erosion of adjacent bone. No deleterious tissue reaction was observed around gold, silver, lead and pure aluminium, but these materials were too soft and weak for fixation. Stellites, a cobalt-based alloy was observed to have satisfactory results.

In 1926, 18% chromium - 8% nickel (18 - 8) stainless stell was introduced into surgical applications.

In 1929, another cobalt-based alloy, vitallium, was developed and shortly thereafter was introduced as a dental alloys. In 1936, Venable and Stuck initiated an extensive search for more inert implant alloys. Those workers observed that vitallium was completely inert in the body and provoked minimal destruction of bone around implanted specimens. At about the same time Burch, Carney and others observed a similar mertness of tantalum in vivo. In view of limitations in techniques of purification and manufacture, tantalum showed poor mechanical attributes which rendered the material unacceptable for orthopaedic surgery.

In 1947, the United States Committee on the treatment of fractures of the American Colleague of Surgeons had recommended the following materials; vitallium a 19% chromium - 9% nickel stainless steel, the 18% chromium - 8% nickel - 2 - 4% molybdenum stainless steel, or pure tantalum; for bone plate and screws.

In the region of the neck of femur were the most widely complex problem, in 1931, Smith - Peterson devised a nail with three radial flanges which possessed good rigidity in bending and a satisfactory resistance to rotational forces. Johnnsen modified the "trifin" nail with a central hole for a small guide wire.

In ***1937, Thornton*** and ***McLaughlin*** attached a plate to the distal end of the Smith - Petersen nail and secured the plate to the shaft of the femur by the use of screws.

In 1940, Küntscher, in Germany, presented a major advancement in internal fixation with the U-shaped medullary nail. During the next year, he modified his device to elaborate the rigid medullary nail with a clover - leaf cross section for use in the femur. In 1950, Herzog modified the nail with an anterior curve to introduce the era of rigid medullary nailing for fractures of the tibia. The concept of reaming in the intramedullary cavity was provided by ***Moatz in 1942***, who sought a perfect fit between the metal and the bone.

Few workers as Daniz, the Belgium orthopaedic surgeon, observed that the healing process is influenced by the rigid fixation and axial compression.

The recognition of these district mechanisms of fracture healing gave internal fixation a scientific background and stimulated further research in the 1960's.

On the other hand, treatment of joint stiffness or ankylosis had aroused the curiosity of surgeon for centuries. In 1913, William Baer outlined methods for treatment for ankylosis as: manipulation, injection of fluid into the joint or surgical creation of Pseudoarthrosis.

In ***1930, McMurray and Whitman*** revived interest in reconstructive joint procedure with their osteotomies of the proximal femur. They applied a hip spica for immobilization. In ***1943, Blount and in 1944 Moore*** described a blade plate for the fixation.

The crucial studies on the potential for arthroplasty of joints were made by Smith - Pterson of Boston. He undertook carefully documented experimental studies in which a solid material or "mould" was positioned between the head of femur and the acetabulum and about 30 - 40% of the patients have a mobile pain-free reconstructed joint.

Perhaps the first serious and systemic attempt to design a prosthetic femoral head was initiated by the ***Judet brothers in 1946,*** then Scales and ***Zarek*** have reported the biomechanical analysis of the hip joint but Judet underestimated the mechanical forces to which the hip joint is exposed. It stimulated enormous efforts towards the improvement of arthroplasty and in elucidation of the biomechanics of hip joint as well as the careful laboratory assessment of mechanical, chemical and mechanochemical properties of implantable materials.

In *1950's Charnley* in England, initiated his attempt to develop a successful arthroplasty of the hip. The two principale problems were (i) the method of anchoring the implantable devices to bone and (ii) the suitable materials for the articulating surfaces. His experiments showed that a mixture of polymethacrylate monomer and preploymerized polymethylmethacrylate will form a "cement" when inserted in the medullary cavity and fully occupying the space between the stem of prosthesis and bone.

Charnley had disastrous results when he attempt to articulate astriculate stainless steel with "teflon" as it produced a toxic wear particles, then he discovered a highly satisfactory polymer, high density polyethylene, which showed excellent wear resistance.

Most recently workers have attempted to replace the plastic articular component with ceramic. While others attempted to develop surgical implants that incorporate the unique attribute of living tissues with implantable materials. The ingrowth of bone into the porous implant provides a method of skeletal attachment in which at least part

IMPLANT MATERIAL

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A wide variety of metals and non-metals have been used in manufacture of Implant materials in orthopaedic surgery. The metallic materials includes alloys of wholly metallic components or containing minor amounts of nonmetallic such as carbon, sulfur or oxygen.

The non-metallic materials include a wide and varied aways of substances such as the crystalline ceramics and the polymeric materials.

METALLIC MATERIALS:

Despite the great number of metals and alloys known to man, remarkably few warrent even preliminary consideration for use as implantable materials. The highly corrosive environment combined with the poor tolerance of the body to even minute concentrations of most metalic dissolution products eliminates from discussion all except certain materials based on iron, cobalt, nickel, titamium, tantalium, ziroconium, silver, gold, and noble materials. Of this group, tantalium and the noble metals do not have suitable mechanical properties for the constriction of most orthopaedic tools and implants. While zirconium is in general too expensive *(Mears, 1979).*

All of the implantable metallic materials are used as alloys, either wholly of metallic components or containing some minor amounts of non-metallic elements as carbon, sulfur or oxygen. The precise composition of an alloy has a profound effect on its phase structure and hence on its properties.

This study will be concerned with metals commonly used in the field of orthopaedic surgery.

Steel:

The most common example of interstitial alloying in the case of carbon in iron, where the solubility limit of carbon is less than 0.02% at ambient temperature. Beyond this limit the stable phase is cementite, i.e. iron carbide which contains 6.7% carbon. This is the basic alloy system of the steels ***(Cottrell, 1968).*** The only ferrous alloys which are of practical importance in orthopaedic surgery are the stainless steel. The effects of each of the principle alloying elements combined in the steel are to be discussed in a little detail.

Carbon:

The addition of carbon to iron lowers the melting point, raises the