KANSAS JOURNAL of MEDICINE

# Early Outcomes of Cemented versus Cementless Total Knee Arthroplasty

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## ABSTRACT

**Introduction.** Total knee arthroplasty (TKA) has been proven to be very effective for long-term pain relief in the degenerative knee. Few studies have investigated short-term clinical and functional outcomes between the cemented and cementless TKA. The specific aim of this study was to assess the potential difference of functional outcomes in the early post-operative period between these two surgical options using the Knee Society Score (KSS) and range of motion (ROM).

**Methods.** A total of 164 knees that had undergone TKA by a single surgeon at a single institution between 2007 and 2010 were reviewed. Three different TKA prosthetic designs (cruciate retaining (CR), posterior stabilized (PS) and cruciate substituting (CS)) were included. Data collection included patient demographics, pre- and post-operative ROM, and pre- and post-operative KSS at each visit (1.5 months, 3 months, and 12 months). Two separate KSS scores were assigned: functional score and clinical score.

**Results.** Sixty-seven knees underwent cemented TKA and 97 knees underwent cementless TKA. No significant difference was recognized in either age or body mass index for these two TKA groups. The cementless group showed a significant early ROM improvement after 1.5 months post-operative ($p < 0.05$), while the cemented group showed ROM improvement only after three months post-operative. No significant difference was detected in terms of KSS between the cemented and cementless TKA groups at each measured time period. Both groups showed marked KSS improvement (cemented: 135%, cementless: 125%) after 1.5 months post-operative and the KSS seemed to be stabilized after three months post-operative for both groups (cemented: $p = 0.36$; cementless: $p = 0.07$).

**Conclusions.** There was a significant early ROM improvement for the cementless TKA group compared to the cemented TKA group, but no statistical significant difference was noted in KSS in the early post-operative period when comparing cemented and cementless TKA groups. The findings provide evidence that cementless TKA patients can undergo an identical post-operative protocol to cemented TKA, without concerns about implant stability or function. ***KS J Med 2016;9(4):93-98.***

## INTRODUCTION

The field of orthopedic surgery constantly is searching for more effective and efficient ways to provide patients with the most high quality care. Total knee arthroplasty (TKA) is the standard of care in treatment of end-stage degenerative joint disease of the knee. TKA generally results in relief of pain, improvement of physical function, and a very high level of patient satisfaction.[1,2] As the demand for TKA increases and the procedure is performed more often in younger (fifty-five years or less) and more active patients,[3-8] both long-term clinical outcome and survival rates need to be considered. Early postoperative physical therapy, pain control, and postoperative motion are also important aspects of patient care that must be addressed.

Traditional cemented TKA has demonstrated good clinical outcomes and high survivorship in the general osteoarthritis population. Cemented TKA also has shown a low rate of aseptic loosening in long-term studies.[9-13] However, osteolysis at the cement-bone interface has been demonstrated and raises the question about the long-term durability of cemented TKA.[2,14,15] Cementless TKAs have been developed in an attempt to improve the longevity of implants. An implant that allows bony ingrowth at the bone-implant interface theoretically increases the stability of the implant by creating a biologic fixation that has the ability to remodel over time.[3-5,16-21]

Although several studies have compared intermediate and long-term results of survivability and patient outcome scores for the cemented and cementless TKA,[2,12,14,15,17-27] to our knowledge there are no current studies that investigate short-term clinical and functional results between these two surgical options. With some data suggesting that cementless implants may offer more long-term stability, it is important also to assess the early post-operative outcomes of cementless TKA. Early physical therapy, pain control, range of motion, and post-operative activity are important to patient outcomes and satisfaction. It is important to determine if those cementless TKA patients can undergo an identical post-operative protocol to cemented TKA, without concerns about implant stability or function. The specific aim of this study was to assess the potential difference of functional outcomes in the early post-operative period between cemented and cementless TKA using the Knee Society Score (KSS) and range of motion (ROM).

## MATERIALS AND METHODS

A retrospective study was performed on a total of 164 knees. TKAs were performed by or under the direct supervision of the senior author, at a single institution, between 2007 and 2010. These patients were treated with either cemented or cementless Stryker Duracon TKA prostheses (Stryker Orthopaedics, Mahwah, NJ) based on the primary surgeon's clinical judgment and shared decision making with the patient. Before commencing, this study protocol was reviewed and approved by Institutional Review Board.

Patients between 35 and 80 years of age that received TKA with either cemented TKA prosthesis or press-fit cementless prosthesis were included regardless of age, gender, body mass index (BMI), bone density, medical comorbidities, or social factors. Patients that did not undergo total knee arthroplasty with either prosthesis, and patients who had undergone previous knee replacement surgery, were excluded.

Three different TKA prosthetic designs with identical external geometries and dimensions were included in this study: cruciate retaining (CR), posterior stabilized (PS) and cruciate substituting (CS). The cementless components have a porous press-fit surface with hydroxyapatite coating for contact with the bone cut surfaces, whereas the cemented components have a smooth nonporous finish. Standard tibial polyethylene inserts were used.

Standard TKA surgical techniques were performed on each patient, and a tourniquet was used. The knee was approached through a midline incision with a standard medial parapatellar arthrotomy. Bone cuts were made using the manufacturer's protocol and cutting blocks. A decision was made regarding posterior cruciate retaining or sparing technique based on intra-operative stability as determined by the primary surgeon. In knees with cemented fixation, the cut surfaces of both femur and tibia were washed with normal saline solution by pulsatile lavage to remove blood, fat, bone marrow, and other bone debris. The femoral and tibial implant components were implanted using the Surgical Simplex-P bone cement (Stryker Howmedica Osteonics, Mahwah, NJ). For tibial implant, the positive pressure intrusion technique was performed by applying bone cement onto the tibial bone cut surface, then finger packing the cement into the bone. The tibial component was impacted into place. For femoral implant, cement was applied to the anterior chamfer and flange of the femur, and also applied to the distal and posterior chamfer regions of the femoral component. Excess cement was removed from around the implants, and the knee was held in full extension until the cement had polymerized completely. In knees with cementless fixation, femoral and tibial components were inserted with a press fit directly onto the cut bony surfaces. Component stability was confirmed manually by flexing and extending the knee to extremes of motion, and applying varus and valgus stress.

Data collection included patient demographics, pre- and post-operative range of motion (ROM), and knee society scores[28] at each visit. Patient demographic data included patient age, sex, weight, height, body mass index (BMI), and primary diagnosis. The active ROM of the knee with the patient in the supine position was determined pre-operatively and at three follow-up visits (1.5 months, 3 months, and 12 months) using a standard goniometer. Knee scores were calculated with the system established by the Knee Society.[28] Two separate scores were assigned: functional and clinical scores. The functional score was based on the patient's ability to walk, climb stairs, and use walking aids; whereas the clinical score was related to patient pain, range of motion, and stability. All patients with either cemented or cementless TKA received the same supervised post-operative care including: early mobilization (out of bed the day after surgery), weight bearing as tolerated, and, for most, formal physical therapy.

## STATISTICAL ANALYSIS

Independent samples t-tests using SPSS software (Version 19.0; SPSS Inc, Chicago, IL) with 95% confidence interval were used to determine significant differences in numerical variables (age, BMI, ROM, and KSS) between the cemented TKA prosthesis and the press-fit cementless prosthesis.

## RESULTS

A total of 164 consecutive knees (139 patients) revealed that 67 knees (59 patients) were in the cemented TKA group and 97 knees (80 patients) were in the cementless TKA group. Out of the 67 knees in the cemented TKA group, 37 knees were female and 30 were male, while out of the 97 knees in the cementless TKA group, 51 were female and 46 were male. The mean patient ages were 55.7 ± 6.1 years (range: 36 - 65) for the cemented TKA group and 57.3 ± 8.8 years (range: 37 - 79) for the cementless TKA group. The mean patient BMI was 36 ± 8 (range: 22 - 55) for the cemented TKA group and 35 ± 8 (range: 20 - 59) for the cementless TKA group. No significant difference was recognized in either age or BMI between these two groups (Table 1).

**Table 1. Details of patient demographic data for cemented and cementless TKA prosthesis design.**

| | Implant design | Number of knees | Age | | Female | Male | BMI | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean ± SD (range) | p value | | | Mean ± SD (range) | p value |
| Cemented | PS | 8 (12%) | 54.3 ± 6.9 (43 - 61) | 0.20 | 5 | 3 | 33 ± 5 (24 - 38) | 0.37 |
| | CR | 44 (66%) | 55.8 ± 5.9 (36 - 65) | | 24 | 20 | 36 ± 8 (25 - 52) | |
| | CS | 15 (22%) | 56.3 ± 6.4 (44 - 63) | | 8 | 7 | 37 ± 10 (22-55) | |
| Cementless | PS | 7 (7%) | 50.6 ± 4.5 (44 - 54) | | 3 | 4 | 36 ± 7 (25 - 42) | |
| | CR | 27 (28%) | 57.3 ± 8.5 (43 - 79) | | 12 | 15 | 32 ± 8 (22 - 53) | |
| | CS | 63 (65%) | 58.1 ± 9.0 (37 - 79) | | 36 | 27 | 36 ± 8 (20 - 59) | |

## RANGE OF MOTION (ROM)

When the pre- and post-operative ROM for both groups were compared, the cementless group showed a significant early improvement at the 1.5-month post-operative time (cemented: 3º improvement; cementless: 4º improvement), while the cemented group showed improvement only at the 3-month post-operative point (cemented: 10º improvement; cementless: 9º improvement; Figure 1, p = 0.42). For both cemented and cementless TKA groups, the ROM seemed to be stabilized at the 3-month post-operative time, as there were no significant differences detected between the 3-month and 12-month period (Table 2). However, there was a trend of improvement in ROM from pre-operative to 12-month post-operative for both groups (Figure 1, Table 2).

When the ROM was compared between each time period and on each individual TKA prosthetic design, the PS TKA prosthetic design had no significant difference apparent for both cemented and cementless TKA group (Table 3), but this could be due to low power (cemented: n = 8; cementless: n = 7). For the CR TKA prosthetic design, the CR-cementless group showed a significant early improvement at the 1.5-month post-operative point ($p < 0.05$, Figure 2a; Table 3), while the CR-cemented group showed improvement only at the 3-month post-operative time, and there were no statistically significant differences in ROM between Pre-Op and the 1.5-month period for the cemented TKA group (Figure 2b, Table 3). For the CS TKA prosthetic design, the CS-cemented group showed a slow improvement in terms of ROM from pre- to post-operative with no significant differences detected between each time period; whereas the CS-cementless group exhibited a significant improvement in ROM after three months post-operative (Figure 2, Table 3).

**Table 2. Statistical analyses for range of motion.**

| | | | p value |
|---|---|---|---|
| Cemented | Pre-Op | 1.5 months | 0.419 |
| | | 3 months | 0.000 |
| | | 12 months | 0.000 |
| | 1.5 months | 3 months | 0.012 |
| | | 12 months | 0.000 |
| | 3 months | 12 months | 0.067 |
| Cementless | Pre-Op | 1.5 months | 0.006 |
| | | 3 months | 0.000 |
| | | 12 months | 0.000 |
| | 1.5 months | 3 months | 0.001 |
| | | 12 months | 0.000 |
| | 3 months | 12 months | 0.378 |
| Pre-Op | Cemented | Cementless | 0.210 |
| 1.5 months | Cemented | Cementless | 0.014 |
| 3 months | Cemented | Cementless | 0.075 |
| 12 months | Cemented | Cementless | 0.546 |

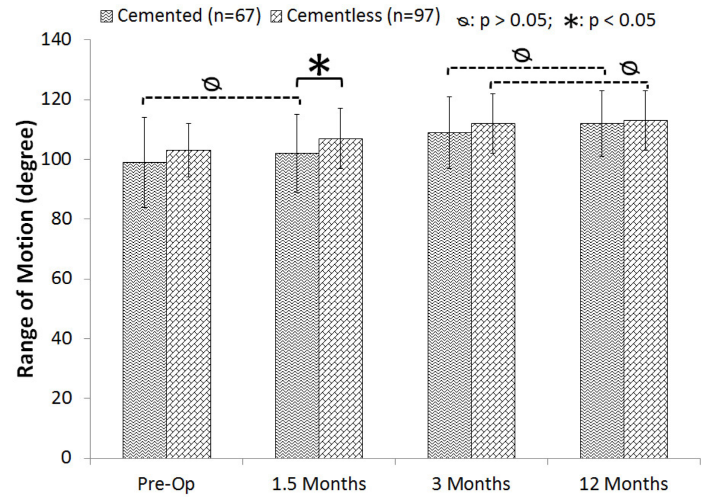


Figure 1. Range of motion results.

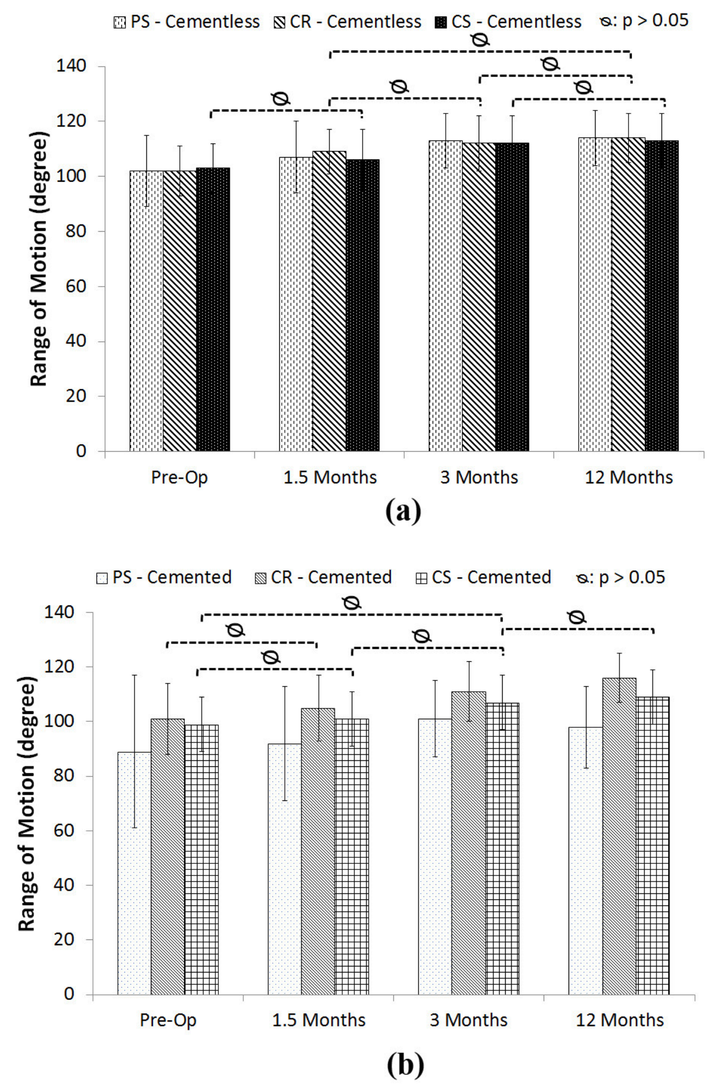


Figure 2. Range of motion of individual implant design: (a) cementless TKA and (b) cemented TKA.

**Table 3. Statistical analyses for ROM for the three different TKA prosthetic designs.**

| | | | | p value |
|---|---|---|---|---|
| PS TKA | Cemented (n = 8) | Pre-Op | 1.5 months | 0.93 |
| | | | 3 months | 0.42 |
| | | | 12 months | 0.48 |
| | | 1.5 months | 3 months | 0.35 |
| | | | 12 months | 0.44 |
| | | 3 months | 12 months | 0.91 |
| | Cementless (n = 7) | Pre-Op | 1.5 months | 0.68 |
| | | | 3 months | 0.27 |
| | | | 12 months | 0.24 |
| | | 1.5 months | 3 months | 0.47 |
| | | | 12 months | 0.41 |
| | | 3 months | 12 months | 0.90 |
| CR TKA | Cemented (n = 44) | Pre-Op | 1.5 months | 0.33 |
| | | | 3 months | 0.00 |
| | | | 12 months | 0.00 |
| | | 1.5 months | 3 months | 0.01 |
| | | | 12 months | 0.00 |
| | | 3 months | 12 months | 0.03 |
| | Cementless (n = 27) | Pre-Op | 1.5 months | 0.00 |
| | | | 3 months | 0.00 |
| | | | 12 months | 0.00 |
| | | 1.5 months | 3 months | 0.23 |
| | | | 12 months | 0.05 |
| | | 3 months | 12 months | 0.50 |
| CS TKA | Cemented (n = 15) | Pre-Op | 1.5 months | 0.95 |
| | | | 3 months | 0.10 |
| | | | 12 months | 0.03 |
| | | 1.5 months | 3 months | 0.08 |
| | | | 12 months | 0.02 |
| | | 3 months | 12 months | 0.49 |
| | Cementless (n = 63) | Pre-Op | 1.5 months | 0.18 |
| | | | 3 months | 0.00 |
| | | | 12 months | 0.00 |
| | | 1.5 months | 3 months | 0.00 |
| | | | 12 months | 0.00 |
| | | 3 months | 12 months | 0.55 |

## KNEE SOCIETY SCORE (KSS)

Using the KSS outcome score, no significant differences were detected between the cemented and cementless TKA groups at each measured time period (Figure 3). Both groups showed a significant improvement (cemented: 135%, cementless: 125%) in KSS at 1.5 months post-operative and appeared to be stabilized after three months, with no statistically significant differences detected between the 3-month and 12-month post-operative periods (Figure 3).

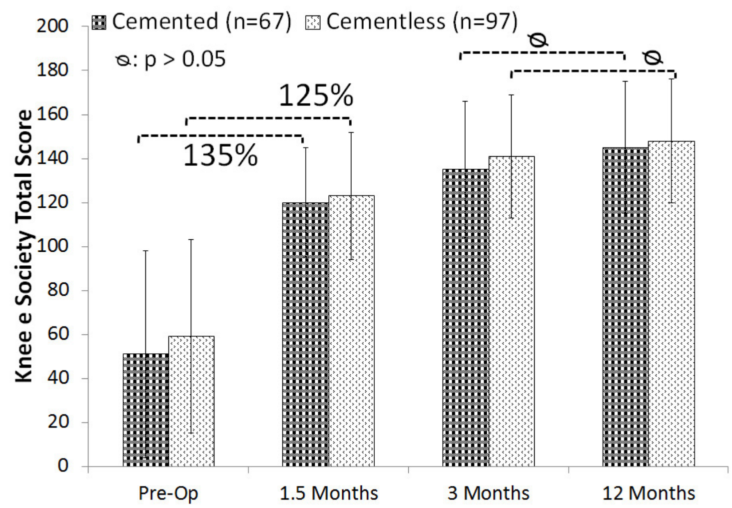


Figure 3. Knee Society Score results.

The Knee Society Clinical Score was compared between each time period and on each individual TKA prosthetic design. The PS TKA prosthetic design had no significant clinical improvement for the cementless TKA group between each measured time period, but this could be due to low power (n = 7). However, there was a significant clinical improvement detected between the cemented TKA group when comparing the pre-operative and the 1.5-month post-operative period (Figure 4a). For the CR TKA prosthetic design, both the CR-cemented and the CR-cementless groups showed a significant clinical improvement at the 1.5-month post-operative point and continued to show improvement at the 3-month post-operative time ($p < 0.05$, Figure 4a). For the CS TKA prosthetic design (which is similar to the CR TKA) both the CS-cemented and the CS-cementless groups showed a significant clinical improvement at the 1.5-month post-operative point and continued to show improvement after three months ($p < 0.05$, Figure 4a).

When the Knee Society Functional Score was compared between each time period and on each individual TKA prosthetic design, the PS-cemented TKA prosthetic design showed a significant functional improvement between the pre-operative and the 1.5-month post-operative periods (Figure 4b). The CR-cemented group also showed no significant functional improvement between each measured time period. However, the CR-cementless TKA group showed a significant functional improvement at the 1.5-month post-operative point ($p < 0.05$, Figure 4b), but there was no significant improvement beyond the 3-month post-operative interval. For the CS TKA prosthetic design, both the CS-cemented and the CS-cementless groups showed a significant functional improvement at the 1.5-month post-operative time and continued to show improvement at 3-month post-operative ($p < 0.05$). However, the knee functional score appeared to be stabilized after three months post-operative for both groups, with no statistically significant difference detected between 3-month and 12-month post-operative period (Figure 4b).

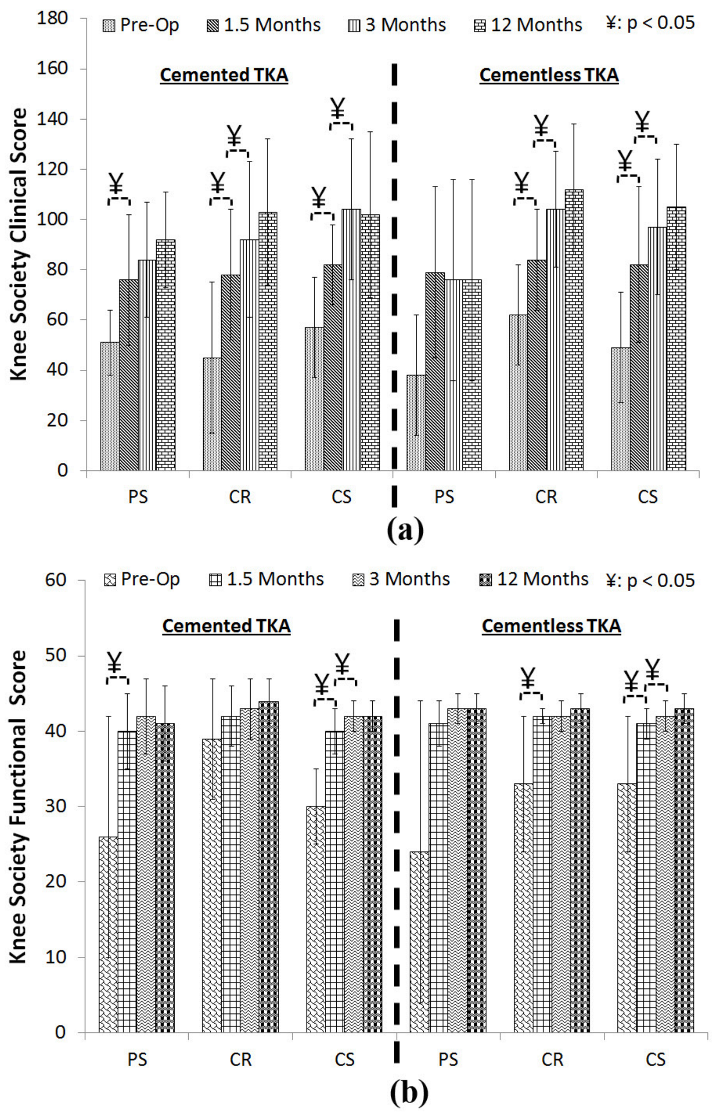


Figure 4. Knee Society Scores of individual implant design: (a) Knee Society Clinical Score and (b) Knee Society Functional Score.

## DISCUSSION

The success of modern TKA has come as a result of the evolution of implant design, improved surgical techniques, careful patient selection, and standardized post-operative rehabilitation protocols.[24,29-31] Laboratory and clinical studies have shown that bony ingrowth into porous hydroxyapatite-coated implants can provide a stable interface for component fixation.[32] Hydroxyapatite has been shown to convert a movement-induced fibrous membrane into a bony implant anchor.[33] However, bone ingrowth needs time, and restriction of post-operative knee motion and limitation of weight bearing is not conducive to successful outcomes and patient satisfaction.[34] The greatest improvement in knee flexion occurs within the first six to seven weeks post-operatively. TKA patients that acquire 95 - 120° of knee flexion at 12-months post-operative achieve satisfactory function and perform most activities of daily living.[34-37]

These studies highlight the importance of early active knee flexion for maximum patient satisfaction, and the findings of our study are congruent with these studies. The cementless TKA group showed a significant early improvement ROM compared to the cemented TKA group.

Some potential benefits of cementless TKA include preservation of bone stock (which potentially provides a better and more durable bone-implant interface), decreased operative time, avoidance of intramedullary pressurization and possible fat emboli, decreased soft tissue inflammation (thermal injury from curing cement), and carries no risk of mechanical cement failure. These advantages may have important positive benefits for longevity of TKA.

There are data suggesting that cementless components provide a more intimate relationship with bone that will increase the longevity of the implant interface and decrease the propensity for loosening of components. This becomes particularly important considering the increasing number of TKAs performed in younger patients. Demey et al.[25] showed a significant difference in radiolucent lines between cemented and cementless TKA. Gao et al.[26] also showed no difference in magnitude and pattern of migration of the femoral press-fit implant compared with cemented components as measured by radiostereometric analysis at two year follow-up.

There are a number of limitations associated with this study. First, the sample size was small and patients were recruited from a single surgeon. This did not allow for differences that may occur from varied surgical approaches and different prostheses, which could produce differences in results. Second, there was no strict control of physical therapy protocol, as patients were free to choose their therapist after leaving the hospital. In addition, no radiographic studies were utilized to look at implant fixation or osteolysis, and patients were not randomized to a specific treatment group. Furthermore, this study focused solely on the early functional outcome after TKA in terms of KSS and range-of-motion, but did not collect or evaluate the patient's daily function or subjective satisfaction with the procedure.

## CONCLUSIONS

This study demonstrated that there was a significant early improvement in ROM for the cementless TKA group compared to the cemented TKA group, but no statistical significant difference in Knee Society Scores between both TKA groups. However, both TKA groups eventually reached similar ROM and KSS scores after a three-month, post-operative interval.

The findings of this study provided evidence that cementless TKA patients can undergo an identical post-operative protocol to cemented TKA, without concerns about implant stability or function.

## ACKNOWLEDGEMENTS AND DISCLOSURE

The authors thank Dr. Ryan Albrecht for his assistance in data collection.

## REFERENCES

[1] Hawker G, Wright J, Coyte P, et al. Health-related quality of life after knee replacement. J Bone Joint Surg Am 1998; 80(2):163-173. PMID: 9486722.
[2] Epinette JA. Long lasting outcome of hydroxyapatite-coated implants in primary knee arthroplasty: A continuous series of two hundred and seventy total knee arthroplasties at fifteen to twenty two years of clinical follow-up. Int Orthop 2014; 38(2):305-311. PMID: 24382665.
[3] Freeman MA, Bradley GW, Blaha JD, Insler HP. Cementless fixation of the tibial component for the ICLH knee. J R Soc Med 1982; 75(6):418-424. PMID: 7086790.
[4] Freeman MA, McLeod HC, Levai JP. Cementless fixation of prosthetic components in total arthroplasty of the knee and hip. Clin Orthop Relat Res 1983; (176):88-94. PMID: 6851346.
[5] Freeman MA, Tennant R. The scientific basis of cement versus cementless fixation. Clin Orthop Relat Res 1992; (276):19-25. PMID: 1311226.
[6] Meneghini RM, Hanssen AD. Cementless fixation in total knee arthroplasty: Past, present, and future. J Knee Surg 2008; 21(4):307-314. PMID: 18979934.
[7] Silverton CD. Cemented and cementless fixation: Results and techniques. Instr Course Lect 2006; 55:429-437. PMID: 16958478.
[8] Kurtz SM, Lau E, Ong K, Zhao K, Kelly M, Bozic KJ. Future young patient demand for primary and revision joint replacement: National projections from 2010 to 2030. Clin Orthop Relat Res 2009; 467(10):2606-2612. PMID: 19360453.
[9] Lombardi AV Jr, Berasi CC, Berend KR. Evolution of tibial fixation in total knee arthroplasty. J Arthroplasty 2007; 22(4 Suppl 1):25-29. PMID: 17570273.
[10] Bauer TW, Schils J. The pathology of total joint arthroplasty. I. Mechanisms of implant fixation. Skeletal Radiol 1999; 28(8):423-432. PMID: 10486010.
[11] Scuderi GR, Insall JN. Total knee arthroplasty. Current clinical perspectives. Clin Orthop Relat Res 1992; (276):26-32. PMID: 1537163.
[12] Kim YH, Kim JS, Choe JW, Kim HJ. Long-term comparison of fixed-bearing and mobile-bearing total knee replacements in patients younger than fifty-one years of age with osteoarthritis. J Bone Joint Surg Am 2012; 94(10):866-873. PMID: 22617913.
[13] Kim YH, Kim JS, Park JW, Joo JH. Comparison of the low contact stress and press fit condylar rotating-platform mobile-bearing prostheses in total knee arthroplasty: A prospective randomized study. J Bone Joint Surg Am 2011; 93(11):1001-1007. PMID: 21655893.
[14] Khaw FM, Kirk LM, Morris RW, Gregg PJ. A randomized, controlled trial of cemented versus cementless press-fit condylar total knee replacement. Ten-year survival analysis. J Bone Joint Surg Br 2002; 84(5):658-666. PMID: 12188480.
[15] Baker PN, Khaw FM, Kirk LM, Esler CN, Gregg PJ. A randomized controlled trial of cemented versus cementless press-fit condylar total knee replacement: 15-year survival analysis. J Bone Joint Surg Br 2007; 89(12):1608-1614. PMID: 18057361.
[16] Bassett RW. Results of 1,000 Performance knees: Cementless versus cemented fixation. J Arthroplasty 1998; 13(4):409-413. PMID: 9645521.
[17] Epinette JA, Manley MT. Hydroxyapatite-coated total knee replacement: Clinical experience at 10 to 15 years. J Bone Joint Surg Br 2007; 89(1):34-38. PMID: 17259413.
[18] Tooma GS, Kobs JK, Thomason HC 3rd, Kelley SS. Results of knee arthroplasty using the cemented press-fit condylar prosthesis. Based on a preliminary report. Am J Orthop (Belle Mead NJ) 1995; 24(11):831-834. PMID: 8581440.
[19] Attar FG, Khaw FM, Kirk LM, Gregg PJ. Survivorship analysis at 15 years of cemented press-fit condylar total knee arthroplasty. J Arthroplasty 2008; 23(3):344-349. PMID: 18358370.
[20] Mokris JG, Smith SW, Anderson SE. Primary total knee arthroplasty using the Genesis Total Knee Arthroplasty System: 3- to 6-year follow-up study of 105 knees. J Arthroplasty 1997; 12(1):91-98. PMID: 9021508.
[21] Duffy GP, Berry DJ, Rand JA. Cement versus cementless fixation in total knee arthroplasty. Clin Orthop Relat Res 1998; (356):66-72. PMID: 9917669.
[22] Crowder AR, Duffy GP, Trousdale RT. Long-term results of total knee arthroplasty in young patients with rheumatoid arthritis. J Arthroplasty 2005; 20(7 Suppl 3):12-16. PMID: 16213997.
[23] Chana R, Shenava Y, Nicholl AP, Lusted FJ, Skinner PW, Gibb PA. Five- to 8-year results of the uncemented Duracon total knee arthroplasty system. J Arthroplasty 2008; 23(5):677-682. PMID: 18534393.
[24] McCaskie AW, Deehan DJ, Green TP, et al. Randomised, prospective study comparing cemented and cementless total knee replacement: Results of press-fit condylar total knee replacement at five years. J Bone Joint Surg Br 1998; 80(6):971-975. PMID: 9853487.
[25] Demey G, Servien E, Lustig S, Aït Si Selmi T, Neyret P. Cemented versus uncemented femoral components in total knee arthroplasty. Knee Surg Sports Traumatol Arthrosc 2011; 19(7):1053-1059. PMID: 21161174.
[26] Gao F, Henricson A, Nilsson KG. Cemented versus uncemented fixation of the femoral component of the NexGen CR total knee replacement in patients younger than 60 years: A prospective randomised controlled RSA study. Knee 2009; 16(3):200-206. PMID: 19097910.
[27] Beaupré LA, al-Yamani M, Huckell JR, Johnston DW. Hydroxyapatite-coated tibial implants compared with cemented tibial fixation in primary total knee arthroplasty. A randomized trial of outcomes at five years. J Bone Joint Surg Am 2007; 89(10):2204-2211. PMID: 17908897.
[28] Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 1989; (248):13-14. PMID: 2805470.
[29] Berger RA, Lyon JH, Jacobs JJ, et al. Problems with cementless total knee arthroplasty at 11 years followup. Clin Orthop Relat Res 2001; (392):196-207. PMID: 11716383.
[30] Buechel FF Sr. Long-term followup after mobile-bearing total knee replacement. Clin Orthop Relat Res 2002; (404):40-50. PMID: 12439236.
[31] Schrøder HM, Berthelsen A, Hassani G, Hansen EB, Solgaard S. Cementless porous-coated total knee arthroplasty: 10-year results in a consecutive series. J Arthroplasty 2001; 16(5):559-567. PMID: 11503114.
[32] Hofmann AA, Heithoff SM, Camargo M. Cementless total knee arthroplasty in patients 50 years or younger. Clin Orthop Relat Res 2002; (404):102-107. PMID: 12439246.
[33] Søballe K, Hansen ES, Brockstedt-Rasmussen H, Bünger C. Hydroxyapatite coating converts fibrous tissue to bone around loaded implants. J Bone Joint Surg Br 1993; 75(2):270-278. PMID: 8444949.
[34] Devers BN, Conditt MA, Jamieson ML, Driscoll MD, Noble PC, Parsley BS. Does greater knee flexion increase patient function and satisfaction after total knee arthroplasty? J Arthroplasty 2011; 26(2):178-186. PMID: 20413247.
[35] Mockford BJ, Thompson NW, Humphreys P, Beverland DE. Does a standard outpatient physiotherapy regime improve the range of knee motion after primary total knee arthroplasty? J Arthroplasty 2008; 23(8):1110-1114. PMID: 18534481.
[36] Naylor JM, Ko V, Rougellis S, et al. Is discharge knee range of motion a useful and relevant clinical indicator after total knee replacement? Part 2. J Eval Clin Pract 2012; 18(3):652-658. PMID: 21414108.
[37] Rowe PJ, Myles CM, Walker C, Nutton R. Knee joint kinematics in gait and other functional activities measured using flexible electrogoniometry: How much knee motion is sufficient for normal daily life? Gait Posture 2000; 12(2):143-155. PMID: 10998612.

*Keywords: orthopedics, total knee arthroplasty, treatment outcome*