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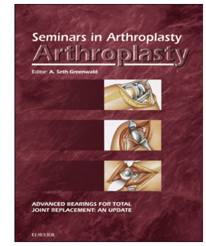

Acetabular options: Notes from the other side

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ABSTRACT

Total hip arthroplasty (THA) has been associated with excellent functional outcomes and survival rates (Cushner et al., 2010 [1]). Selection of acetabular shell and technique of implantation is an important factor as is the stem for a successful THA. Both cemented all-polyethylene cups and cementless sockets have benefited from improvements in surgical techniques, cup designs, and bearing surfaces. This paper is a review of the current literature that focuses on the options for the acetabular components of a modern total hip replacement, aiming to answer common questions and controversies on this topic.

1. Introduction

Total hip arthroplasty (THA) has been associated with excellent functional outcomes and survival rates [1]. Selection of acetabular shell and technique of implantation is an important factor as is the stem for a successful THA. It is reported in various national joint replacement registries that acetabular components have higher revision rates than the femoral component [2–4]. Aseptic loosening of the cup and polyethylene wear has been reported as the most frequent indications for revision of THA after 3 years [4,5].

Both cemented all-polyethylene cups and cementless sockets have benefited from improvements in surgical techniques, cup designs, and bearing surfaces. This paper is a review of the current literature that focuses on the options for the acetabular components of a modern total hip replacement, aiming to answer common questions and controversies on this topic.

2. Cemented vs. cementless fixation

A review of the data from national registries demonstrates a significant variability in surgeons' preferences regarding the type of fixation for the acetabular component [2,4]. Greater than 90% of the sockets are cementless in North America and Australia, whereas 85% of the sockets are cemented in the Scandinavian countries [2,4,6].

Cemented all-polyethylene acetabular components have been used for total hip arthroplasty (THA) since the introduction of the “low friction arthroplasty” by Sir John Charnley in the 1960s. Cemented fixation is primarily mechanical in nature. It is therefore strongest at the day of implantation, and for this reason it might be considered in clinical situations where biologic activity of the underlying bone is deficient (i.e., metabolic diseases and post-irradiation). Adequate cement interdigitation is required, and whenever this cannot be achieved (i.e., Paget disease or renal carcinoma where cancellous bleeding could be substantial) cement fixation may not be optimal [7,8].

The surgical technique for cementing of a polyethylene acetabular component is technically demanding [9]. Few orthopedic residents trained in the past 10–15 years in North America have seen this procedure performed and the technique may be truly considered as a “disappearing art.” Cementless sockets, on the other hand, offer intraoperative versatility, and the implantation technique is easier and

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expedient and therefore performed by most surgeons [7]. Factors including sex, age, diagnosis, and bearing couples have a significant influence on the intermediate to long-term survivorship of contemporary cemented and cementless THA and therefore conclusions should be made with caution [7].

In a recent meta-analysis, Toossi et al. [10] showed that there was no effect on survivorship or revision rate based on acetabular fixation. The authors suggested that cement fixation of acetabular components is more reliable than that of cementless components beyond the first postoperative decade. Moreover, the cemented acetabular component has been suggested as a cost-effective implant choice for the elderly patient undergoing THA [11]. Despite this, the use of the cemented acetabular component tends to decline dramatically even in national health systems that have traditionally adopted cemented fixation for a variety of reasons [2].

3. Shape and geometry of cementless cups

The principle of cementless fixation of acetabular components increased in popularity after the bone cement introduced by Charnley did not fulfill all expectations of stable long-term anchoring. Historically, threaded cups made from ceramics and polyethylene followed. However, these implants required a pre-cut thread, and early to mid-term outcome was disappointing. Development of self-cutting threaded spherical or conical cups from cobalt–chromium–molybdenum and later from titanium led to good initial results and a rapid propagation on this fixation principle. However, good initial results were followed by an increasing number of failures with cementless threaded acetabular components. The Mecron-threaded ring was associated with high loosening rates at mid-term follow-up, which were higher than those with cemented or press-fit cups [12].

In the second generation of cementless threaded cups, several refinements were made including broad use of titanium as a more biocompatible metal alloy and thin threads with a large distance between turns, allowing for increased contact with the bone bed [13].

Most cementless acetabular components in use currently are hemispherical in geometry and under-reaming results in a uniform amount of interference from the dome to the rim. This shape led to a physiological load transmission into the periacetabular bone and to reduced loss of subchondral bone stock as a result of limited reaming [14].

Some components, however, have an elliptic design, in which the rim can be 1–2 mm larger in diameter than the dome of the component [15]. It is essential that the surgeon have an exact knowledge of the geometry of the cementless acetabular component they are using, as this will have an effect on the amount of under-reaming necessary to obtain the desired degree of interference fit and full seating of the component. Reaming 1 mm less than the maximum diameter of the cup seems to produce the safest and most predictable degree of interference fit for most implant designs.

Elliptical cups have a rim diameter that is 2 mm larger than the corresponding hemispherical cup of the same size (i.e., a 50-mm elliptical cup has a 52-mm rim diameter). For this reason, especially for the nonmodular monoblock elliptical acetabular components that are associated with increased insertion forces, we prefer to under-ream rather than 2 mm in order to reduce the reported risk of intraoperative acetabular-rim fracture [15]. In patients with a good quality acetabular bone, full seating and “bottoming out” of the cup may be difficult to obtain with under-reaming or even line-to-line reaming.

Spikes, lugs, and fins peripherally placed on the acetabular component have been used successfully to achieve initial fixation and resistance to shear forces [16]. Other implant design features, such as screws, pegs, spikes, and fins, provide adjunctive fixation of cementless acetabular components until bone ingrowth occurs [17]. These features are especially important in patients with marginal bone quality and when cementless acetabular components are repositioned after initial insertion, as the quality of interference fit is frequently diminished after repositioning and reinsertion. However, they may interfere with fine-tuning of the cup position and prevent full seating of the implant without vigorous impaction.

Screw fixation is used most commonly for additional fixation because it allows the cup position to be optimized and subsequently screws added to the extent necessary to achieve stability of the socket within the bone cavity.

4. Cementless implants—Types of coating

Stable implant fixation of cementless acetabular components relies on tissue ingrowth into or onto the porous metal surface covering the component. Implant–bone interface micromotion should be less than 150 μm in order to achieve reliable bone ingrowth [18]. This can typically be accomplished by frictional or interference “press fit” in patients with reasonable bone quality and adequate implant apposition to host bone; the better the coaptation of implant to bone, the greater the probability of long integration.

A variety of porous coatings, including grit-blasted, plasma-sprayed titanium, crystalline hydroxyapatite, titanium fiber-metal, and new “ultraporous” or “trabecular” metals, have been shown to provide for reliable and predictable “osteointegration” of cementless acetabular components to host bone.

The titanium-sintered-bead fixation surface is associated with a history of long-term fixation. Engh et al. published data on 427 acetabular components with sintered-bead surface and peripheral screws and found excellent mid- to long-term results. The reported cumulative survivorship was 99.3% with revision for loosening being the end point for failure. In another study that included 2547 acetabular components with sintered-bead surface and spike fixation, there was only one revision for aseptic loosening at 2- to 15-year follow-up [19].

Titanium plasma-spray surface is a bony ongrowth fixation surface. Although published data have shorter follow-up, results have been excellent. In a cohort consisting of 145 acetabular components, Reina et al. [20] reported no cup revisions at an average 8-year follow-up period. In another study, Manley et al. [21] found no revisions after an average of 5.6 years in a series that included 101 total hip arthroplasties. Of note, in this series the bearing articulation was ceramic on