Original Article

Ceramic on ceramic hip arthroplasty in fused hips

Kyung-Soon Park, Taek-Rim Yoon, Tae-Min Lee, Yeong-Seub Ahn

Abstract

Background: Most literature in the field of total hip arthroplasty (THA) for fused hips, until date has reported the results of using metal on polyethylene and ceramic on polyethylene bearings. Results of THA using ceramic on ceramic (CoC) bearings in fused hips have not been published in literature. This study reports the results of cementless THA using CoC articulation perfomed in fused hips.

Materials and Methods: Twenty-three patients (25 hips) with fused hips underwent conversion to THA using CoC bearings and were followed up for a mean 5.4 years. The conventional posterolateral approach was used in 15 hips, a modified two incision technique in 7 hips and a direct lateral approach with greater trochanteric osteotomy in 3 hips. Postoperatively, range of motion exercises were encouraged after 2–3 days of bed rest and subsequent gradual weight bearing using crutches was begun.

Results: Mean Harris hip score improved from 42.4 to 84.2 and mean leg lengthening of 36.6 mm was achieved. In the average 5.4 years (range 2.8-9.1 years) followup there were no cases with osteolysis around acetabular cup and femoral stem. In this study, there was no case of ceramic fracture. There was one case of squeaking.

Conclusion: This study suggests that cementless THA performed for fused hips with CoC bearings can provide good early clinical results.

Key words: Ceramic on ceramic, fused hip, total hip arthroplasty, bearing surfaces, cementless total hip arthroplasty
MeSH terms: Hip, ankylosis, arthroplasty, ceramics

Introduction

A fused hip is a very disabling condition. It can lead to degenerative changes and pain in other joints like ipsilateral knee, contralateral hip and lumbar spine. In the past, hip arthrodesis was a valuable and commonly performed procedure in a young, active, high demand patient with unilateral involvement and damage to the hip.[1,2] A well performed and successful arthrodesis provides long term pain relief and allows the resumption of activities including heavy labor. This however is achieved at the cost of lack of motion at the hip and resultant compensatory movement at other uninvolved joints to produce a useful gait.[2] Therefore total hip arthroplasty (THA) is now considered a better option than hip fusion to achieve movement postoperatively and to spare effect on other joints.[2]

Severe bony deformity with contracture and atrophy of surrounding soft tissues, makes conversion to THA, a technically difficult procedure.[1,2] In addition, THA for fused hip has a higher complication rate with more neurovascular injuries, postoperative infections and inconsistent clinical improvement compared to THA for other indications, such as osteoarthritis and osteonecrosis of the femoral head.[3,4] It has been reported that up to 10% of patients needed re-operation after the initial THA for fused hip.[4] However, despite the reported difficulties, THA for fused hip is increasingly recognized as the standard surgical therapy and carries numerous benefits, such as reduction of other joint pain and correction of limb length discrepancy.[4-6]

Historically, in THA, implant failure was frequently the result of aseptic loosening, causing failure of fixation and implant fracture.[7] Improvements in prosthetic materials, designs and implant fixation resulted in wear of the bearing surface being the primary mechanical limitation in otherwise correctly implanted metal-on-conventional

Department of Orthopedic, Center for Joint Disease, Chonnam National University Hwasun Hospital, 160, Ilsim-Ri, Hwasun-Eup, Hwasun-Gun, Jeonnam, 519-809, Korea

Address for correspondence: Prof. Taek-Rim Yoon,
Center for Joint Disease, Chonnam National University Hwasun Hospital,
160, Ilsim-Ri, Hwasun-Eup, Hwasun-Gun, Jeonnam, 519-809, Korea.
E-mail: tryoon@chonnam.ac.kr

Access this article online	
Quick Response Code:	Website: www.ijoonline.com
	DOI: 10.4103/0019-5413.156209

polyethylene components.[7,8] Improvements in technology of articulating surfaces for the hip have focused on increasing implant survival by decreasing articulation wear and resultant osteolysis thereby reducing dislocation rates. The need for more wear-resistant bearings has led to the development and use of ceramic on ceramic (CoC) bearing couples. These bearings have the potential advantages in terms of improved implant tribology (lubrication, friction, wear), increased longevity and reduced dislocation rates. D'Antonio *et al*.[9] reported that CoC bearing surfaces have advantage of higher survivorship and reduced osteolysis compared with metal on metal or metal on polyethylene (MoP) bearing couples. However, potential disadvantages of CoC bearings, such as fractures and squeaking still remains a concern.[10] Most literature for THA in fused hip till date has reported the results of MoP or ceramic on polyethylene bearings.[4,11-14] There has been no report of results of THA performed in fused hips using CoC bearings to the best of our knowledge. This study reports the results of cementless THA using CoC articulation performed for fused hips.

Materials and Methods

23 patients (25 hips) with fused hips were operated for THA with CoC bearing implants between October 2003 to November 2009. This included 11 males and 12 females, with a mean age of 42.1 years (range 21–70 years). 18 of these hips had fused spontaneously and 7 hips had had surgical fusion [Table 1]. It consisted of 12 pyogenic arthritis, 4 tuberculous arthritis, 4 ankylosing spondylitis, and 5 trauma cases [Table 1]. Patients who had pyogenic and tuberculous arthritis were quiescent at the time of conversion to THA. All surgeries were performed by a hip specialist (T.R.Y). The postero-lateral approach was used in 15 hips, modified two incision technique[15] in 7 hips and direct lateral approach with greater trochanteric osteotomy in 3 hips. If the bony anatomy of the hip was found to be well preserved, we chose a modified two incision technique and if bony anatomy of the hip was severely deformed, we chose posterolateral approach [Table 2]. During the posterolateral approach, anterior capsulotomy and capsule release was done through interval between tensor fascia lata and gluteus medius. An iliopsoas tenotomy was optional. In patients with severe bony deformity and soft tissue adhesions, where muscle interval of tensor fascia lata and gluteus medius could not be found, we took a direct lateral approach with greater trochanteric osteotomy. During the surgery, after acetabular reaming, we confirmed placement of the acetabular cup in the true acetabulum by comparing both sides on C-arm images. In all patients, the sciatic nerve was identified and the nerve tension was checked before trial reduction.

Table 1: Demographics of the patients

Parameters	Data
Average age (year)	42.1 (21-70)
Average followup duration (year)	5.4 (2.8-9.1)
Sex (%)	
Male:female	11 (48.3):12 (51.7)
Site (%)	
Right:left	15 (61.3):10 (38.7)
Fusion type (%)	
Spontaneous:surgical	18 (72):7 (28)
The causative disease (%)	
Childhood pyogenic coxitis	12
Tuberculosis	4
Ankylosing spondylitis	4
Childhood trauma	5

Table 2: Surgical approach and types of implants

Approaches and implants	Number of cases
Approaches	
Conventional posterolateral approach	15
Modified minimally invasive two incision	7
Posterolateral combined with GT osteotomy	3
Acetabular cup	
Secur-FitTM (Stryker Osteonics, New Jersey, USA)	13
Delta PF (Lima-Lto, Udine, Italy)	12
Femoral stem	
M/L Taper (Zimmer, Warsaw, IN, USA)	12
Wagner Cone Prosthesis (Zimmer, Winterthur, Switzerland)	11
Accolade (Stryker Orthopedics, Mahwah, NJ)	2

GT=Greater trochanter

The prosthesis used were Secur-FitTM (Stryker Osteonics, New Jersey, USA) acetabular shell in 13 cases and Delta PF® (Lima-Lto, Udine, Italy) acetabular shell in 12 cases, with M/L Taper stem (Zimmer, Warsaw, IN, USA) in 12 cases, Wagner Cone Prosthesis stem (Zimmer, Winterthur, Switzerland) in 11 cases and Accolade stem (Stryker Orthopedics, Mahwah, NJ) in 2 cases [Table 1, Figure 1A and 1B]. All patients were fitted with an alumina Biolox Forte (Ceram Tec, Plochingen, Germany) neutral liner and an alumina Biolox Forte (Ceram Tec, Plochingen, Germany) modular head. The head diameter was 28 mm in 11 patients, 32 mm in 9 and 36 mm in 5. The neck lengths used were short in 10, medium in 8 and long in 7 patients.

Postoperatively, the hip joint was maintained in abduction brace. The drain was removed when blood collected was <100 mL over 24 h. On day 1, quadriceps strengthening exercises and ankle ROM exercises were started on second postoperative day the hip joint was gradually placed in a more neutral position and partial weight bearing was allowed using 2 crutches.

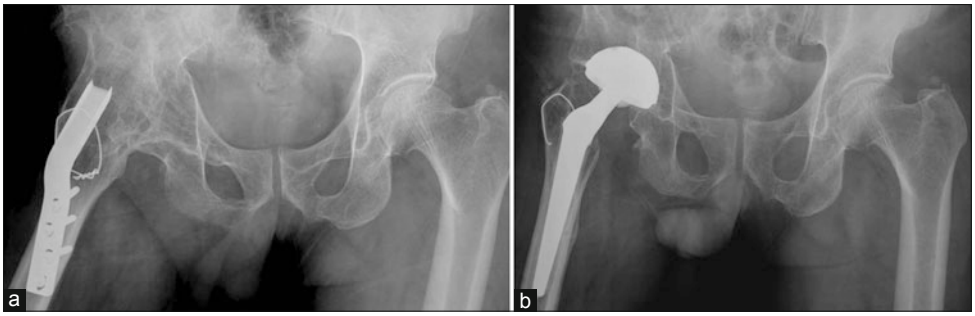

Figure 1A: X-ray pelvis showing both hips anteroposterior view in a 57 year old male with a history of right hip surgery for fusion with angled blade plate 20 years ago due to sequelae of developmental dysplasia of hip (a) Preoperative radiograph showing a solid fusion with 30° abduction malposition. (b) 7 years followup radiograph showing good bone ingrowth on femoral and acetabular implants without osteolysis or radiolucent line. Secur-FitTM (Stryker Osteonics, New Jersey, USA) acetabular shell and Wagner Cone Prosthesis stem (Zimmer, Winterthur, Switzerland) were used with alumina Biolox® Forte (Ceram Tec, Plochingen, Germany) liner and head. The surgery was performed without greater trochanter osteotomy

Outcomes measured in this study were intraoperative blood loss, preoperative and postoperative Harris hip scores (HHS), patient's subjective satisfaction, the ability to sit cross legged. Postoperative complications and radiological outcomes were also recorded. Patients' subjective satisfaction was assessed preoperatively and postoperatively by asking them to classify their hip function as excellent, good, moderate or dissatisfied.

Radiological outcomes, in addition to the standard measures of anteversion of the acetabular cup, lateral opening angle and axis of the femoral stem were assessed for the following criteria. To measure lateral opening angles and acetabular cup anteversions, we used the method described by Sah and Estok[16] and to measure amounts of leg lengthening, we measured vertical distance changes of greater trochanter tip or lesser trochanter from the horizontal line bisecting both inferior margins of tear drops on both hip anteroposterior radiographs. If the anatomical landmark of the greater trochanter or lesser trochanter is not visible on radiographs, we measure the difference of distance from hip joint center to the center of the knee joint on teleoroentgenogram. The software (Marosis PACS; Marotech Inc., Seoul, South Korea) allowed measurements of angles and lengths, accurate to two decimal points after compensating for magnification, which were then rounded off.

The Engh *et al*.[17] classification of femoral stem fixation, the Gruen *et al*.[18] classification of femoral stem osteolysis and the Callaghan *et al*.[19] classification of stem subsidence were used to evaluate femoral stem stability. Furthermore, to evaluate acetabular components, we used the DeLee and Charnley[20] classification of acetabular osteolysis. Heterotopic ossification was evaluated according to the system of Brooker *et al*.[21]

Statistical analysis was performed using the Mann–Whitney test in the SPSS software package (Base

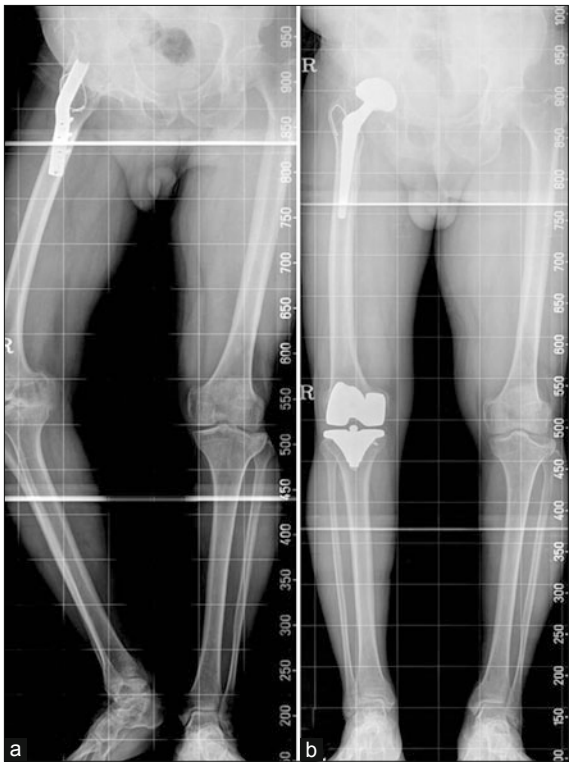

Figure 1B: (a) Preoperative teleoroentgenogram showing pelvis right side tilting and right knee varus deformity with severe joint space narrowing. (b) Teleoroentgenogram after 7 years right total hip arthroplasty showing improved pelvic tilt and it shows right total knee arthroplasty which was performed 3 years after right total hip arthroplasty at another hospital

20.0 SPSS Inc., Chicago, IL, USA), and $P < 0.05$ was deemed significant.

Results

The average followup period was 5.4 years (range 2.8-9.1 years). Mean duration of surgery was 178.6 min (range 65–250 min), with mean total blood loss of 1420.1 mL (range 630–1700 mL). The preoperative HHS

was 42.4 (range 21.0–79.0), which improved to 84.2 (range 75.0–98.0) at last followup ($P < 0.05$). This correlated with patient's subjective satisfaction, with 14 patients (15 hips [58.6%]) answering excellent, 6 patients (7 hips [20.6%]) answering good, 2 patients (2 hips [13.8%]) answering moderate and 1 patient (1 hip) dissatisfied. In terms of the ability to sit cross-legged, 12 patients (13 hips [48.4%]) said they were comfortable, 5 patients (5 hips [19.4%]) said possible with mild discomfort, 4 patients (5 hips [19.4%]) said possible with moderate discomfort and 2 patients (2 hips [12.9%]) responded that it was impossible. Limb length discrepancy was optimized from 51 mm (range 3–72 mm) preoperatively to 9 mm (range 0–29 mm) postoperatively with a mean correction of 36.6 mm (range 0–50 mm).

Radiological evaluation showed mean anteversion of the acetabular cup was 18.1° (range 4.6–30.1°) and the mean lateral opening angle was 32.8° (range 16.5–47.1°). The femoral stem was placed in varus 0.4° (range varus 3.2–valgus 2.2°) on average. There was no migration of the acetabular cup, change in slope or migration of the femoral stems in any case. Focal osteolytic change was observed in 1 patient (3.2%) adjacent to the acetabular cup, but not on the femoral stem. Heterotopic ossification was observed in 3 hips with type I in 2 and type II in 1.

Two postoperative complications were seen in one patient: Posterior dislocation of the hip joint and transient femoral nerve palsy. No other complications were seen. More specifically, there was no femoral stem loosening, ceramic breakage, infection, deep vein thrombosis or pulmonary thromboembolism. There was one patient who complained of squeaking, but the sound was not audible. The dislocated hip joint was treated by closed reduction under radiological guidance. The transient femoral nerve palsy spontaneously recovered on postoperative day 1.

Discussion

Total hip arthroplasty for fused hips was performed in 1970s and subsequently successful surgical reconstruction of arthrodesed hip with total joint arthroplasty has been reported.[1,2,22] THA helped these patients to improve activities of daily living and they felt overall satisfaction.[4,10,11,23] Fused hip secondary to diseases, such as pyogenic arthritis or childhood trauma, can cause adjacent soft tissue contracture and atrophy and makes surgical approach very difficult due to extensive scarring, fibrotic tissue and distortion of anatomical landmarks.[1,2,24] Rutz *et al*.[25] showed that THA after spontaneous ankylosis gave better functional outcomes as compared with conversion to THA after surgical fusion (arthrodesis hip). Strathy and Fitzgerald[26] reported in their study of 80 patients that failure rate for THA in spontaneous fused hip is 5%, while THA in surgical fused hips had a failure rate of 48.3%. In particular, increased failure rates were found in patients <50 years of age or when THA was performed early after the onset of hip fusion.[13,27] This was attributed to the poor condition of hip abductors and the altered configuration of the bone, which led to poor positioning or poor fixation of the prosthesis, or both.

It is known that patients with fused hip have weakened abductors compared with patients who undergo THA for other indications. The complications such as dislocation of THA and postoperative abnormal gait appear to be more common in this group.[24] Joshi *et al*.[12] described almost 4 of 5 dislocations that occurred in patients who underwent the arthrodesis before the age of 15 years. The functional score, as judged by walking ability, was found to be slightly better in the group of patients who were older than 15 years at the time of arthrodesis. An associated underdevelopment of the greater trochanter and abductor muscle may lead to a poor functional outcome. A noteworthy result in this study is that only 3 patients underwent greater trochanteric osteotomy, to preserve the function of the abductors that were already atrophied. In previous studies of THA for fused hip, greater trochanteric osteotomy had been performed in most cases in order to gain adequate exposure.[11,12,28]

Furthermore, THA in fused hips is associated with an increased incidence of complications.[4,13,14,29-33] Dislocation has been reported as the most common complication in THA for hip fusion, occurring in 2–4.8% of cases.[31] In this study, we have reported one case of dislocation and one case of transient femoral nerve palsy. The rate of dislocation in our series was 4%, which is slightly higher than that in the general population of patients managed with THA, but less than that reported in other studies on fused hips converted to THA.[13,14,29-31]

Despite difficult surgery, we attributed the relatively low rate of dislocation to the excellent exposure, which allows the osseous bed to be prepared and the components to be implanted in optimum orientation and at the correct anatomical level, restoration of proper soft tissue tension by a minimally invasive approach and careful rehabilitation of the abductor muscles in our study. The patient who suffered dislocation post THA for fused hip had a 90° flexion contracture preoperatively and the dislocation was treated by closed reduction under radiological guidance. We suspect that the dislocation occurred due to the severity of soft tissue deficiency,

severe bone deformity and persistent 60° flexion state with inadequate physiotherapy after surgery. A hip abductor orthosis, limiting hip flexion and adduction, may have prevented dislocation in this patient. In the same patient, transient femoral nerve palsy was resolved spontaneously on postoperative day 1. Although there was no nerve injury during the operation, extensive soft tissue injury may have occurred during the operation causing edema or hematoma in the adjacent soft tissue, causing transient nerve palsy. It is reported that the complication rate is up to 7% for femoral nerve or sciatic nerve palsy.[12,31] The etiology of nerve palsy after THA is multifactorial.[12] Contributing factors include the distorted anatomy and scarring secondary to previous surgery, the inadvertent misplacement of retractors and the use of traction to gain exposure. Even though, the use of somatosensory-evoked potential monitoring during surgery has been reported to reduce the prevalence of nerve injury by some operators,[31] we performed sciatic nerve exploration during surgery instead of use of monitoring. Postoperative identification and early management of femoral or sciatic nerve palsies is of utmost importance after THA for fused hip [Table 3].

Related complications have been reported in MoP soft bearings in long term followup.[7,8] We have used a CoC surface commonly used in THA for other indications and we anticipate avoiding complications associated with erosion of the articular bearing surface. This is especially the case given that the use of CoC bearings is considered as an effective way to prolong the life of the artificial prosthesis in THA for other indications such as osteoarthritis and osteonecrosis of the femoral head. Recently, there are reports about the long term good results of CoC bearing[10] and even in a young patients, CoC produced good results without visible wear. However, longer term followup is required to determine the presence of prosthesis related complications and lifespan of the prostheses infused hip.

Overall, there are many factors that may influence the outcomes reported in this study, including the use of minimally invasive two-incision approach, intra operative sciatic nerve exploration, the use of hard bearings and postoperative rehabilitation. Further research into above mentioned areas and longer followup of our patients is necessary in order to further validate the use of THA with CoC bearings for fused hip.

Table 3: Comparison of the other author's results of total hip arthroplasty in ankylosed hip

Years	Authors	Number of case	Articulation	Approach	Followup duration (years)	Revision rate	Complications	Complication rate (%)
1990	Kilgus *et al*.[11]	41	M/P		5.4	9 (22)	N/P-1 D/L-1 Component failure-10 Removal of trochanteric wire-4 Trochanteric retachment-1 H/O-1 Wound prob.-1	15 (37)
1995	Reikerås *et al*.[13]	46			8	7 (15)	Mechanical Failure-7	7 (15)
2000	Schäfer *et al*.[14]	15	M/P		5.4	4 (26.7)	N/P-2 Deep infection-2 Loosening-2	4 (26.7)
2002	Joshi *et al*.[12]	187	M/P	Lateral approach C trochanteric osteotomy	9.2	12 (6.4)	N/P-15 D/L-5 PTE-1 Wound prob.-3	24 (12.8)
2005	Schuh *et al*.[4]	34			6.5	4 (12)	N/P-2 Wound prob.-2 Periprosthetic fractures-2 H/O-2 Recurrence of ankylosis-1- Reduction of motion-1	9 (21)
2007	Spangehl[32]	19	M/P	Lateral approach C trochanteric osteotomy	7.1	1 (5.3)	D/L-1	1 (5.3)
	Present study	25	C/C		5.4	0 (0.0)	N/P-1 D/L-1	2 (6.5)

M/P=Metal on polyethylene, C/C=Ceramic on ceramic, N/P=Nerve palsy, D/L=Dislocation, H/O=Heterotopic ossification

To conclude THA for fused hip presents a variety of technical difficulties when compared to traditional THA. However, we report that it can be an effective treatment in the hands of a well trained hip surgeon with low complication rates.

References

1. Amstutz HC, Sakai DN. Total joint replacement for ankylosed hips. Indications, technique, and preliminary results. J Bone Joint Surg Am 1975;57:619-25.
2. Hardinge K, Williams D, Etienne A, MacKenzie D, Charnley J. Conversion of fused hips to low friction arthroplasty. J Bone Joint Surg Br 1977;59-B: 385-92.
3. Hardinge K, Cleary J, Charnley J. Low-friction arthroplasty for healed septic and tuberculous arthritis. J Bone Joint Surg Br 1979;61-B:144-7.
4. Schuh A, Zeiler G, Werber S. Results and experiences of conversion of hip arthrodesis. Orthopade 2005;34:218, 220-4.
5. Kim YL, Shin SI, Nam KW, Yoo JJ, Kim YM, Kim HJ. Total hip arthroplasty for bilaterally ankylosed hips. J Arthroplasty 2007;22:1037-41.
6. Lubahn JD, Evarts CM, Feltner JB. Conversion of ankylosed hips to total hip arthroplasty. Clin Orthop Relat Res 1980;146-52.
7. Crowther JD, Lachiewicz PF. Survival and polyethylene wear of porous-coated acetabular components in patients less than fifty years old: Results at nine to fourteen years. J Bone Joint Surg Am 2002;84-A:729-35.
8. Harris WH. The problem is osteolysis. Clin Orthop Relat Res 1995;46-53.
9. D'Antonio JA, Capello WN, Naughton M. Ceramic bearings for total hip arthroplasty have high survivorship at 10 years. Clin Orthop Relat Res 2012;470:373-81.
10. Lee YK, Ha YC, Yoo JJ, Koo KH, Yoon KS, Kim HJ. Alumina-on-alumina total hip arthroplasty: A concise followup, at a minimum of ten years, of a previous report. J Bone Joint Surg Am 2010;92:1715-9.
11. Kilgus DJ, Amstutz HC, Wolgin MA, Dorey FJ. Joint replacement for ankylosed hips. J Bone Joint Surg Am 1990;72:45-54.
12. Joshi AB, Markovic L, Hardinge K, Murphy JC. Conversion of a fused hip to total hip arthroplasty. J Bone Joint Surg Am 2002;84-A:1335-41.
13. Reikerås O, Bjerkreim I, Gundersson R. Total hip arthroplasty for arthrodesed hips 5- to 13-year results. J Arthroplasty 1995;10:529-31.
14. Schäfer D, Dick W, Morscher E. Total hip arthroplasty after arthrodesis of the hip joint. Arch Orthop Trauma Surg 2000;120:176-8.
15. Yoon TR, Park KS, Song EK, Seon JK, Seo HY. New two-incision minimally invasive total hip arthroplasty: Comparison with the one-incision method. J Orthop Sci 2009;14:155-60.
16. Sah AP, Estok DM 2nd. Dislocation rate after conversion from hip hemiarthroplasty to total hip arthroplasty. J Bone Joint Surg Am 2008;90:506-16.
17. Engh CA, Massin P, Suthers KE. Roentgenographic assessment of the biologic fixation of porous-surfaced femoral components. Clin Orthop Relat Res 1990;107-28.
18. Gruen TA, McNeice GM, Amstutz HC. Modes of failure of cemented stem-type femoral components: A radiographic analysis of loosening. Clin Orthop Relat Res 1979;17-27.
19. Callaghan JJ, Salvati EA, Pellicci PM, Wilson PD Jr, Ranawat CS. Results of revision for mechanical failure after cemented total hip replacement, 1979 to 1982. A two to five-year followup. J Bone Joint Surg Am 1985;67:1074-85.
20. DeLee JG, Charnley J. Radiological demarcation of cemented sockets in total hip replacement. Clin Orthop Relat Res 1976;20-32.
21. Brooker AF, Bowerman JW, Robinson RA, Riley LH Jr. Ectopic ossification following total hip replacement. Incidence and a method of classification. J Bone Joint Surg Am 1973;55:1629-32.
22. Courpied JP, Kerboul M, Bellier G, Postel M. Total replacement of ankylosed hips (author's transl). Rev Chir Orthop Reparatrice Appar Mot 1981;67:289-96.
23. Fernandez-Fairen M, Murcia-Mazón A, Torres A, Querales V, Murcia A Jr. Is total hip arthroplasty after hip arthrodesis as good as primary arthroplasty? Clin Orthop Relat Res 2011;469:1971-83.
24. Brewster RC, Coventry MB, Johnson EW Jr. Conversion of the arthrodesed hip to a total hip arthroplasty. J Bone Joint Surg Am 1975;57:27-30.
25. Rutz E, Schäfer D, Valderrabano V. Total hip arthroplasty after hip joint ankylosis. J Orthop Sci 2009;14:727-31.
26. Strathy GM, Fitzgerald RH Jr. Total hip arthroplasty in the ankylosed hip. A ten-year followup. J Bone Joint Surg Am 1988;70:963-6.
27. Peterson ED, Nemanich JP, Altenburg A, Cabanela ME. Hip arthroplasty after previous arthrodesis. Clin Orthop Relat Res 2009;467:2880-5.
28. Hamadouche M, Kerboull L, Meunier A, Courpied JP, Kerboull M. Total hip arthroplasty for the treatment of ankylosed hips: A five to twenty-one-year followup study. J Bone Joint Surg Am 2001;83-A:992-8.
29. Idulhaq M, Park KS, Diwanji SR, Yoon TR, Wie JS. Total hip arthroplasty for treatment of fused hip with 90 degrees flexion deformity. J Arthroplasty 2010;25:498.e5-9.
30. Kim YH, Oh SH, Kim JS, Lee SH. Total hip arthroplasty for the treatment of osseous ankylosed hips. Clin Orthop Relat Res 2003;136-48.
31. Spangehl MJ. Total hip arthroplasty after hip fusion. In: Liberman JR, Berry DJ, editors. Advanced Reconstruction of the Hip. Rosemont, IL: American Academy of Orthopaedic Surgeons; 2004. p. 151.
32. Richards CJ, Duncan CP. Conversion of hip arthrodesis to total hip arthroplasty: Survivorship and clinical outcome. J Arthroplasty 2011;26:409-13.
33. Aderinto J, Lulu OB, Backstein DJ, Safir O, Gross AE. Functional results and complications following conversion of hip fusion to total hip replacement. J Bone Joint Surg Br 2012;94:36-41.

How to cite this article: Park KS, Yoon TR, Lee TM, Ahn YS. Ceramic on ceramic hip arthroplasty in fused hips. Indian J Orthop 2015;49:336-41.

Source of Support: Nil, **Conflict of Interest:** None.