EVOLUTION OF BEARING SURFACES IN TOTAL HIP ARTHROPLASTY

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بسم الله الرحمن الرحيم

قالوا سبحانك لا علم لنا الا ما علمتنا انك انت العليم الحكيم

صدق الله العظيم

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ASR…… Articular Surface Replacement
AP…….. Antero-Posterior
ASTM…. American Society for Testing and Materials
AVN…… Avascular Necrosis
BHR…… Birmingham Hip Resurfacing
CMM….. Computerized coordinate Measuring Machines
Co…… Cobalt
COC…… Ceramic-on-Ceramic
COM…… Ceramic-on-Metal
COP…….. Ceramic-on-Polyethylene
Cr……. Chromium
DHS …….Dynamic Hip Screw
DNA…… Deoxyribonucleic Acid
EHL……. Elastohydrodynamic Lubrication
GFAAS… Graphite Furnance Atomic Absorption Spectrometry
HA…… Hydroxyapatite
HB…… Haemoglobin
HHS……. Harris Hip Score
IL…….. Interleukin
LLD…….. Limb Length Discrepancy
Mo…… Molybdenum
MOM…… Metal-on-Metal
Ni……. Nickel
OA…… Osteoarthritis
ORIF…… Open Reduction and Internal Fixation
PE……. Polyethylene
PG ……..Prostaglandin
PIF-ROM.. Prosthetic Impingement-Free Range Of Motion
PMMA….. Polymethylmethacrylate
PSIS…….. Posterior Superior Iliac Spine
PTFE…… Polytetrafluoroethylene

RMS……. Root Mean Square
ROM……. Range Of Motion
SEM…….. Scanning Electron Microscope
SF…….. Short Form
SSA…… Stem Shaft Angle
Std. dev... Standard deviation
THA…… Total Hip Arthroplasty
THARIES..... Total Hip Articular Replacement using Internal Eccentric Shells
TNF…… Tissue Necrosis Factor
THR…… Total Hip Replacement
UCLA …..University of California, Los Angeles
UHMWPE…… Ultra High Molecular Weight Polyethylene
VHD…… Vertical Head Displacement
WBAT…. Weight Bearing As Tolerated
XL-head… X large head

Introduction

Osteoarthritis of hip joint is a clinical syndrome of joint pain and stiffness. Its prevalence rises with age and its impact is determined by the extent of the disability and severity of pain it causes.[(1)] Various surgical procedures have been directed toward the relief of pain and restoration of movement of the afflicted hip joint.[(2)]

Initial surgical attempts to treat arthritic hip included arthrodesis, osteotomy, nerve division to relieve pain and joint debridement to smoothen the surface of the joint.[(3)]

First trials aimed at replacing the damaged surfaces were called 'interpositional arthroplasty' which included the use of muscles '1880', fat and fascia '1908',chromatized pig bladder '1919' and placenta, in addition to gold, magnesium and zinc to resurface the hip joint. All were met with failure.[(4)]

Marius Smith-petersen introduced the mold arthroplasty in 1923, glass was the material fo first molds followed by other materials as celluloid derivatives '1925', Pyrex '1933', Bakelite '1939' and Vitallium, a cobalt-chromium alloy,[(5)] then acrylic by the Judet brothers who developed the first short-stemmed acrylic prosthesis in 1946.[(6)]

Philip Wiles is credited with performing the first hip arthroplasty in 1938, It was metal-on-metal which was commonly used until the concept of low friction arthroplasty was introduced by Sir "John charnley".[(7)]His first attempt was the use of Teflon shells on surface of the femoral and acetabular components in 1958. Rapid failure of Teflon led to development of a socket

made of high molecular weight polyethylene articulated with highly polished stainless steal ball.[8][9]

Since 1961, metal-on-polyethylene bearings have demonstrated well to excellent clinical results and are considered the standard against which all altenative bearings must be compared. However, wear of polyethylene and resultant periprosthetic osteolysis are major long-term concerns that affect implant longevity, particularly for young active patients.[10]

Periprosthetic osteolysis and aseptic loosening are thought to be primarly due to the body reaction to polyethylene particulate debris generated from the metal on polyethylene articulation. Accumulation of particulate debris can result in an aggregation of macrophages that attempt to phagocytize it. The ensuing chronic inflammatory response is characterized by release of lytic enzymes, proinflammatory cytokines and bone-resorbing mediators, resulting in osteolysis that can cause aseptic loosening and fixation failure.[11][12]

Current prosthesis design utilizes strategies for minimizing the generation of polyethylene debris and its damaging effects. New bearings for total hip arthroplasty have been introduced with the aim of reducing the number of biologically active wear particles. There are two approaches: one is to improve the wear resistance of polyethylene through cross-linking and the other is to avoid polyethylene and utilize alternative bearings. The latter approach has fueled the development and reintroduction of new ceramic-on-ceramic and metal-on-metal bearings.[13]

Alternative to metal on polyethylene, the following bearings are available:

1. Metal or ceramic on highly cross-linked polyethylene.

2. Ceramic on ceramic.
3. Metal on metal.

Alternative bearing surfaces, with lower wear rates, can potentially improve the longevity of implant survival for the higher-demand patient by decreasing particulate debris formation and the resultant osteolysis. Patients who are older and less active will continue to be well served by metal-on-polyethylene bearings, because such bearings will undergo less cycling and thus be subject to less wear.[14]

Alternative bearing surfaces have the potential to be the next major breakthrough in thwarting these problems and increasing implant longevity, especially in younger, more active patients.

Aim of the work

This essay shall look on various types of bearing couples of total hip arthroplasty, reporting on the evolution and development and also highlighting the advantages and possible complications.

1- Anatomical considerations of the hip

The hip joint is a ball and socket synovial joint which is formed of the femoral head (the ball) and the acetabulum (the socket)**,** fig 1

Acetabulum:

The iliac, the ischium, and the pubic bones unite to form the acetabular cup. At birth the bones are separated by the triradiate cartilage, which disappears about puberty. The cup faces distally, laterally, and anteriorly. It has prominent and reinforced superior and posterior margins to counteract the pressures exerted by the weight-bearing femoral head both in flexion and extension. **(15)**

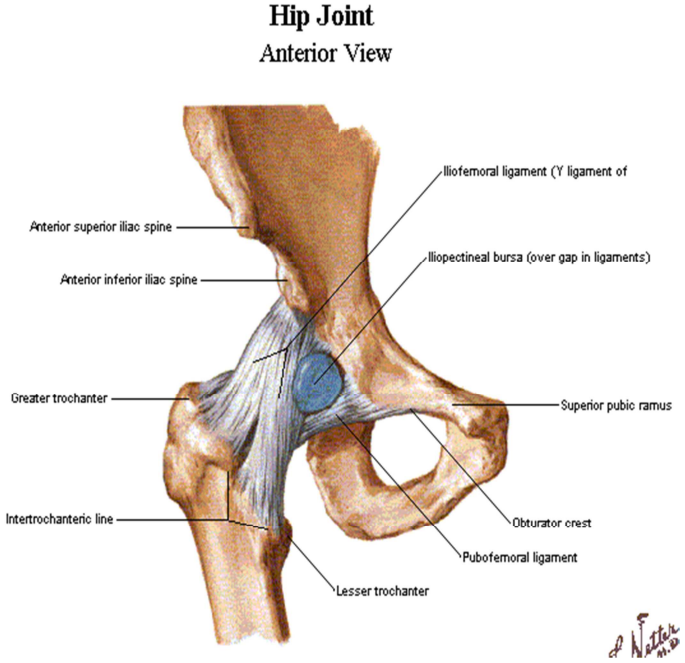

Figure 1: Anatomy of the hip joint. (1)

The acetabular labrum provides a dense fibro-cartilaginous ring that is firmly attached to the bony margin and continues as the transverse ligament across the inferior acetabular notch. This malleable fibrous ring increases the depth of the acetabulum and so enhances the joint stability, also due to its malleability, it

increase range of motion without bony impingement and it gives attachment to joint capsule.[16]

The acetabular surface is orientated approximately 45° caudally and 15° anteriorly.The acetabulum has a mostly circular contour in its superior margin, but it has only enough hemi-spherical depth to allow for 170° coverage of the femoral head .[17]

For arthroplasty, important surgical landmarks within the acetabulum include the anterior and posterior rims, the base of the fovea, and the transverse acetabular ligament .The anterior and posterior rims can help determine if appropriate acetabular component anteversion and flexion are present. The base of the fovea serves as a guide to the extent to which the acetabulum can be medially reamed. The transverse acetabular ligament provides a landmark to identify the inferior-most aspect of the acetabulum, the anterior superior iliac spine (ASIS) is an extra-acetabular landmark that is helpful as a guide for the placement of transacetabular screws. [18]

The proximal femur:

The proximal femur includes the head, neck, lesser and greater trochanters, and proximal femoral diaphysis.

The femoral head forms two-thirds of sphere. The cartilage covering the femoral head is thickest on the medial-central surface and thinnest towards the periphery. The variations in the thickness of the cartilage result in a different strength and stiffness in different regions of the femoral head .The hemispherical femoral head diameter averages 46 mm (range 35 to 58) and joins the femoral neck at the sub-capital sulcus.[19]

The neck-shaft angle is defined as the angle between the central axis of the femur and the axis of the femoral neck. The neck-shaft angle averages 135 (range 105 to 155 with wide variability). [19]