Summary Arthritis of the hip primarily involves the articulation between the femoral head and the acetabulum. The primary surgical objective is to replace these articular surfaces. In achieving this it is desirable to attempt to obtain a homogeneous transfer of forces to the proximal femur. This is best provided by retention of the femoral neck.

Survivorship of the implant is determined by the durability of fixation and of the articular interface. Early attempts to achieve a conservative hip replacement were betrayed by poor materials, inadequate fixation and failure of the articulation. This paper explores how these shortcomings were addressed during the evolution of total hip arthroplasty to produce the contemporary designs of conservative hip implants.

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Introduction

Arthritis of the hip affects predominantly the joint itself. Early attempts at surgical treatment of hip arthritis were directed at replacing the joint surfaces—either by interpositional or resurfacing arthroplasty (RA). While there were a few good long-term outcomes, material and design deficiencies generally led to poor results. However, improved materials, better fixation and a greater understanding of the tribological imperatives have generated a resurgence of interest in metal-on-metal resurfacing arthroplasty (Fig. 1). Encouraging early results have been reported. The limits of the clinical application are yet to be defined. However, resurfacing arthroplasty does not fall within the scope of this article.

In 1987 Jones and Hungerford coined the term “cement disease” to describe osteolysis. While this proved to be a misnomer, it added impetus to the swing towards cementless fixation. Long-term success of hip implants is determined by both durability of fixation and articulation. Early cementless implants obtained reproducible fixation distally. However this was associated with thigh pain, and the distal off-loading predisposed to stress shielding with loss of proximal bone stock. Indeed, when considering the efficacy of porous-coated cementless fixation, Amstutz noted “The incidence of thigh pain, radiographic stress shielding and removal problems must still be solved...” All these issues are addressed by conservative implants.

Patients today are better informed than ever before. They are politically empowered to demand early surgical intervention to restore quality of life. Ever younger cohorts are presenting for total hip
arthroplasty. The high probability of revision in these younger more active patients has been one of the main factors driving the quest for more bone-sparing conservative options at total hip replacement (THR). More bone would then be available in the proximal femur for any subsequent revision surgery. Conservative implants also appeal to those surgeons embracing the increasingly popular concept of minimally invasive surgery with accelerated rehabilitation regimens.

This paper will review the development of conservative implants over the years.

**Conservative implants**

There are a variety of short-stemmed prostheses that obtain proximal fixation, such as the CFP (Waldemar-Link), Stellcor (Sulzer) and SHO (Biom mechanica). However this paper will principally consider only those implants that are virtually confined to the metaphysis.

Huggler and Jacobs designed the thrust plate prosthesis (TPP), which was first implanted in 1978. They reviewed their results in 1993. The implant (Fig. 2a) is designed to load the medial cortex of the femoral neck as physiologically as possible. The TPP has evolved through three generations. The latest version has an oval thrust plate attached to the mandrel. A central bolt passes through the lateral plate just below the greater trochanter and engages with a screw thread.
contained within the mandrel thrust plate unit. It is of interest how closely this implant resembles the implant designed by Philip Wiles first inserted in 1938 (Fig. 2b).

In seeking a “conservative” uncemented implant with proximal fixation, surgeons at the Mayo Clinic recognised that a wedge-shaped device which tapered in both the sagittal and coronal planes should give stability when inserted into an irregularly shaped cavity by providing multiple point contact. In 1982 these features were incorporated into a short double-tapered titanium alloy proximal femoral replacement—the Mayo Conservative Hip (Fig. 3). The distal end of the implant was curved inferiorly to provide a flat surface to contact the lateral cortex. The rigidity of mechanical fixation in all planes was found to be similar to that of a conventional cementless implant.

The ESKA femoral neck endoprosthesis (CUT) is a mini-prosthesis which is anchored in the metaphysis and provides proximal physiological stress trans-

![Figure 3 The Mayo conservative femoral prosthesis (illustration kindly provided by Dr. B Morrey).](image)

mission, thus avoiding stress shielding (Fig. 4). It lends itself to minimal access surgery and is itself minimally invasive as only the femoral head is removed. It has been recommended for young arthritic patients with good bone quality.11

The IPS (DePuy) femoral stem (Fig. 5a) was developed approximately 10 years ago. This anatomic stem was designed to provide pure proximal loading, thus optimising load transfer in the metaphyseal region and reducing stress shielding. The stem was used principally for alignment and was designed to have no contact in the diaphysis, thus avoiding distal off-loading. In 1999 Walker et al.12 noted that a lateral flare which loaded the lower region of the greater trochanter would assist in transmitting loads to the proximal femur. They also suggested that stems with a lateral flare could be made shorter than designs not incorporating a lateral flare.

In 1995 Santori designed a customised short-stemmed implant with the team at Stanmore Customs. This stem provided an anatomic fit in

![Figure 4 The ESKA femoral neck endoprosthesis.](image)
the metaphysis with longitudinal slots for rotational stability, a pronounced lateral flare and no distal stem. The design and manufacture of this implant was taken over by DePuy International in 2002 (Fig. 5b).

The similarity of the design of the metaphyseal region between the IPS and the Santori stem was recognised and the Proxima stem was evolved as a result of the combination of these philosophies. The Proxima is a stemless, proximally fixed anatomic implant (Fig. 5c). Appropriate sizing and the anatomic shape provide rotational and axial stability.

DePuy have also developed a wedge-shaped cylindrical implant—the Silent Hip—which has a textured surface and is impacted into the neck to provide initial stability (Fig. 6). Long-term stability is provided by bone ingrowth. This is a very
Results

Buergi et al.\textsuperscript{13} reported on the radiological and clinical outcome of 102 consecutive THRs in which the third generation of thrust plate was used.\textsuperscript{12} The mean follow-up was 58 months (range 26–100). Eighty per cent of patients were younger than 60 years of age. Four implants were revised—two for infection and two for aseptic loosening. They noted that in 85\% of cases load transmission occurred through the most proximal part of the medial cortex. Huggler et al. reviewed their “long-term” results in 1993 and noted that the basic feature of the thrust plate is direct load transfer to the medial cortical bone of the femoral neck. They reported that histological examination of an implant removed at 8 years confirmed that newly formed

conservative implant and is not dissimilar to the ESKA “cigar” prosthesis.

Figure 6 (a, b) The Silent femoral neck prosthesis.
bone is in direct contact with the thrust plate with no interposed fibrous tissue. Ishaqui et al.14 reviewed 170 thrust plate prostheses clinically and radiologically at a mean follow-up of 5–8 years. Kaplan–Meier survivorship at 8 years was 90.5%. However they noted that good to excellent clinical results were achieved after revising the thrust plate.

Morrey et al.15 reported on 162 total hip replacements in which the Mayo conservative un cemented femoral component was used. The mean age of the patients was 50.8 years and the mean follow-up 6.2 years (range 2–13). Survival without mechanical loosening was 98.2% at both 5 and 10 years, while survival without osteolysis was 99% at 5 and 91% at 10 years. While recognising the problem of osteolysis associated with wear debris, the authors note that its reliable mechanical stability makes this implant an attractive design, particularly for use in younger patients. They also observed a statistically significant reduction in the amount of blood loss compared with a control group of un cemented implants and ascribe this to the absence of reaming of the femoral canal. In addition they frequently saw increased bone density in zones 3 and 6.

Kim16 prospectively followed up a consecutive series of 60 hips (50 patients) for a minimum of 6 years in which a “close proximal fit and short tapered distal stem” prosthesis (IPS) was used. The mean age was 46.6 years with a mean follow-up of 6.3 years. Transitory thigh pain was present in 2% of cases. No component had been revised and there was no radiological evidence of aseptic loosening. However, a metal-on-polyethylene couple was used in all hips and a higher rate of polyethylene wear was noted in these younger patients.

We have reviewed 81 consecutive IPS stems followed up for a mean of 3 years 9 months (range 2–6 years). One hip was revised for deep infection. There have been no other revisions and there was no radiological evidence of aseptic loosening. Indeed good buttressing of the bone was routinely encountered in the metaphyseal region. No patient complained of thigh pain. This review is due to be presented at the 7th EFORT Congress in Lisbon in June 2005.

The author reviewed 106 Santori customised femoral stems. The mean age of the patients was 55 years. There were no revisions at a mean follow-up of 2 years (range 1–9 years). Good condensation of bone was noted circumferentially around those implants that were confined to the metaphysis with no stem. There was no evidence of bone resorption in any zone in these implants. Early results are encouraging.

Discussion

There has been a recent tremendous resurgence of interest in resurfacing arthroplasty. This is the only surgical treatment for arthritis of the hip which preserves the femoral head. However, RA does not lend itself to minimal access surgery and clinical concerns remain regarding the vascularity of the femoral head and the incidence of femoral neck fracture—both in the short and the longer term. In addition there are well-identified contra-indications for RA. These can be broadly defined as follows:

- Anatomical: excessive anteversion, severe slip of the femoral epiphysis, etc.
- Biomechanical: inability to restore offset and limb length (valgus neck, coxa breva, coxa plana, etc.).
- Pathological: poor supporting bone (osteonecrosis, multiple large cysts, etc.).

There is therefore a need for alternative conservative prostheses. There are two major contemporary issues that are driving the development of conservative implants. Firstly the increasing popularity of minimally invasive surgery and secondly the desire to optimise the loading of the proximal femur and to preserve bone stock.

Ever younger cohorts of patients are presenting for total hip replacement. These patients demand restoration of their quality of life, which is reflected by their ability to pursue their recreational activities such as golf, tennis, skiing, etc. Implants inserted in these patients will not only have to last longer, they will also be exposed to an increased level of activity.

Minimally invasive surgery should be associated with reduced soft tissue damage, shorter hospitalisation and an accelerated programme of rehabilitation and recovery. Minimally invasive should also relate to conservation of bone stock—although this is seldom the practice of surgeons carrying out this surgical technique. A concept relating to both the soft tissue and the bone is to be applauded, but should be embraced with caution. Few mid-term and long-term results are available for the conservative implants. In addition the mini-incision may be associated with an increased risk of complications. Woolson et al.17 compared THRs performed with a standard or a mini-incision and found that the mini-incision group had a significantly higher risk of wound complications, acetabular component malposition and poor fit and fill of cementless femoral components.
Wroblewski et al.\textsuperscript{18} noted that the successful long-term clinical results with the Charnley low friction torque arthroplasty identified proximal femoral shielding as a long-term problem. They ascribed this problem to distal load transfer in a stiffer stem that no longer fractured. Wroblewski introduced the triple taper polished cemented stem to address this problem.\textsuperscript{18}

Proximal stress protection is encountered earlier with cementless stems, particularly those which gain fixation in the diaphysis. Many surgeons have therefore sought a more bone preserving, bone conserving option for younger more active patients. It has been shown that forces developed on weightbearing are more evenly distributed to the proximo-medial femur if the femoral neck is preserved. This also allows for anatomical reconstruction of the proximal femur and provides enhanced rotational stability. However a disadvantage of these femoral neck implants is that they cannot adjust for or accommodate anatomic abnormalities of the proximal femur (e.g. excessive anteversion, etc.).

Achieving initial stability may also present a problem and this initial stability is essential for osseointegration and subsequent durable fixation. This led Santori\textsuperscript{19} to develop the “two-step solution” in which a titanium femoral neck prosthesis was initially inserted through the lateral cortex. At 3 months, having achieved secure bony fixation, the femoral head is removed, the acetabulum is replaced and a prosthetic femoral head is applied. While this highlights the potential problem of achieving adequate initial stability in those cigar-shaped prostheses that rely on impaction into the femoral neck for fixation, I doubt if this two-stage solution would find wide acceptance.

Significant cortical bone mass has been demonstrated at the proximo-lateral flare of the femur.\textsuperscript{20} Experiments have shown that if a femoral stem has a medial and lateral flare proximally, the loads are transferred to the proximal femur and stress protection in this area is avoided. This is particularly true if there is no stem contact distally, which could promote distal off-loading. Indeed, the results suggest that a stem below the lesser trochanter is unnecessary.\textsuperscript{12}

Another important benefit of a bone-sparing and preserving proximal femoral implant is the relative ease with which this can be converted to a “conservative” revision prosthesis, which need only invade the proximal diaphysis. This provides one extra step in the revision programme of a younger patient.

**Conclusion**

There is an old surgical aphorism “the ability to perform an operation is not an indication to do it”. Similarly the mere ability to manufacture and to insert a conservative femoral implant is not necessarily an indication to use it. If the surgeon is confident that the implant that he routinely uses will outlast the patient—then he should use it. Otherwise he should think about the next operation and consider a bone-sparing option. Conservative proximal femoral implants offer such an option.

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**References**

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