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Early Results of a Modular Revision System in Total Knee Arthroplasty

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Abstract

Background: The number of revision total knee arthroplasty (TKA) procedures is projected to rise dramatically over the next fifteen years. These procedures are technically more demanding than routine primary TKA. Modular component options can assist the surgeon in addressing complex reconstructions in TKA, providing customization to remedy bony deficits, deformity, malalignment and instability. We review the early clinical results of a modular revision system that offers full interchangeability enhanced with a wide array of options for augmentation, offset, and constraint as well as modular stems.

Materials and Methods: A query of our practice's arthroplasty registry revealed a consecutive series of 100 patients (101 knees) who signed an IRB-approved general research consent allowing retrospective review, and underwent total knee arthroplasty performed with the modular revision system between May 2011 and May 2012. Reconstruction constructs and components, demographic variables, pre and post-operative clinical variables, failure modes, and survivorship were analyzed.

Results: At an average follow-up of 1 year (range, 0.1 to 2.2 years) there has been one aseptic failure for instability. One patient required incision and debridement of a non-healing wound. Three patients, all status-post reimplantation, failed secondary to recurrent infection, with one treated single-staged and the others undergoing another 2-staged exchange. Average ROM improved from 96.4° preoperatively to 104.8° at most recent evaluation. Average Knee Society clinical scores (0 to 100 possible) improved from 45.5 to 78.0, and function scores (0 to 100 possible) improved from 41.3 to 48.3. There have been no patient deaths during the follow-up period. Postoperative radiographs were available for review for 97 knees. Satisfactory position, fixation and alignment were observed in 92 (95%). Heterotopic ossification was observed at the lateral tibial aspect in 1 knee with CR lipped bearing. A stable radiolucency was observed around the tibial component of one knee. Minor radiolucencies were observed in femoral zones I and II and tibial zone 1 on lateral view of one knee, in tibial zones III and IV on AP view in one knee, and in tibial zone IV on AP view in one knee.

Conclusion: The early results of this modular TKA revision system are promising for use in complex TKA, with only one aseptic failure observed. There has been substantial improvements in ROM and function in this cohort.

Key words: *Arthroplasty, Knee, Revision*

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Introduction

Total knee arthroplasty (TKA) is a common procedure with great clinical success and 95% survivorship at 15 years as reported by multiple authors [1,2]. Annual rates of primary TKA are increasing, and projections for revision TKA are expected to rise 601% by the year 2030 [3]. There are significant technical challenges with revision TKA, including bone loss, deformity, malalignment, and instability coupled with a higher rate of both surgical and medical complications. The aim of this study was to investigate the early results of a fully interchangeable, modular revision knee system with a wide array of implant system options for sizing, stems, augmentation, offset, and constraint, designed to address the technical demands of revision surgery.

Materials and Methods

A retrospective investigation of our practice's arthroplasty database registry identified a consecutive series of 100 patients (101 knees) between May 2011 and May 2012 who underwent revision TKA with a modular revision knee system (Vanguard SSK 360, Biomet, Inc., Warsaw, IN, USA). A signed institutional review board (IRB) approved general research consent allowing retrospective review was obtained from all patients. The database was reviewed to analyze component constructs and level of constraint, demographic variables and preoperative and postoperative clinical assessment data including Knee Society scores, range of motion, limb alignment, indication for revision, and survivorship. Postoperative radiographs were reviewed in 97 knees.

There were 41 men and 59 women. Age averaged 64.2 years (range, 33-90) and BMI averaged 34.7 kg.m2 (range, 20-67). Procedures were revision of unicompartmental to total in 3 knees, revision in 69 (68%), and reimplantation after 2-stage treatment of infection in 29 (29%). Non-infectious indications for revision included aseptic loosening in 30 knees, instability in 38 knees, arthrofibrosis in 10 knees, periprosthetic fracture in 2, and malalignment in 2.

Two knees had no revision performed on the femoral side while 3 were revised to a cruciate retaining femoral component mated to the modular revision tibial component. Seven knees had no revision of the tibial component, while one was revised to a primary fixed I-beam tibial component mated with the modular revision femoral. The tibial inserts utilized were standard cruciate-retaining (CR) in one, CR-lipped in one, ultracongruent anterior stabilized in 3, nonconstrained posterior-stabilized in 12 and varus-valgus constrained in 84 (84%). Offset adapters were used with 42 femoral components and 28 tibial components. Average femoral and tibial offset, when utilized, was 4.8 and 4.7mm, respectively. A cruciate wing was added to 19 tibial components. Femoral and tibial stems were utilized in 96 and 91 knees, respectively. Femoral stems were 97% splined and with lengths of 40mm (n=6), 80mm (n=37), 120mm (n=45), 160mm (n=6), and 200mm (n=2). Tibial stems were 94% splined and with lengths of 40mm (n=3), 80mm (n=32), 120mm (n=56), and 160mm (n=3). Femoral augments were utilized in 52 cases and porous metal femoral augments in an additional 9 cases. Tibial augments were used in 26 cases and porous metal tibial augments in an additional 9 cases.

Results

Clinical outcomes improved significantly after the revision TKA compared with preoperative levels (Figure 1). At an average follow-up of 1 year (range, 0.1 to 2.2 years), range of motion improved from 96 degrees preoperatively to 105 degrees postoperatively. Knee Society clinical scores (range 0 to 100 possible) improved from 45.4 to 78.0, and function scores (0 to 100 possible) improved from 41.2 to 48.4.

One patient required incision and debridement of a non-healing wound. Three patients, all status-post reimplantation, failed secondary to recurrent infection, with one treated single-staged and the others undergoing another 2-stage treatment. One patient required polyethylene exchange for instability (polyethylene thickness increased 4mm). There have been no patient deaths during the follow-up period.

Postoperative radiographs were available for review for 98 knees. Satisfactory position, fixation and alignment was observed in 93 (95%). Heterotopic ossification was observed at the lateral tibial aspect in 1 knee with CR lipped bearing. A stable radiolucency was observed around the tibial component of one knee. Minor radiolucencies were observed in femoral zones I and II and tibial zone 1 on lateral view of one knee, in tibial zones III and IV on AP view in one knee, and in tibial zone IV on AP view in one knee.

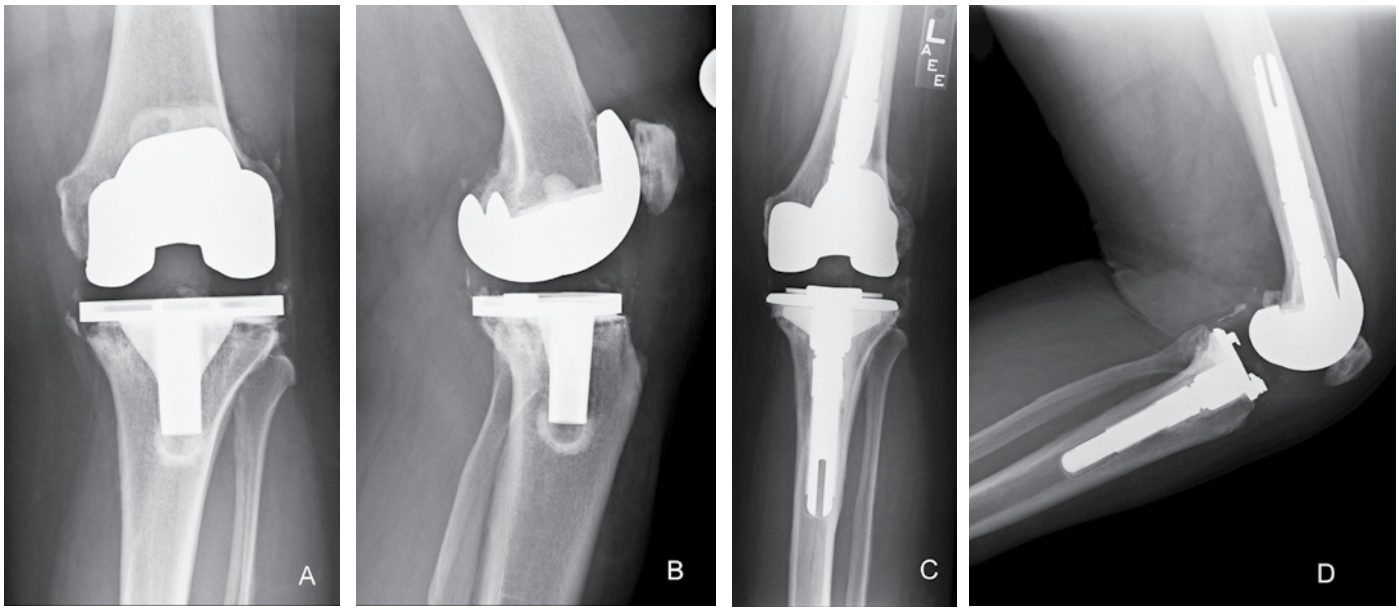

Figure 1. A 68-year-old female patient presented with moderate left knee pain and instability 10 years after undergoing primary total knee arthroplasty with a cemented, posterior-stabilized device. Preoperative anteroposterior (A) and lateral (B) radiographs demonstrate aseptic loosening and tibiofemoral alignment of 8° varus. Anteroposterior (C) and lateral (D) radiographs at 2 years postoperative demonstrate well-fixed components in satisfactory position and alignment. Patient has been treated with left cemented revision TKA using a 62.5mm component with 10mm posterior augment, 2.5mm offset adaptor and 16x80mm splined stem on the femoral side, and 67mm tray with 16x63/67mm constrained insert, 16x80 splined stem, and small cruciate wing on the tibial side. The patellar component was not revised. Her Knee Society clinical score is 99 and function score is 50.

Discussion

The revision burden for TKA is increasing annually. Unfortunately, failure of revision TKA is not uncommon with some authors reporting rates as high as 63% within the first 5 years, predominately due to infection, instability, loosening, and patellofemoral problems [4]. These etiologies are also common in late failures, although polyethylene wear and aseptic loosening of cemented components predominates [5]. Additional risk factors for failure include younger age at the time of index arthroplasty, coronal malalignment, elevated body mass index, and lower socioeconomic and educational status [6]. Despite the various failure modes, the goal of revision arthroplasty, similarly to primary TKA, is to reduce pain and improve function. Revision TKA has been shown to be successful in improving patient outcomes in a cost-effective manner, however, in comparison to primary TKA, it is more expensive, has a higher complication rate, and has lower quality of life outcome scores [7-9].

Revision TKA is technically demanding and is potentially complicated by multiple factors not present during primary TKA including the need to remove components, sepsis, scarring and arthrofibrosis, ligamentous insufficiency or compromise, bone defects, metallic and polyethylene wear debris with variable levels of osteolysis, and deformity. Modern revision TKA systems offer a high degree of modularity, offset, metallic augmentation, stem lengths and fixation methods, and degree of constraint (Table 1). The revision knee system evaluated in this study addresses these needs with a comprehensive interchangeability between femoral and tibial sizes, 360 degrees of femoral and tibial offset options to allow for component position optimization for the best load transfer, a high degree of varus/valgus constraint without the use of a hinged prosthesis, and a simplified trial first approach to revision to provide for a more efficient surgery. The early results of this retrospective database review are promising, with improvement in pain and functional scores with only one failure for aseptic means at early follow-up. Continued monitoring of this cohort is paramount to analyze mid-term and long-term results.

Conclusion

The early results of this modular TKA revision system are promising for use in complex TKA, with only one aseptic failure observed. There has been substantial improvements in ROM and function in this cohort.

Table 1. Results of Constrained Total Knee Arthroplasty

Study	Number of Knees	Device	Description	Follow-up (years)	Survival
Donaldson III et al., CORR 1988 [10]	31	TC III	17 Primary, 14 Revision	3.8	80.6%
Chotivichit et al., J Arth 1991 [11]	27	TC III	9 Primary, 18 Revision	4.3	100%
Hohl et al., CORR 1991 [12]	61	TC III	Complex Primary & Revision	6.1	95.1%
Kavolus et al., J Arth 1991 [13]	16	TC III	5 Primary, 16 Revision	4.5	100%
Rand, J Arth 1991 [14]	21	TC III	Revision, severely damaged knees	4	85.7%
Rosenberg et al., CORR 1991 [15]	36	TC III	Revision	3.8	97.2%
Stern et al., CORR 1991 [16]	8	NA	Primary, valgus ≥ 10°	4.5	100%
Haas et al., JBJS Am 1995 [17]	19	IB CCK	Revision, uncemented stems	3.6	89%
Vince & Long, CORR 1995 [18]	13	IB CCK	Revision	6	75%
Lachiewicz & Falatyn, J Arth 1996 [19]	46	TC III & Constrained Condylar	25 Primary, 21 Revision	46	95.7%
Lombardi et al., Seminars in Arthroplasty 1996 [20]	66	Maxim PSC	Revision	2	92.4%
Font-Rodriguez et al., CORR 1997 [21]	64	Constrained Condylar	Primary, cemented	7	98.1%
Peters et al., J Arth 1997 [22]	43	TC III, Constrained Condylar, Maxim PSC	Revision, cemented	5.2	97.7%
Hartford et al., J Arth 1998 [23]	33	TC III	17 Primary, 16 Revision, 8 Reimplantation	5	91%
Easley et al., CORR 2000 [24]	44	IB CCK	Primary for valgus deformity	7.8	100%
Nazarian et al., CORR 2002 [25]	207	IB CCK	Revision, 55 no stems	4.7	92.8%
Sheng et al., JBJS Br 2005 [26]	16	TC III	Revision, inflammatory	6.2	81.3%
Anderson et al., CORR 2006 [27]	55	Optetrak CCK	Primary without stems for valgus deformity	3.6	100%
Berend et al., CORR 2006 [28]	5	Maxim PSC	Primary, flexion contracture >20°	3.1	100%
Lachiewicz & Soileau, J Arth 2006 [29]	54	IB CCK & TC III	Primary	10	96%
Lombardi & Berend, Orthopedics 2006 [30]	421	Maxim PSC	47 Primary, 284 Revision, 90 Reimplantation	5	88.6%
Sheng et al., Acta Orth 2006 [31]	71	TC III	Revision	5.9	91.5%
Anderson et al., J Knee Surg 2007 [32]	248	Optetrak CCK	Primary without stems	3.9	97.5%
Lombardi et al., JBJS Am 2007 [33]	61	Maxim PSC	Complex Primary	5.6	88.5%
Kim & Kim, JBJS 2009 [34]	114	LCCK	Revision	7.2	96%
Peters et al., J Arth 2009 [35]	184	Maxim PSC & Vanguard PSC	Revision, cemented with cementless stems	4.1	91.8%
Hwang et al., COS 2010 [36]	25	LCCK	Revision, cemented	2.5	100%
Lachiewicz & Soileau, J Arth 2011 [37]	27	LCCK	Primary	5.4	96%
Lee et al., KSSTA 2013 [38]	79	LCCK	Revision	5.3	89.9%
Lee et al., J Arth 2013 [39]	27	LCCK with PS insert	Revision	7.0	100%
Pang et al., KSSTA 2013 [40]	50	LCCK & PFC Sigma TC III	Primary, type II valgus	8.3	96%

TCIII = Total Condylar III (Depuy, a Johnson & Johnson company, Warsaw, IN); NA = not available; IB CCK = Insall-Burstein Constrained Condylar Knee (Zimmer, Warsaw, IN); Constrained Condylar (Zimmer); Maxim PSC = Maxim Posterior Stabilized Constrained (Biomet, Warsaw, IN); Optetrak CCK = Optetrak Constrained Condylar Knee (Exactech, Gainesville, FL); Vanguard PSC = Vanguard Posterior Stabilized Constrained (Biomet); LCCK = Legacy Constrained Condylar Knee (Zimmer); PFC Sigma = Press-Fit Condylar Sigma (DePuy).

References

1. Ritter MA, Berend ME, Meding JB, Keating EM, Faris PM, Crites BM. Long-term followup of anatomic graduated components posterior cruciate-retaining total knee replacement. Clin Orthop Relat Res 2001;388:51-57.
2. Ranawat CS, Flynn WF Jr, Saddler S, Hansraj KK, Maynard MJ. Long-term results of total condylar knee arthroplasty: A 15-year survivorship study. Clin Orthop Relat Res 1993;286:94-102.
3. Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007;89(4):780-785.
4. Fehring TK, Odum S, Griffin WL, Mason JB, Nadaud M. Early failures in total knee arthroplasty. Clin Orthop Relat Res. 2001;392:315-8.
5. Sharkey PF, Hozack WJ, Rothman RH, Shastri S, Jacoby SM. Why are total knee arthroplasties failing today? Clin Orthop Relat Res. 2002;404:7-13.
6. Saleh KJ, Santos ER, Ghomrawi HM, Parvizi J, Mulhall KJ. Socioeconomic issues and demographics of total knee arthroplasty revision. Clin Orthop Relat Res. 2006;446:15-21.
7. Burns AWR, Bourne RB, Chesworth BM, MacDonald SJ, Rorabeck CH. Cost effectiveness of revision total knee arthroplasty. Clin Orthop Relat Res. 2006;446:29-33.
8. Ong K, Mowat F, Chan N, Lau E, Halpern M, Kurtz S. Economic burden of revision hip and knee arthroplasty in Medicare enrollees. Clin Orthop Relat Res. 2006;446:22-8.
9. Greidanus NV, Peterson RC, Masri BA, Garbuz DS. Quality of life outcomes in revision versus primary total knee arthroplasty. J Arthroplasty. 2011;26:615-20.
10. Donaldson WF 3rd, Sculco TP, Insall JN, Ranawat CS. Total condylar III knee prosthesis. Long-term follow-up study. Clin Orthop Relat Res. 1988;(226):21-8.
11. Chotivichit AL, Cracchiolo A 3rd, Chow GH, Dorey F. Total knee arthroplasty using the total condylar III knee prosthesis. J Arthroplasty. 1991;6(4):341-50.
12. Hohl WM, Crawfurd E, Zelicof SB, Ewald FC. The Total Condylar III prosthesis in complex knee reconstruction. Clin Orthop Relat Res. 1991;(273):91-7.
13. Kavolus CH, Faris PM, Ritter MA, Keating EM. The total condylar III knee prosthesis in elderly patients. J Arthroplasty. 1991;6(1):39-43.
14. Rand JA. Revision total knee arthroplasty using the total condylar III prosthesis. J Arthroplasty. 1991;6(3):279-84.
15. Rosenberg AG, Verner JJ, Galante JO. Clinical results of total knee revision using the Total Condylar III prosthesis. Clin Orthop Relat Res. 1991;(273):83-90.
16. Stern SH, Moeckel BH, Insall JN. Total knee arthroplasty in valgus knees. Clin Orthop Relat Res. 1991;(273):5-8.
17. Haas SB, Insall JN, Montgomery W 3rd, Windsor RE. Revision total knee arthroplasty with use of modular components with stems inserted without cement. J Bone Joint Surg Am. 1995;77(11):1700-7.
18. Vince KG, Long W. Revision knee arthroplasty. The limits of press fit medullary fixation. Clin Orthop Relat Res. 1995;(317):172-7.
19. Lachiewicz PF, Falatyn SP. Clinical and radiographic results of the Total Condylar III and Constrained Condylar total knee arthroplasty. J Arthroplasty. 1996;11(8):916-22.
20. Lombardi AV Jr, Mallory TH, Eberle RW, Adams JB. Results of revision knee arthroplasty using constrained prostheses. Seminars in Arthroplasty. 1996;7(4):349-355
21. Font-Rodriguez DE, Scuderi GR, Insall JN. Survivorship of cemented total knee arthroplasty. Clin Orthop Relat Res. 1997;(345):79-86.
22. Peters CL, Hennessey R, Barden RM, Galante JO, Rosenberg AG. Revision total knee arthroplasty with a cemented posterior-stabilized or constrained condylar prosthesis: a minimum 3-year and average 5-year follow-up study. J Arthroplasty. 1997;12(8):896-903.
23. Hartford JM, Goodman SB, Schurman DJ, Knoblick G. Complex primary and revision total knee arthroplasty using the condylar constrained prosthesis: an average 5-year follow-up. J Arthroplasty. 1998 Jun;13(4):380-7.
24. Easley ME, Insall JN, Scuderi GR, Bullek DD. Primary constrained condylar knee arthroplasty for the arthritic valgus knee. Clin Orthop Relat Res. 2000;(380):58-64.
25. Nazarian DG, Mehta S, Booth RE Jr. A comparison of stemmed and unstemmed components in revision knee arthroplasty. Clin Orthop Relat Res. 2002;(404):256-62.
26. Sheng PY, Jämsen E, Lehto MU, Konttinen YT, Pajamäki J, Halonen P. Revision total knee arthroplasty with the Total Condylar III system in inflammatory arthritis. J Bone Joint Surg Br. 2005;87(9):1222-4.
27. Anderson JA, Baldini A, MacDonald JH, Pellicci PM, Sculco TP. Primary constrained condylar knee arthroplasty without stem extensions for the valgus knee. Clin Orthop Relat Res. 2006;442:199-203.
28. Berend KR, Lombardi AV Jr, Adams JB. Total knee arthroplasty in patients with greater than 20 degrees flexion contracture. Clin Orthop Relat Res. 2006;(452):83-87.
29. Lachiewicz PF, Soileau ES. Ten-year survival and clinical results of constrained components in primary total knee arthroplasty. J Arthroplasty. 2006;21(6):803-8.
30. Lombardi AV Jr, Berend KR. The role of implant constraint in revision TKA: striking the balance. Orthopedics. 2006;29(9):847-9.
31. Sheng PY, Jämsen E, Lehto M, Pajamäki J, Halonen P, Konttinen YT. Revision total knee arthroplasty with the total condylar III system: a comparative analysis of 71 consecutive cases of osteoarthritis or inflammatory arthritis. Acta Orthop. 2006 Jun;77(3):512-8.
32. Anderson JA, Baldini A, MacDonald JH, Tomek I, Pellicci PM, Sculco TP. Constrained condylar knee without stem extensions for difficult primary total knee arthroplasty. J Knee Surg. 2007 Jul;20(3):195-8.
33. Lombardi AV Jr, Berend KR, Leith JR, Mangino GP, Adams JB. Posterior-stabilized constrained total knee arthroplasty for complex primary cases. J Bone Joint Surg Am. 2007;89-A(Suppl 3):90-102.
34. Kim YH, Kim JS. Revision total knee arthroplasty with use of a constrained condylar knee prosthesis. J Bone Joint Surg Am. 2009;91(6):1440-7.
35. Peters CL, Erickson JA, Gililland JM. Clinical and radiographic results of 184 consecutive revision total knee arthroplasties placed with modular cementless stems. J Arthroplasty. 2009;24(6 Suppl):48-53.
36. Hwang SC, Kong JY, Nam DC, Kim DH, Park HB, Jeong ST, Cho SH. Revision total knee arthroplasty with a cemented posterior stabilized, condylar constrained or fully constrained prosthesis: a minimum 2-year follow-up analysis. Clin Orthop Surg. 2010;2(2):112-20.
37. Lachiewicz PF, Soileau ES. Results of a second-generation constrained condylar prosthesis in primary total knee arthroplasty. J Arthroplasty. 2011;26(8):1228-31.
38. Lee JK, Lee S, Kim D, Lee SM, Jang J, Seong SC, Lee MC. Revision total knee arthroplasty with varus-valgus constrained prosthesis versus posterior stabilized prosthesis. Knee Surg Sports Traumatol Arthrosc. 2013;21(3):620-8.
39. Lee JK, Kim SJ, Choi CH, Chung HK. Revision total knee arthroplasty using a constrained condylar knee prosthesis in conjunction with a posterior stabilized articular polyethylene. J Arthroplasty. 2013;28(4):566-9.
40. Pang HN, Yeo SJ, Chong HC, Chin PL, Chia SL, Lo NN. Joint line changes and outcomes in constrained versus unconstrained total knee arthroplasty for the type II valgus knee. Knee Surg Sports Traumatol Arthrosc. 2013;21(10):2363-9.