CERAMIC ON CROSSLINKED POLYETHYLENE IN TOTAL HIP REPLACEMENT: ANY BETTER THAN METAL ON CROSSLINKED POLYETHYLENE?

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ABSTRACT

The authors evaluated the use of ceramic femoral heads on crosslinked polyethylene bearing couples versus metal on crosslinked polyethylene couples in a consecutive series of hips performed by a single surgeon over a one year interval. Ceramic femoral heads and more extensively crosslinked polyethylene were used more commonly in the younger aged patients with utilization of ceramic heads in patients average age 50.2 versus 63.9 for metal heads, and utilization of more extensively crosslinked polyethylene in patients average age 54.1 versus 77.2 years for patients receiving less extensive crosslinked polyethylene. The authors explain the cost effectiveness of this approach where the difference in cost is approximately 36%.

INTRODUCTION

Following the work of Semlitsch and coworkers[6] which demonstrated a 20:1 reduction in wear with alumina ceramic on polyethylene versus chrome cobalt on polyethylene bearing surfaces in a wear simulator, the use of alumina ceramic-polyethylene couples in total hip replacement became popular in Asia and Europe. The potential reason for this improvement with alumina ceramic heads included the superior lubricating properties (more wettable, hence better able to maintain lubricant on the surface), the hardness of the surface and the relative inertness of the material. These characteristics could potentially provide a decrease in the coefficient of friction at the bearing surface, less susceptibility to third body wear and scratching of the surface and less biologic response to any debris generated by ceramic wear particles[6] In clinical practice there have been some encouraging reports with ceramic polyethylene bearing surface couples in total hip replacement. Oonishi and coworkers[4] in 1989 reported a 0.1 mm per year head penetration rate with alumina ceramic femoral heads compared with a 0.25 mm per year rate with metal femoral heads. We reported a series of 32 millimeter modular femoral heads mated to gamma irradiated in air polyethylene at 17 to 21 years with a 0.034 mm per year rate of head penetration.[9] Wroblewski et al.[11] reported a head penetration rate of 0.019 mm per year with a 22.225 mm alumina ceramic femoral head–chemically crosslinked polyethylene bearing surface at 17 year follow-up. These results encouraged the senior author to use ceramic femoral heads with crosslinked polyethylene at the bearing surface in patients he considered to be at a relatively high risk for accelerated wear. This study evaluates the usage trends of various bearing surface couples of a single surgeon practice over a one-year period. The authors hypothesized that the most expensive bearing surface couples would be utilized in the patients at higher risk for wear.

MATERIALS AND METHODS

We evaluated 133 consecutive primary total hip replacements performed by a single surgeon (JJC) over the course of a one-year interval (June 2007 to June 2008). A 5 megarad remelt gamma irradiated (Marathon, DePuy, Warsaw, Indiana) or a 7.5 megarad remelt gamma irradiated (Altrx, DePuy, Warsaw, Indiana) polyethylene was utilized in all cases. These were coupled with a metal (Articuleze, DePuy, Warsaw, Indiana) or ceramic (Articuleze Delta Ceramic, DePuy, Warsaw, Indiana) femoral head with diameters of 28 mm, 32 mm, or 36 mm in all cases except one. The remaining case was 26 mm metal head (Bantam Femoral Head, DePuy, Warsaw, Indiana). All acetabular and femoral components were cementless porous coated devices. The age, sex, and body mass index (BMI) of the patient cohort are summarized in Table I as are the head material and polyethylene treatment.

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Each author certifies that his institution has approved the reporting of these cases, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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TABLE 1
Summary of Entire Cohort

	Total Hips (n = 133)	%
Head Material:		
Metal	70	52.6%
Ceramic	63	47.4%
Polyethylene Liner		
5 megarad	19	14.3%
7.5 megarad	114	85.7%
Age (years)		
Mean	57.4	
Median	59	
Range	17 - 94	
Avg Age Males	56.1	
Avg Age Females	58.6	
Sex		
M	64	48.1%
F	69	51.9%
BMI		
Mean	32.2	
Median	31.2	
Range	19.1 - 57.9	

We evaluated the usage trends of the various bearing couples in terms of the patient demographics of age, sex and BMI. In addition, a cost analysis was performed based on the manufacturer's list price of the various components.

RESULTS

The demographics of the patients who underwent primary total hip arthroplasty during the time interval studied along with the distribution of patients receiving the various bearing surface materials (heads and liners) are listed in Table 1. The distribution of femoral head material utilized versus demographics are listed in Table 2. The distribution of polyethylene type versus demographics are listed in Table 3.

In regards to age, the younger patients received the more costly ceramic femoral heads ($p < 0.0001$ t-test) with the average age of patients with ceramic heads 50.1 years versus 63.9 years for patients with chrome cobalt femoral heads. Likewise in regards to age, the younger patients received the more costly 7.5 megarad gamma radiated remelt crosslinked polyethylene (average age 54.1 years) rather than the 5.0 megarad gamma radiated remelt crosslinked polyethylene (average age 77.2 years), $p < .001$ (Tables 2 and 3). Older patients received a greater percentage of 36 mm heads and younger patients received a greater percentage of 28 mm heads (TUKEY's multiple comparisons $p = 0.0005$). Males tended to receive heads of larger diameters ($p = 0.009$ Fisher Exact). Males tended to receive 7.5 megarad polyethylene more often than females ($p = 0.01$ Chi Square test). This was the case even though the average age of males was similar to the age of females (56.1 vs 58.6, respectively). When 5.0 megarad polyethylene was used, the surgeon was more likely to use a large (36 mm) diameter head because this polyethylene was used in the older age group of patients ($p < .0001$). The ceramic femoral heads were more commonly mated with the 7.5 megarad polyethylene (Chi Square test $p < 0001$).

TABLE 2
Comparison of Femoral Head Components

	Metal Heads (n = 70)	%	Ceramic Heads	% (n = 63)
Head Size				
26 mm	1	1.4%		
28 mm	16	22.9%	14	22.2%
32 mm	34	48.6%	36	57.1%
36 mm	19	27.1%	13	20.6%
Age				
Mean	63.9		50.2	
Median	65		52	
Range	17 - 94		19 - 69	
Sex				
M	24	34.3%	40	63.5%
F	46	65.7%	23	36.5%
BMI				
Mean	32.9		31.4	
Median	31.6		30.3	
Range	19.1 - 57.9		19.3 - 46.8	

TABLE 3
Comparison of Polyethylene Components

	5 megarad (n = 19)	%	7.5 megarad (n = 114)	%
Cup Size				
46 mm	1	5.3%		
48 mm	1	5.3%	4	3.5%
50 mm			9	7.9%
52 mm	10	52.6%	63	55.3%
54 mm	4	21.1%	16	14.0%
56 mm	2	10.5%	20	17.5%
60 mm			2	1.8%
70 mm	1	5.3%		
Age				
Mean	77.2		54.1	
Median	80		57	
Range	23 - 94		17 - 74	
Sex				
M	4	21.1%	60	52.6%
F	15	78.9%	54	47.4%
BMI				
Mean	29.4		32.6	
Median	29.6		31.6	
Range	20.3 - 43.3		19.1 - 57.9	

The list price for a 36 mm ceramic head mated with a 7.5 megarad remelt crosslinked polyethylene liner is $4,619.88 compared to the price of a 36 mm metal femoral head mated with a 5.0 megarad remelt crosslinked polyethylene liner is $3,391.53. Hence, the ceramic-7.5 megarad remelt crosslinked polyethylene articulation cost 36% more than the metal-5.0 megarad remelt crosslinked polyethylene articulation.

DISCUSSION

Wear simulator studies as well as long term clinical studies have demonstrated the potential benefit in wear reduction of a ceramic femoral head on polyethylene bearing surface couple in total hip arthroplasty.[4,6,7,9] This potential benefit has been attributed to the wettability, hardness, and inertness of the alumina ceramic material.[6] The concerns over the use of ceramic femoral head on polyethylene versus metal on polyethylene bearing surfaces are the increased cost of materials and the potential for femoral head fracture.[1,10] The present study evaluated the usage of ceramic femoral heads on crosslinked polyethylene and metal heads on crosslinked polyethylene at the articulating surface of primary total hip replacements performed by a single surgeon over a one year interval. This study was intended to analyze whether the more costly ceramic heads as well as a more costly crosslinked polyethylene were utilized in the patients at higher risk for wear.

As hypothesized, the ceramic femoral heads were utilized in the younger patients (average age 51.1 years versus 63.9 years for the metal heads). Likewise, the more extensively crosslinked material was utilized in the younger patients with an average age 54.1 years for the 7.5 megarad material versus 77.2 years for the 5.0 megarad material. The ceramic heads were most commonly mated with the 7.5 megarad polyethylene and both were more commonly utilized in males. Long term follow up studies of total hip replacement patients have documented increased polyethylene wear, determined by femoral head penetration, in younger patients as well as in males versus females.[5] Body mass index did not correlate with the use of any specific bearing couple. Hence the more expensive ceramic head on more extensively crosslinked polyethylene was more commonly utilized in the younger more at risk population for increased wear and the threshold to use the more expensive bearings was lower in the more, at risk for wear, male population. The ceramic head-more extensively crosslinked bearing couple was used at a 36% increased expense using list price figures. This represents an increase of $1,225.

Bozic et al[2] have calculated that an incremental cost in total hip arthroplasty of a new technology in a 50 year old of $2,000 would need a 19% reduction in 20 year survival over an older technology. Conversely, an alternative bearing that added only $500 to the cost of a conventional total hip arthroplasty could be cost-effective in a population of patients over the age of 65 years, even if it were associated with only a modest reduction in the revision rate. At least in terms of a marked reduction in wear demonstrated with a ceramic on polyethylene bearing surface both with gamma in air polyethylene, 0.034 mm/year[7], and crosslinked polyethylene, 0.019 mm/year[9], compared to the best studies demonstrating 0.1 mm/year[5] with metal on gamma in air polyethylene and 0.03 mm/year with metal on crosslinked polyethylene,[3] it appears to be a reasonable cost effective strategy to use ceramic on crosslinked polyethylene in the younger aged population as was utilized in this study when one considers the cost increase would probably be one half or less of the $1,225 increase we calculated using list prices. Especially with the most recent reports of less than 0.004% fracture rates with ceramic heads[8] and the hope that the newer alumina zirconia heads may further lower this rate, any catastrophic consequences of fracture including the inferior results with revision of these fractures because of the debris may be close to eliminated.[1]

The authors recognized that a limitation of this study is the inability to definitely measure any cost effectiveness of our strategy because of the limited data on revision rate comparisons of these two bearing surface couple option in total hip replacement. With the evidence available however, the senior author continues to use ceramic head-exensively crosslinked polyethylene in the patients at higher risk for wear in his total hip arthroplasty procedures.

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