

# Short and mid term results of revision total knee arthroplasty with Global Modular Replacement System

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## ABSTRACT

**Background:** The original knee megaprotheses with fixed or rotating hinge articulation were custom made and only used for reconstruction of the knee following distal femoral or proximal tibial tumor resections. The aim of the study was to analyze the short- and mid-term results of revision total knee arthroplasty with Global Modular Replacement System (GMRS) used in difficult situations not amenable to reconstruction with standard total knee replacement implants.

**Materials and Methods:** Nine patients (9 knees) were treated with this comprehensive modular implant system, with a mean age of 73.7 years (range 56–83 years) and a mean followup of 5 years (range 3–8 years). Two patients were treated for distal femoral nonunion, five for distal femur periprosthetic fracture and two for periprosthetic joint infection.

**Results:** The mean Knee Society Score: Knee and functional scores were 77.9 and 40 points, respectively. All demonstrated full extension and flexion was at least 90°. Recurrence of infection was present in one patient. No signs of loosening, dislocation, or implant failure were observed.

**Conclusions:** Based on our small series of patients that represent severe cases, GMRS provides relatively good mid-term functional results, pain relief, and good implant survivorship with a low complication rate. This salvage procedure allows elderly, infirm patients to regain early ambulatory ability.

**Key words:** Knee arthroplasty, loosening, revision, complications, periprosthetic fractures nonunion

**MeSH terms:** Arthroplasty, replacement, knee, prosthesis loosening, revision, joint

## INTRODUCTION

The original knee megaprotheses with fixed or rotating hinge articulation were custom made and only used for reconstruction of the knee following distal femoral or proximal tibial tumor resections.<sup>1-3</sup> Improvements in technology and greater experience with limb salvage procedures have increased demand for modular revision implants in cases of metastatic disease, comminuted periarticular fracture, nonunion at the side of the knee after failed open reduction and internal fixation (ORIF)

and salvage revision total knee arthroplasty (TKA).<sup>4-7</sup> The decision to use a reconstructive knee implant should be made with care, and should also take into account both the pathology of the knee and the general condition of the patient. The goals of this operation are the stable fixation of the prostheses to the host bone and restoration of the joint line to achieve a stable range of motion consistent with the daily activities of the patient. This form of TKA offers several advantages such as early stability, mobilization, and weight-bearing capacity. The Global Modular Replacement System (GMRS) is a reconstructive TKA solution that has been used by one of the present authors (Jacek Kowalczewski).<sup>4,5,7</sup>

The aim of the study was to analyze the short- and mid-term results of revision TKA with GMRS used in difficult situations

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Access this article online	
Quick Response Code:	Website: www.ijoonline.com
	DOI: 10.4103/0019-5413.205684

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**How to cite this article:** Marczak D, Kowalczewski J, Czubak J, Okoń T, Synder M, Sibiński M. Short and mid term results of revision total knee arthroplasty with Global Modular Replacement System. Indian J Orthop 2017;51:324-9.

not amenable to reconstruction with standard total knee replacement implants.

**MATERIALS AND METHODS**

A retrospective analysis was performed of clinical and radiological data obtained from 9 patients (9 knees) treated with GMRS. These procedures were performed by the senior author (Jacek Kowalczewski) during the period 2006–2011 in an orthopedic center specializing in hip and knee replacement surgery. The clinical and demographic data of the patients are given in Table 1. All nine cases required distal femur replacement. The age of the patients ranged from 56 to 83 years (mean 73.7 years) and the time to followup ranged from a minimum of 3 to 8 years (mean 5 years). Two patients were treated with GMRS for distal femoral nonunion, enabling treatment with other operative methods (patients 1 and 2) [Table 1]. Five cases required revision arthroplasty for distal femur periprosthetic fracture

with no chances of success for ORIF (patients 3–7) [Table 1], and the remaining two had a history of periprosthetic joint infection (PJI) (patients 8 and 9) [Table 1]. In cases of previous deep PJI, reimplantation was performed after microbiological evaluation and exclusion of infection. All patients had walking difficulties (or could not walk) with a significant functional deficit, they were not able to perform normal day-to-day activities.

The GMRS system is designed to facilitate limb-sparing surgery by permitting the replacement of the proximal, distal or total femur and the proximal tibia. The procedure provides skeletal support for missing bones and allows mobility. Its modularity allows different configurations of the component parts.

In all those nonstandard rare cases, we had no standard clinical algorithm. Those were limb salvage procedures and every case was treated individually. Good preoperative

**Table 1. Clinical and demographic details of patients**

No	Gender	Age at operation (years)	Clinical data	Followup (years)	Preoperative KSS/functional score	ROM before TKA Extension /flexion	Final KSS/ functional score	ROM after TKA Extension /flexion
1	♂	75	Supracondylar fracture femur treated with cast immobilization, skeletal traction. Five ORIFs performed during 10 years with no success - femur fracture nonunion	8	24/20	0°/0°	88/50	0°/90°
2	♂	56	Open comminuted fracture of right distal femur after motor accident. Four operative attempts to gain union with no success. Wheelchair user. Right distal femur nonunion	7	19/5	20°/20°	78/25	0°/130°
3	♀	82	Comminuted periprosthetic fracture of distal right femur with no chances of success for ORIF. Cast immobilization at admission	5	0/0	NA	79/50	0°/120°
4	♀	83	Comminuted periprosthetic fracture of distal right femur with no chances of success for ORIF. Cast immobilization at admission	4	0/0	NA	79/30	0°/125°
5	♀	77	Comminuted periprosthetic fracture of distal right femur with no chances of success for ORIF. Cast immobilization at admission	4	6/0	NA	79/40	0°/130°
6	♂	79	RA. periprosthetic left femur fracture 2 years after TKA. Unsuccessful attempt to treat the fracture with cast immobilization	6	11/20	NA	73/45	0/115°
7	♀	77	Massive bone lost after femoral component loosening. Cast immobilization at admission	4	11/20	NA	79/15	0/100°
8	♂	61	Septic TKA loosening treated twice with two stage revision. GMRS was implanted during second revision	3	22/30	0/40°	73/65	0/90°
9	♀	73	Septic loosening after total knee realloplasty. During third and fourth aseptic revision GMRS was implanted	4	17/30	NA	73/40	0/90°
Mean		73.7		5	12,2/13,9		77.9/40	0/110°

GMRS=Global Modular Replacement System, ORIF=Open reduction and internal fixation, TKA=Total knee arthroplasty, RA=Rheumatoid arthritis, ROM=Range of motion, KSS=Knee Society Score, ♂=Male, ♀=Female, NA=Not available

planning was performed, mostly to assess possibility of firm implant fixation to the femur and tibia. If there was a lack of femoral condyles or massive lack of distal femur, the GMRS was used as an alternative for amputation.

All patients received clinical and radiographic followup examinations after 6 weeks, after 3, 6, and 12 months, and then each year afterwards. All nine patients were available for review. Knee Society Score (KSS) was used for assessment: Knee and functional score.<sup>8</sup> In six patients, range of motion could be assessed before the operation. Five patients were immobilized in a cast at admission (patients 3–7) [Table 1] and one presented a modular rotating-hinge (MRH) femoral stem breakage (patient 9) [Table 1]. Radiological assessment was conducted according to The Knee Society TKA Rentgenographic Evaluation and Scoring System.<sup>9</sup> All X-rays and clinical results were assessed by MS, who did not participate in the operative treatment of patients. At the final followup visit, all X-rays were assessed for loosening, alignment, and implant migration.

The study was performed in accordance with the ethical standards of the 1964 Declaration of Helsinki. All patients gave their informed consent prior to their inclusion in this study. The study was approved by the ethics committee at our institution.

## RESULTS

During the most recent followup visits, all patients presented improvement in knee function [Table 1]. Last followup KSS: Knee and functional score as well as range of movement showed improvement comparing to preoperative status. The mean KSS: Knee and functional scores were 77.9 and 40 points, respectively, and the mean improvement in the scales was 65.7 and 26.1, respectively. Three of nine

patients needed support and 6 were independent ambulators. The reason to use crutches by those three patients was anxiety of falling due to multiple operations and weak quadriceps muscle. Full extension was noted in every case and flexion was at least 90°. They could walk shortly after surgery, bearing weight on the joint and were relatively pain free.

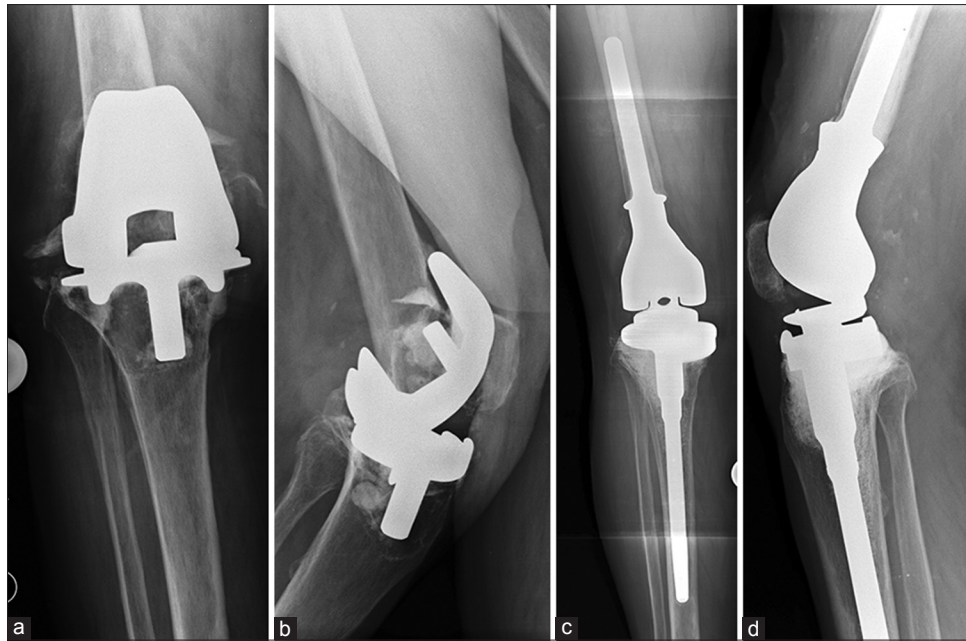
Two patients required revision TKA after septic loosening (patients 8 and 9). Patient 8 (body mass index 40, C-reactive protein 151.0 mg/L) was treated twice with two-stage revision TKA. After second revision, recurrence of infection and loosening of tibial component was found at the time of the most recent followup, antibiotic suppression therapy has been continued [Table 1]. He did not agree for further treatment. Patient 9 required primary TKA in year 2002 and aseptic loosening was noted in year 2008. MRH implant was used for revision, but this operation was complicated by infection. Second revision due to septic loosening was required and another MRH implant was used in December 2008. In January 2011, patient sustained femoral stem breakage and a third revision for aseptic loosening was performed with GMRS. After 3 years, progressive loosening of femoral component was noted, which was the indication for the next GMRS implant. Hence, GMRS re-arthroplasty with cemented stem was performed for the aseptic loosening of the femoral component. No recurrence of infection or signs of loosening were observed at last followup [Figure 1]. No signs of loosening, dislocation, or implant failure were observed in other patients [Figure 2].

## DISCUSSION

A comprehensive modular implant system was considered in patients from our cohort with extensive bone loss after severe trauma or periprosthetic fracture of the distal femur or nonunion, and multiple revision procedures of the knee after previous failed TKA.



**Figure 1:** (a-f) Radiographs of the knee anteroposterior and lateral views of patient number 9 in Table 1 showing loosening of modular rotating-hinge implant with femoral stem breakage (a and b) treated with Global Modular Replacement System revision. After 3 years progressive loosening of femoral component was noted (c and d) requiring next revision with another Global Modular Replacement System (radiograph from the last followup visit) (e and f)



**Figure 2:** X-ray of knee joint anteroposterior and lateral views of patient 5 in Table 1 showing (a and b) periprosthetic femur fracture of right knee (c and d) treated with Global Modular Replacement System, at 4 years followup no sign of loosening

Implant selection in case of segmental bone defects is based on the status of the ligaments and the dimension of bone loss. Standard prostheses with metal augments, cement, allograft or bone grafts can be used for small segmental bone defects.<sup>10,11</sup> However, in cases of severe bone loss or complete clinical insufficiency of all major ligaments (medial or lateral collateral ligament, anterior cruciate ligament, posterior cruciate ligament), increased constraint is required, from a posterior stabilized prosthesis to a condylar constrained knee, or a rotating hinge device.<sup>12,13</sup> GMRS is a comprehensive modular implant system with rotating hinge that allows for massive bone reconstruction after tumor resections, fractures, nonunions, or salvage TKA revision.<sup>14,15</sup>

The results obtained in our group should be considered valid, as most of the patients were elderly and with low physical demands. GMRS was used as a salvage procedure, when other treatment options failed or gave low chances of success. The KSS outcome obtained in this population was 78, with a functional score of 40 points. Ambulation was possible in all cases, with three of patients requiring permanent support by crutches. After the operation, it was possible to allow for full weight bearing and early mobilization, which is particularly important in this group of patients. The results were very well accepted by patients, as although most were not able to walk before operation, this procedure allowed them efficient ambulation afterwards.

Springer *et al.* presented similar results from a comparable group of patients in terms of indications, followup and age. KSS ranged from 45.4 to 75.5 and functional score

from 8.6 to 25.<sup>7</sup> The results presented in the recent study are slightly better with respect to range of motion and final results. Keenan *et al.* reported good or excellent results in six of seven patients for the treatment of supracondylar femoral fractures above total knee prostheses with custom made rotating hinge prosthesis.<sup>16</sup> Davila *et al.* also report satisfactory results and excellent range of motion after surgery in the treatment of persistent supracondylar femoral nonunions in two elderly patients treated with megaprotheses. They concluded that this treatment was well tolerated, permits early ambulation and return to daily living activities.<sup>17</sup> Berend and Lombardi reviewed 37 patients with rotating-hinged distal femoral replacement devices for nontumor cases. KSSs improved from 39 preoperatively to 87, and pain scores improved from 18 preoperatively to 43. However, three patients reported deep infection, one periprosthetic fracture, and one patient had polyethylene insert exchange to treat hyperextension.<sup>18</sup>

Also Fakler *et al.* recommend this procedure especially for elderly patients after complex fractures and posttraumatic sequelae with massive bone destruction.<sup>5</sup> Park *et al.* conclude that prosthetic replacement is a reliable method of reconstruction for pathological fractured isolated bone metastases.<sup>1</sup> All authors recommend prosthetic replacement as it allows immediate full weight bearing, early mobilization and shows relatively good functional outcome.<sup>1,4,7,16-18</sup>

The clinical outcome and prosthetic survival of all modular tumor and revision systems are clearly inferior to those of conventional total hip or total knee systems.<sup>19,20</sup> These implant systems are used on large osseous defects which

need to be bridged and soft tissue defects. The fixation techniques are more complicated and more complex restoration of joint biomechanics is needed.

The disadvantages of prosthetic reconstructions are the limited revision options and difficult reattachment of the patellar tendon with gastrocnemius muscle flap coverage especially when proximal tibia replacement components are used. If rotating hinge prostheses fail, revision surgeries are challenging procedures, because the only possibilities are the reinsertion of another rotating hinge knee, an allograft-prosthesis composite, arthrodesis or amputation.

An alternative option for knee prosthetic reconstructions is the use of less advanced implants with allografts or bone substitutes. Mascard *et al.* and Biau *et al.* conclude that limb salvage surgery at the knee would have a better outcome using a tumor prosthesis than an allograft implant composite.<sup>21,22</sup> A comparative study by Wunder *et al.* also shows that limb salvage surgery at the knee has a better and more predictable outcome with a tumor prosthesis than with an allograft implant reconstruction.<sup>3</sup> It seems that longer life expectancies can be accomplished in younger patients if segmental bone defects are reconstructed with an allograft-prosthesis composite. Older, less active individuals with higher surgical risk, similar to the patients described in the present study, require a modular, segmental replacement prosthesis.<sup>6</sup>

Aseptic loosening, infection, mechanical failure, and periprosthetic bone fracture are still the most common complications in the prosthetic reconstruction of the knee.<sup>7,18,21-25</sup> However, only one recurrence infection was noted in our patients at the mean 5-year followup.

According to previous studies, aseptic loosening is the most frequent cause of failure, followed by infection.<sup>3,21,23</sup> It occurs mostly at the distal femur and is relatively rare on the tibial side. The range of failure related to aseptic loosening ranges from 9% to 17% in the literature.<sup>3,7,21,23,24,26</sup> However, some of these studies include patients with both tumor and nontumoral cases. Salvage TKA for tumor resection is performed also in younger patients, where the risk of loosening is greater due to a higher level of activity.<sup>2</sup> Furthermore, modular knee implants represent a wild spectrum of implant combinations which may influence the outcome. Finally, older studies included the results of fixed-hinge TKA implants, which are inferior to the newer rotating hinge prosthesis.<sup>27</sup>

The study has some limitations. The main limitation is small sample size. Furthermore, this group of patient is

nonhomogenous with variety of indications to surgery. There was also difficulty to perform precise clinical examination in some patients before operation as they were sent to surgery in casts. We are fully aware that in those severe cases none of the scales (KOOS, Oxford, WOMAC, IKDC) is suitable to assess pre- and postoperative status of the knee. We can predict that postoperative score may be less than favorable, but the limb before operation is nonfunctional. The only way to do clinical assessment is subjective rating of the patient. We aimed to show, that this kind of procedures can be performed in nontumor cases and can be treated as an alternative for limb amputation. We believe that this weakness can be justified, as indications for GMRS as non-neoplastic are rare, number of patients small and the treatment is worth popularization as a salvage procedure.

Based on our small series of patients that represent severe cases, GMRS provides relatively good mid-term functional results, pain relief and good implant survivorship with a low complication rate. This salvage procedure allows elderly, infirm patients to regain early ambulatory ability.

#### Financial support and sponsorship

Nil.

#### Conflicts of interest

There are no conflicts of interest.

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