Constrained Condylar Knee Without Stem Extensions for Difficult Primary Total Knee Arthroplasty

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ABSTRACT: Two hundred forty-eight constrained condylar total knee arthroplasties consecutively implanted without the use of diaphyseal stem extensions were studied in 180 patients. Preoperative deformity was severe (82% Ahlbäck grade 4-5). One hundred ninety-two knees (148 patients) were reviewed at mean 47-month follow-up (range: 24-72 months). Knee Society score improved from 36 to 89 points, and function score improved from 42 to 76 points. Failure rate was 2.5% (2 infections, 1 aseptic loosening, 1 supracondylar femoral fracture, and 1 tibial post fracture). Five (2.5%) knees had patellofemoral complications. Nonprogressive radiolucent lines were present in 16% of cases.

Use of a nonmodular constrained condylar knee for primary severely damaged knees demonstrated reliable short- to mid-term results with a low complication rate and questioned the routine use of intramedullary stem extensions in all such cases.

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INTRODUCTION

In complex primary total knee arthroplasty (TKA), the surgical management of severe deformity can be challenging. The integrity of the soft-tissue envelope of these advanced varus or valgus knees often is compromised. The correction of this axial deformity, which often is also complicated by flexion contracture, requires extensive ligamentous release.[21,23,24] This may result in an elevated joint line, patella baja, and possible residual instability.[8,16,23] Additional constraint afforded by the prosthesis enhances the stability of the knee when the ligaments are damaged or deficient. The inherent stability of a constrained TKA is due to a post in the tibial tray that fits intimately between the femoral component condyles. The fit obtained by this articulation limits varus–valgus and torsional moments. However, the increased constraint has raised concern about the possibility of early loosening, secondary to increased transfer of loads to the implant–bone interface.[4,22] Consequently, most authors have advocated the use of intramedullary stems with constrained components for revision and complex primary surgery[11,17] to allow load-sharing over the diaphyseal portion of the tibia and femur.[4,5,22,26] One biomechanical study showed that stemmed and stemless constrained condylar knee implants had similar patterns of load transfer, in the presence of adequate metaphyseal bone stock.[18] When significant metaphyseal bone defects are present, or when augments are used,[4] it has been common to use cemented or cementless stem extensions. However, the use of these stem extensions involves: 1) invasion of the intramedullary canal, which increases the risk of embolization and the overall morbidity of the procedure; 2) increased operating time and cost; 3) possible end-of-stem pain; and 4) a more difficult revision procedure, if required. The question, therefore, is: Are stem extensions always required when using a constrained insert for TKA?

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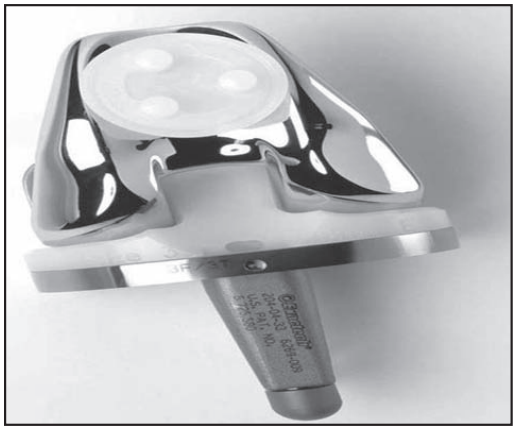

Figure. Front view of the Non-Modular Constrained (NMC; Exactech, Gainesville, Fla) prosthesis.

The present study aimed to analyze the short- to mid-term results of a primary constrained condylar knee prosthesis implanted without diaphyseal stem extensions (ie, "nonmodular" components) in a population of moderately to severely damaged knees.

MATERIALS AND METHODS

Institutional review board approval was granted for this study. Between 1998 and 2001, 248 consecutive primary nonmodular constrained condylar (NMC; Exactech, Gainesville, Fla) knee prostheses without intramedullary stem extensions were implanted in 180 patients by the two senior authors (T.P.S., P.M.P.) (Figure). The NMC prosthesis was named "nonmodular" because the femoral component has been designed as a primary component without the possibility of adding modular parts such as stem extensions or augments.

Patients were self- and physician-referred. Only primary patients with at least 2-year follow-up were included. Fifty-six knees were lost to follow-up; 15 patients (25 knees) had died and 17 patients (31 knees) were unable to be contacted. Families of the deceased were contacted, and all reported that the prosthetic knees had been functioning well at time of death. The study cohort of 148 patients (192 knees) included 104 women and 44 men with an average age of 68 years (range: 25-88 years). The preoperative diagnoses were osteoarthritis in 166 knees, rheumatoid arthritis in 17 knees, post-traumatic arthritis in 8 knees, and post-tuberculosis in 1 patient (1 knee). Overall, the degree of arthritis preoperatively was advanced (82% of knees were Ahlbäck grade 4, corresponding to bony erosions $\leq$5 mm; or Ahlbäck grade 5, corresponding to bony erosions $>$5 mm with tibial subluxation). Preoperatively, valgus deformity was present in 59% and averaged 15° (range: 7°-33°), whereas varus deformity was present in 41% of patients and averaged 13° (range: 5°-22°). Fifty-seven percent of patients had multiple joint involvement (Knee Society category C).

All procedures used a straight skin incision and medial parapatellar approach. The articular surface of the tibia was resected perpendicular to the anatomic axis using an extramedullary guide. Collateral ligament release was performed when required. Anterior referencing was used in all knees, and the anterior rough-cut and distal femoral cuts were referenced off an intramedullary guide in the femur. The distal cut was made in 2° or 5° of valgus off the anatomic axis of the femur, depending on preoperative valgus or varus alignment, respectively. Rotation of the femoral component was set using multiple references: anteroposterior (AP) Whiteside's line, epicondylar axis, and posterior femoral condyles.[25] Patellar tracking was assessed intraoperatively, and a lateral retinacular release was performed in 23% of cases. Retinacular release was performed only when the patella was laterally tilted or subluxed during the "no-thumb" test performed with trial components. Average tourniquet time was 43 minutes (range: 26-86 minutes).

Data were collected using the clinical, functional, and radiographic Knee Society scores.[13] Preoperative data were obtained retrospectively through chart review and review of radiographs. Postoperatively, all patients were examined, questioned, and postoperative radiographs were analyzed (AP and lateral weight-bearing and Merchant views). Postoperative physical examinations were performed by independent examiners (A.B., J.H.M.), and scores were calculated by another member of the research team (J.A.A.).

RESULTS

The average Knee Society score improved from 36 points (range: 3-62 points) to 89 points (range: 42-100 points) at follow-up (P=.002). Average follow-up was 47 months (range: 24-72 months). The average Knee Society function score improved from 42 points (range: 0-70 points) to 76 points (range: 25-100 points) (P=.03). Preoperatively, the average range of motion was from 5° (range: 0°-40°) of extension loss to 103° (range: 70°-130°) of flexion. This improved to 0.5° of extension (range: 0°-5°) and 112° flexion (range: 70°-130°) at follow-up. Preoperatively, 16% of knees had $>$10° of varus–valgus laxity, 50% had 6°-9°, and 34% $<$5°. Postoperatively, 98% of knees had $<$5° of varus–valgus laxity, whereas only 2% had 6°-9° of varus–valgus laxity. Knee score results at follow-up were stratified by category: 119 knees (98 [62%] patients) were ex-

cellent, 42 knees (29 [22%] patients) were good, 27 knees (19 [14%] patients) were fair, and 4 knees (2 [2%] patients) were poor. Three of the 4 patients with poor results had similar characteristics: moderate unexplained residual pain, associated limited range of motion, and a well-fixed implant. One patient had a painful patellar clunk that was scheduled for arthroscopic debridement.

Failure rate, as defined by the need for revision, was 2.5% at follow-up. Reasons for revision were due to two late infections, which were both subsequently successfully treated with two-stage revision; one aseptic loosening of the femoral component at 3-year follow-up in an active patient, which required revision with a stemmed femoral component; one supracondylar femoral fracture, which was treated by open reduction and internal fixation; and one tibial post fracture that was successfully revised with a tibial insert exchange. In addition, five (2.5%) knees had patellofemoral complications, including four patellar clunks and one dislocation. Only one of these patellar clunks was symptomatic, whereas the dislocation did not significantly alter knee function. No postoperative peroneal nerve palsies were reported.

At follow-up, the average alignment on AP weightbearing radiographs was 4.5° of valgus (range: 4° of varus to 13° of valgus). The Knee Society radiographic scoring system was used to document radiolucent lines (overall incidence: 16% of knees). In 15 knees, a radiolucent line was noted under the tibial component in zone 1, and in 11 knees, a line was identified under the tibial component in zones 1 and 2. Twelve knees had radiolucencies around the femoral component in zones 1 and 4. None of these lucent lines were progressive and all were <1-mm thick. No obvious polyethylene wear or osteolysis was detected on radiographic analysis at follow-up.

DISCUSSION

The present study analyzed the short- to mid-term results of a primary NMC prosthesis implanted without diaphyseal stem extensions (ie, "nonmodular" components) in a population of moderately to severely damaged knees. Excessively constrained prosthesis designs have been shown to be detrimental to implant survival.[2,6,10,14,17] Early hinged designs have raised concerns regarding implant fixation and the possibility of early aseptic loosening when highly constrained implants are used.[4,5] More recently, the constrained condylar knee design has been studied by numerous authors, with excellent mid- to long-term results.[1,11,12,21] Based on this clinical success, the constrained condylar knee prosthesis has been used in revision TKA as well as for difficult primary cases.[1,12] However, the original constrained condylar knee design always included intramedullary stem extensions to reduce the incidence of loosening by way of a load-sharing phenomenon. In the revision setting, when the metaphyseal bone is damaged or deficient, diaphyseal fixation is mandatory, whatever degree of constraint is used. The use of these stem extensions has a number of disadvantages, such as increased morbidity and costs. Moreover, a biomechanical study showed that results for stemmed and stemless implants are similar in those situations where adequate metaphyseal bone is present.[18]

Therefore, in primary TKA, where the bone stock is sufficient but the soft-tissue balance is difficult to achieve due to severe deformity, the use of a nonmodular constrained knee prosthesis without stem extensions seems to be a reasonable option. The intimate contact between the large post and intercondylar notch provides initial stability, acting as an "internal splint" to allow the compromised medial collateral ligament time to accommodate valgus loads. Additionally, concern about the potential for stress transfer to the bone–implant interfaces was not realized in this group of patients at mid-term follow-up, as only one femoral component loosening occurred, and a low incidence of radiolucent lines were nonprogressive.

Our mid-term results demonstrate that a good-to-excellent outcome can be achieved in approximately 85% of cases, even in a severely deformed population. Importantly, these results have been achieved with a low incidence of complications. The clinical outcomes for this subset of patients are similar to those reported in standard, uncomplicated TKA series.[3,9,15,19,20] In the study by Easley et al,[7] the use of a constrained insert had no adverse effects in 44 valgus knees with an average preoperative deformity of 18°. The Knee Society scores in that study, at average 7.8-year follow-up, were similar to our results. The low complication rate in our study was also comparable to the study by Easley et al,[7] which had no radiographic loosening or prosthetic failures.

Our study had a number of limitations—it was a short- to mid-term retrospective review of two surgeons' experience; the study lacked a matched group and involved the NMC only; indications for the use of either the NMC prosthesis or the posterior-stabilized implant was left to the surgeons' judgment (when the posterior-stabilized prosthesis was deemed to be unstable intraoperatively, the constrained component was used) and was not standardized; and although families of the deceased reported that all of the prosthetic knees had been functioning well at time of death, it does not imply that they were well fixed. However, the study analyzed a significant number of patients, involved adequate follow-up, and had a definitive outcome, consistent with prior publications on the topic.

In the short- to mid-term, an NMC implant without intramedullary stem extensions functions well in patients with severely deformed knees requiring primary TKA and

questions the need for the routine use of stem extensions in such patients. However, further investigation with longer follow-up is required to obtain a definitive conclusion.

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