Ceramics in Orthopaedics

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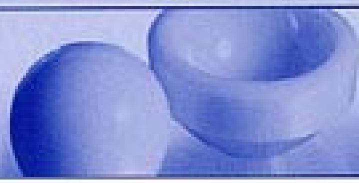
Bioceramics in Joint Arthroplasty



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STEINKOPF DARMSTADT

1.1 Ceramic on Ceramic Bearings Used with Proximal Modular Stems in THA

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Abstract

Introduction: Osteolysis generated by wear debris remains a problem in total hip arthroplasty. Alternate bearings surfaces are sought in an attempt to reduce debris particles and prolong prosthetic wear.

Ceramic on ceramic surfaces have a long clinical history but have encountered a number of problems due to design and material properties. Impingement with malposition of the components, ceramic chipping, and ceramic fractures with malposition of the acetabular component have been problems.

Material: This paper will review 185 ceramic on ceramic bearings used with proximal modular stem designs. Two different stem designs and four different cup designs all utilizing ceramic heads and ceramic inserts manufactured by CeramTec were used.

Conclusion: The recent development of proximal femoral modular stem designs provides better surgical exposure and improved orientation of the prosthetic components. This will reduce the complications due to ceramic implants.

Introduction

The senior authors (KJK, JMK) have performed over 800 ceramic on ceramic total hip arthroplasties at our institution since 1983. Demand for durability, better fit, and greater surgical options has led to the use of newer modular designs in recent years, including nearly 200 modular total hip replacements utilizing ceramic on ceramic interfaces. While early ceramic materials with monoblock designs suffered from ceramic chipping, ceramic fractures with malposition of the acetabular components, and impingement with malposition of the components, it has been our experience and impression that newer modular designs have provided better surgical exposure, improved orientation of the components, and greater flexibility in restoration of normal biomechanics. This has in turn reduced the complications due to ceramic implants and obviated the need for extra long skirted ceramic heads.

Materials and Methods

Medical records were retrospectively reviewed for all patients undergoing primary total hip arthroplasty utilizing both modular designs and ceramic on ceramic interfaces. No patients were excluded from this group. All operations were performed using the modified anterior approach developed by the senior surgeon [1]. Specific parameters examined included demographic data, stem type, acetabular type, and nonmedical complications related to the prosthesis or surgical technique, such as dislocation, malposition, subsidence, fracture, or damage to the ceramic component.

Two proximal modular stem designs were utilized in this series. The first is the Apex Modular7m Hip Stem shown in Figure I (Apex Surgical, LLC, Lakeville, MA). The second is the PROFEMUR TM Z stem shown in Figure 2 (Wright Medical Technology, Inc., Arlington, TN). Four acetabular components were used: the LINEAGE' acetabular system (Wright Medical Technology), the TRANSCEND' acefabular system (Wright Medical Technology), the BICON-PLUS1 acetabular system (PLUS Orthopedics, Son Diego, CA), and the Cer-MetTM acetabular system (Apex Surgical).

Figure 1: Apex ModularTm Hip Stem (Apex Surgical, LLC, Lakeville, MA).

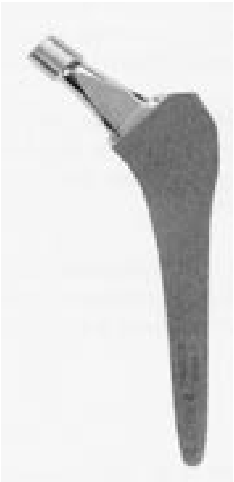

Figure 2: PROFEMUR TM Z stem (Wright Medical Technology, Inc., Arlington, TN).

This data is shown in Table 1 and was comprised of 185 total hip replacements.

Femoral Component	**Acetabular Component**	**Total**
Apex	Lineage	64
	Transcend	23
	Cer-Met	55
	Bicon	2
ProFemur Z	Lineage	23
	Transcend	5
	Cer-Met	11
	Bicon	2
TOTAL		**185**

Table 1:

Summary of all modular ceramic on ceramic THA performed.

Results

Five nonmedical complications were noted in this series of 185 total hip replacements, including two hip dislocations, one acetabular component dislocation, one femoral fracture with stem subsidence, and one failed ceramic acetabular liner. The average length of follow-up was approximately two years, but thus for all four complications that have occurred were apparent within six weeks of the initial surgery. The summary of nonmedical complications is presented in Table **2.**

Femoral Component	**Acetabular Component**	**Complication**
ProFemur Z	Transcend	Ceramic liner fracture at 6 weeks post-op; atraumatic, changed liner/shell/neck/head
ProFemur Z	Cer-Met	Dislocated at 6 weeks post-op and required closed reduction with no further problems
Apex	Bicon	Dislocated with 6 weeks post-op & required open reduction, components retained. [Patient later sustained fractured femur in MVA vs. pedestrian accident and underwent ORIF.]
Apex	Lineage	Acetabular component dislocated at I week; underwent acetabular and femoral head replacement at that time. Previous sciatic nerve palsy pre-operatively after acetabular ORIF (MVA) likely contributed. (See Figure 3).
Apex	Cer-Met	Unappreciated femoral fracture discovered at 6 weeks with component subsidence; converted to Echelon cemented stem.

Table 2:
Summary of nonmedical complications.

The first represented the only failure of the ceramic materials in this series. The patient noted the new onset of pain for one week without recalled antecedent trauma approximately six weeks after undergoing primary total hip arthroplasty with a ProFemur Z stem and Transcend cup with ceramic liner. Evaluation revealed him to have a cracked ceramic liner. It is impossible to state the cause of this fracture; it could be due to pure ceramic materials failure or it may have been an undetected malalignment of the component within its titanium shell. The patient underwent exchange of the liner, acetabular shell, neck, and femoral head without further problems. The modular design proved advantageous in this instance, facilitating modular component exchange.

The second complication was a hip dislocation six weeks post-operatively that was associated with noncompliance with total hip precautions. This patient had undergone a primary THA with a ProFemur Z femoral stem and Cer-Met acetabular component. After undergoing a closed reduction under anesthesia, the patient had no further problems after a year of follow-up.

The third complication involved a patient who underwent primary THA with an Apex femoral stem and a Bicon acetabular component. This patient sustained a dislocation six weeks from the time of surgery after being noncompliant with total hip precautions and required open reduction of the hip with components retained. The patient did well for a limited period of follow-up until suffering extensive trauma as a pedestrian struck by a motor vehicle in which he sustained a periprosthetic femur fracture but no ceramic failure despite his trauma.

The fourth complication was an acetabulor dislocation in a patient with a failed traumatic acetabular fracture ORIF (Figure 3a). It occurred one week postoperatively after primary total hip arthroplasty. This patient had an Apex femoral stem and a Lineage acetabular component. Contributing factors were preexisting sciatic nerve palsy with foot drop, her post-traumatic acetabular bone deficiency, obesity, and active hyperextension of the hip. The revision was relatively easy since it was possible to remove the proximal (modular) neck component and achieve acetabular exposure without removal of the entire femoral prosthesis (Figure 3b). The patient's THA subsequently has remained **stable.**

Figure 3a:
Acetabular componenet dislocation.

Table 1:
Post-operative film after acetabular and femoral head replacements.

The fifth complication occurred with an Apex stem and Cer-Met acetabular component in which a peri-operative femur fracture was unappreciated at the time of surgery. This was subsequently noted six weeks post-operatively with subsidence of the femoral component that necessitated its revision to a cemented Smith-Nephew-Richards (Memphis, TN) EchelonTM femoral stem.

Discussion

Since Pierre Boutin attempted the first ceramic total hip arthroplasty in 1970, there has been interest in ceramic bearing surfaces to improve implant longevity and decrease wear [2]. However, early experience with ceramics indicated high failure rates due to component loosening and early need for revision, with failure rates approaching 27% - 35% in some studies [3,4,5]. Our own early results using the noncemented Autophor were satisfactory and matched the success of Mittelmeier, and we have had some extremely good long term successes with the device in some young and very active patients [6,7,8]. We have not seen any osteolysis on long term follow-up, but the overall failure rate has been unsatisfactory because of inadequate acetabular fixation, acetabular migration, fractures of the thinner acetabulums, and inadequate osteointegration of the femoral component [9].

Although many investigators concluded that much of the fault with these prostheses lay with design and technique in greater part than the ceramic material, ceramic on ceramic joints were abandoned in the United States for over a decade. Ceramic heads in polyethylene acetabular components continued to be used in the United States while the ceramic itself was improved (Biolox-Forte) and its fixation to bone modified in Europe. While first generation ceramics before 1985 had fracture rates as high as 10% in some reports [10], contemporary third generation alumina ceramics have smaller grain size, fewer impurities, and a more stable crystalline structure with fracture rates as low as 4 in 100,000 [111.

Prosthetic designs have also improved with enhancements such as highly polished articular surfaces, optimized clearance between the head and liner to provide a fluid boundary, improved sphericity, tightened tolerances for tapers, and elimination of skirts on ceramic heads. The advent of modular femoral components has also facilitated the insertion and positioning of the ceramic joint itself. A decrease in malaligned acetabulums and femoral necks should optimize long term wear of the ceramics.

The marriage of contemporary ceramic articulating surfaces and proximal modular design affords several benefits. Modular designs allow better surgical exposure, and modularity allows multiple sizing and positioning options to improve orientation of the implants and, ultimately, the stability and biomechanical restoration of the hip replacement. Current designs also do not require the extra long skirted ceramic heads which have historically been more likely to impinge and break.

Our current series of modular ceramic on ceramic hip replacements has shown promising results after an average of one year of follow-up. While this is still an early period of observation, it is our impression that these hip replacement systems perform well and offer a significant addition to the surgeon's armamentarium.

Conclusion

While ceramic on ceramic surfaces have a long clinical history with progressive improvement in materials science, a relatively new approach has been the implantation of ceramic on ceramic surfaces with proximal modular total hip designs. In reviewing all of our modular ceramic on ceramic total hip replacements, we have found them to have excellent performance with few problems in the short term. In particular, there was only a single failure due to chipping or fracture of the ceramic materials - one acetabular liner - and no failures of the ceramic femoral heads. It is our impression that newer modular total hip designs utilizing ceramic interfaces have reduced the complications which were present in earlier monoblock femoral prostheses utilized 15 to 20 years ago. Modular femoral components also allow better surgical exposure, improved component orientation, and reproduction of the proximal femoral anatomical variations such as varus, va1gus, or anteversion.

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