Uncemented hips: current status

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Abstract

Total hip replacement (THR) is an established procedure for symptomatic end stage arthritis of the hip to improve function and alleviate pain thereby improving the quality of life of millions of patients. Of the range of possible joint replacements, it is suggested that THR is a landmark surgery. It is one of the most cost effective and predictable operations. Its success in the short term as well as in the long term has led to THR being performed in younger and more active patients. Survival of THR in the young and active patients was suboptimal for many years and management of this group continues to be a challenge. This paper provides an up-to-date review of the relevant history of uncemented hip replacements, key design features, mechanisms of fixation, current status, guidance to use and long-term results of uncemented hips.

Keywords Osteointegration; total hip replacement; uncemented acetabular component; uncemented hip; uncemented stem

Introduction

Sir John Charnley developed the use of cold-curing acrylic cement, polymethylmethacrylate (PMMA) to fix the THR components, and this continued to be the preferred method of implant fixation till the 1990s. Of the range of possible joint replacements, it is suggested that THR is a landmark surgery (Mellon et al., 2013)[1]. The first major venture into THR involved Charnley's polytetrafluorethylene (Teflon) prosthesis, which had a failure rate over 95%. The reason for the failure was osteolysis and it was the number one problem contributing to THR failure between 1959 and 1962. Jones and Hungerford described cement disease in 1987, which was a combination of acetabular and femoral component loosening associated with bone lysis.[3]

The mechanism of femoral loosening for Charnley type stem (composite beam/shape closed stem) is mechanical. The initiating event in femoral loosening is dominated by debonding which is separation of the stem from the cement at the cement-metal interface. Cracks in the cement through pores also contribute to failure but the critical issue is debonding. The cement—bone interface remains pristine. Debonding causes the single most common radiographic sign of loosening, a radiolucent zone at the cement-metal interface in Zone I. On the other hand, polished tapered collarless stems (force closed stem) like Exeter stem behave like a wedge or self-locking taper. Its design is totally contrary to the other philosophy for cemented stem fixation — namely to try to bond the stem as solidly as possible to the bone cement, often by using a collar and texturing or precoating the stem. The Exeter, conversely, is polished and deliberately not bonded so it is free to micro-subside at the stem—cement interface and thus act as a self-locking taper, effectively and continually tightening step by step throughout the life of the hip. Long-term studies have shown that this process continues, micron by micron, to a total of 1 mm—2 mm over 30 years.

The common pattern of failure of acetabular components is biological. It is caused by macrophage-induced resorption of bone at the cement—bone interface, secondary to the progressive ingress of particulate polyethylene debris[4] and Wroblewski[5] concluded that the all-polyethylene cemented acetabular component is the most challenging problem, certainly in the young.

Implant survival in high-demand patients younger than 50 years has been traditionally reported to be significantly lower than that in older cohorts.[2] This is primarily related to the increased demand being placed on the implants, in particular the bearing surfaces. With traditional metal-on-polyethylene bearings, significant wear of the polyethylene leads to osteolysis and aseptic loosening. In addition, bone cement which is strongest in compression (but not against shear forces) was recognized as a weak link, which contributed to poor survival when used for implant fixation in the young and active patients.

Key design features of cementless THR components

Many aspects of THR have changed since the inception. The aims of these developments were to accelerate early postoperative rehabilitation, improve functional outcome and to preserve bone stock for future revisions. One such development is the introduction of cementless components. Cementless fixation design principles have evolved since the first outcomes were reported in 1979.[6] In 1981, based on human retrieval studies, Albrektsson et al. described 'osseointegration' as the attachment of lamellar bone to implants without intervening fibrous tissue.[7] It takes approximately 4—12 weeks after implantation and may continue for up to 3 years.

There is enough evidence in the current literature that the acetabular site is critical in uncemented THR, especially in younger patients. Hallan et al. looked at The Norwegian Arthroplasty Register for metal-backed acetabular components and noted that the survival ranged between 81% and 92% at 10 years. Eskelinen at al looked at The Finnish Arthroplasty Register for uncemented THR in young patients and noted that all uncemented stems showed a survival rate of over 90% at 10 years while the 10-year survival rates of all brands of cup except one declined to under 80%. Reports of high failure rate of cemented

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femoral components in younger and more active patients have stimulated the development of implant fixation without cement. In the late 1980s, hydroxyapatite was applied on the implant surface in uncemented THR because of its biocompatibility and osteoconductive potential.

Surface-treated hemispherical press-fit acetabular cups are currently the most widely used cementless cups which have evolved through three generations based on their development periods and design characteristics.[8] The first generation of acetabular cups evolved during the 1980s where the poly-liner was extruded from the cup for assembly. The second generation developed during the 1990s when the poly-liner was made thicker to endure impingement better. Third-generation cups were introduced in the 2000s where the poly-liner was not supposed to be extruded.

Cementless femoral stems were classified initially as either straight or curved and they were similarly divided as either fixing proximally on metaphysis or distally on diaphysis. In 2011, the Mont group suggested a classification system for femoral stems with a total of six types based on the bone contact area and subdivisions of fixation sites (proximal to distal). Types 1 to 4 are straight stems, and as the number increases so does the fixation area. Types 1, 2, and 3 are tapered, designed to obtain more proximal fixation, and Type 4 is fully coated to obtain distal fixation. Type 5 is a modular prosthesis, and Type-6 stems are curved, anatomic designs and are used less commonly.

Short femoral stems

Recent preference for metaphyseal fixation technique has led to the development of short femoral stem designs. Expected theoretical advantages of this short femoral stems are: 1) limited loss of femoral bone stock; 2) patients experience less pain; 3) less stress shielding of the proximal femur.

The Mont group also proposed classifications for short femoral stems based on the loading sites on proximal part of femurs and stem fixation principles. In this system, the short femoral stems are classified into four types depending on the increasing area for loading on the stem. Type 1 are femoral neck only, Type 2 are calcar loading, Type 3 are calcar loading with lateral flare, and Type 4 have shortened tapered conventional stems.

Recent trends in uncemented femoral stem design

The preferred stem design is proximally coated single wedge stems with wide yet thin proximal portions and no collars. The distal part of the design is shortened by approximately 4–5 cm, compared to conventional stems. The shoulder of the lateral part of a proximal stem is inclined to make a slope to encourage bone preservation, which lowers the risk of fracture while stems are inserted. The neck is designed to minimize collision between liners and acetabular cups by making it slightly thinner.

Mechanism of fixation of uncemented components

There are two mechanisms of fixation: bone ingrowth (bone grows into porous structure of implant) and ongrowth where bone grows onto the microdivots in the grit-blasted surface.

Uncemented components are designed to osseointegrate and recreate optimal femoro-acetabular biomechanics. Although multiple factors affect osseointegration, implant design, surface treatment, primary mechanical stability, and patient's osteogenesis are the most critical.

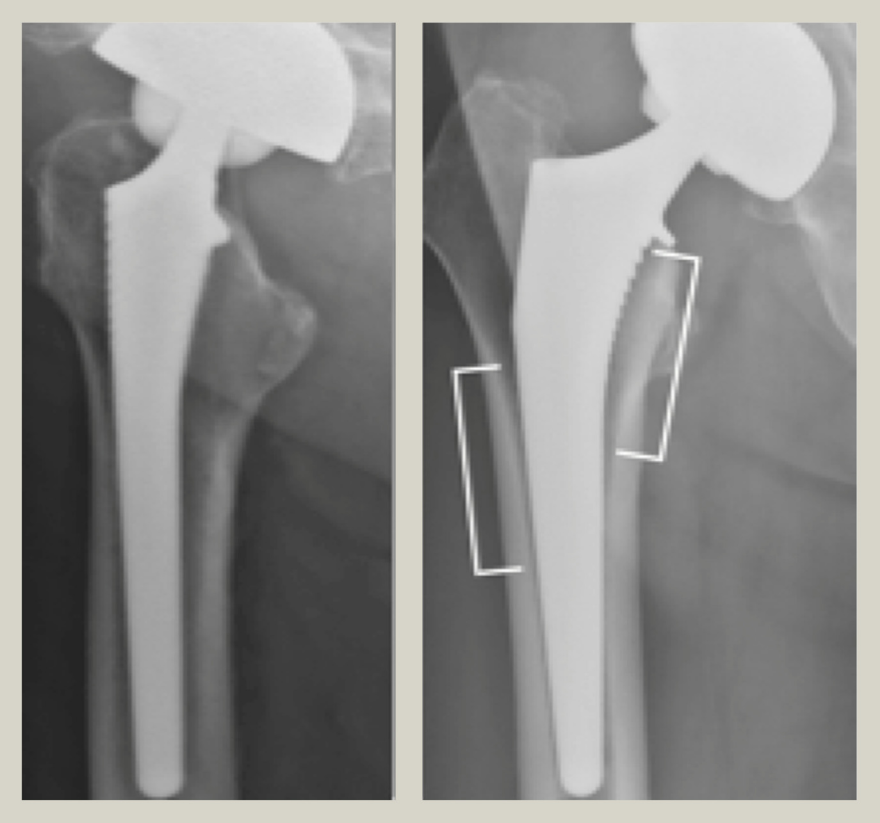

Figure 1 Interference fit achieved by medial to lateral wedging.

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