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Case Series

Robotic Total Knee Arthroplasty in Post-Traumatic Osteoarthritis: A Report of Three Cases

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Abstract

Background: The purpose of this case study is to present three cases in which the robotic assisted TKA device was used to correct a severe post traumatic osteoarthritis. Routine conventional TKA in complex PTOA can be challenging and difficult to execute precisely due to articular distorted anatomy.

Patients and Methods: A single centre retrospective series collated the records of three patients (mean age, 46.3 years) who underwent TKR for post-traumatic osteoarthritis of the knee associated with intra-articular malunion. Mean trauma-to-TKR interval was 8.2 years (range 1 to 6.9 years). Patients were assessed clinically and radiologically at last follow-up, using the Knee Society score and WOMAC score at a mean of 16.3 months.

Results: At a mean overall follow-up of 16.3 months (range 12 to 19 months), mean knee society score improved from 67 to 144.3 and WOMAC score 53.6 to 4.6. Mean flexion gain was 6 ∘ : mean preoperative flexion, 103 ∘ (0 ∘ to 110 ∘), vs. 115 ∘ (0 ∘ to 115 ∘) at final follow-up. No complications were observed in this series.

Conclusion: Robot-assisted surgery allows the surgeon to restore alignment even in patients with severe deformities. In this case series, we have illustrated how the robotic device corrected severe PTOA and flexion deformities in patients, which can be challenging in routine TKA.

Keywords: Robotic Total Knee Replacement; Post Traumatic Osteoarthritis; MAKO

Introduction

Radiological evidence of post-traumatic osteoarthritis (PTOA) after fracture of the tibial plateau is common with end-stage arthritis and requires total knee arthroplasty. This becomes a challenging problem as the incidence of PTOA increases with the severity of the fracture and any loss of reduction, and malalignment of more than 5° [1]. Recent advances in surgical technology have allowed the accurate planning and management of these challenges.

While there are data confirming the ability of robotic devices that correct knee alignment better than the manual technique, there is a lack of data related to the use of robotic devices in more complex cases of proximal tibial deformities with distorted anatomy. In our case series, we discuss challenges and how the Mako Robotic Arm-Assisted Surgery System (Mako Surgical Corp., Stryker, Fort Lauderdale, FL) helped us achieve optimal outcomes. This study aimed to analyze how robotic arm technology helps in complex cases of proximal tibia deformities and to examine the outcome of TKA in these situations.

Statement of informed consent

Each patient was informed that data concerning the case would be submitted for publication and that each patient agreed

Case Reports

Case 1

A 40-year-old man with no medical history presented with pain and deformity of the right knee at the outpatient department. The patient had a history of a road traffic accident and underwent open reduction and internal fixation (ORIF) of the right proximal tibia. Unfortunately, the pain persisted, and implant removal was performed 10 months prior to presentation. The assessment showed a midline scar of 10 cm, a flexion deformity of 20 degrees, and a range of movement of up to110 degrees. The range of movement was painful throughout the arc of motion, and there was crepitation. Ligament integrity and neurovascular status were intact upon examination.

Serial anteroposterior (AP), lateral, skyline views, and scanograms were obtained (Figure 1a and 1b). Blood tests were performed to rule out infection and inflammatory pathologies.MRI was performed to assess ligament integrity and cartilage status. Subsequently, the patient was diagnosed with post-traumatic osteoarthritis. The patient had failed operative management and developed osteoarthritis; therefore, we planned a robotic-assisted right TKA. A preoperative computed tomography (CT) of the knee was performed.

In view of the proximal tibial deformity, meticulous 3D planning was done on the Mako platform. CT scan revealed a malunited multi-fragmented proximal tibia. Informed consent was obtained, and the patient agreed to undergo a TKA after understanding all the possible complications. The patient was placed in a supine position under spinal anesthesia, and a midline parapatellar approach was taken through the previous scar under a tourniquet. To begin the procedure, two bicortical pins were placed proximal and distal to the knee arthrotomy site. A standard medial parapatellar approach was performed with a minimal medial release. The knee was then brought into extension. A checkpoint was placed in the tibia, followed by a checkpoint in the femoral component. Bone registration (Figure 2a) was conducted, and the patient's bony anatomy was matched with their CT scans through navigation technology and registration of checkpoints, allowing the plans to be executed accordingly. This robotic system is a semi-automated system where the surgeon maintains control of the robotic arm, working within the preplanned boundaries. The knee was then brought into 90 degrees of flexion. Navigation data points were collected on the femur and tibia with subsequent confirmation. The resting state in both extension and flexion at 90 degrees was then collected (Figure 2b).

Figure 1a and 1b: Preoperative anteroposterior (AP) and lateral radiograph.

There was a 15 degrees varus deformity and 18 degrees of flexion deformity, correctable to 13 degrees. Data points were collected in both extension and flexion at 90 degrees, with correction of the varus knee misalignment to neutral at both positions. The virtual prosthesis was manipulated on the computer to allow for balancing and realignment so that the flexion and extension gaps were uniform and consistent to approximately 18 mm, which accounts for the thickness of the prostheses. This was achieved by

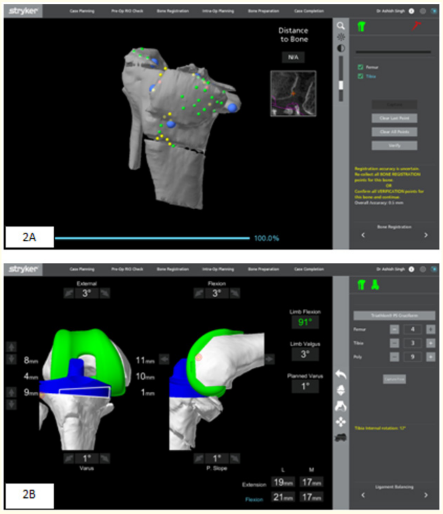

Figure 2a and 2b: Intraoperative bone registration and ligament balancing (robotic screen shot).

Figure 3a and 3b: Anteroposterior (AP) and lateral radiograph at 3-months follow-up.

adjusting the virtual tibia at 2°varus and virtual femur to 3°of external rotation.

After the virtual alignment, the robot was rolled in, and bony cuts were done with minimal retraction and without anterior subluxation of the tibia.The trial implantation was done after the cut was performed. Afterward, stability and patellar tracking were checked in extension, midflexion, and at 90 degrees of flexion. At this juncture, the posteromedial tibia fragment was unstable, which was reduced and fixed with a T-locking compression plate with a trial implant *in situ*. The decision for using a stem was made as the fracture line extended up to the tibial metaphysis, and the combination of the tibial extension stem and a plate made the construct more stable. The knee was copiously irrigated and closed in layers.

Table 2 shows the final implantation and clinical data. Radiographs at 3 months and 1 year are shown in figures 3a, 3b, 4a, and 4b.

Figure 4a and 4b: Anteroposterior (AP) and lateral radiograph at 1-year follow-up.

Case 2

A 55-year-old man with a history of hypertension and diabetes had a proximal tibial fracture treated with ORIF and lateral condylar plate 7 years previously. The patient had pain and limitation of movement since 1 year. Upon examination, the range of movement was from 0 to 110 degrees, and crepitation was present throughout the range of movement and with no ligamentous instability. A 15 cm healed surgical scar was present on the anterolateral aspect. Distal neurovascular status was intact. Multiple imaging views of the left knee revealed advanced degenerative changes in the lateral and medial compartment (Figures 5a and 5b), including subchondral sclerosis, marginal osteophytic change, and complete joint collapse with an implant *in situ*. MRI scan was not performed as the previous record of the implant was not available.

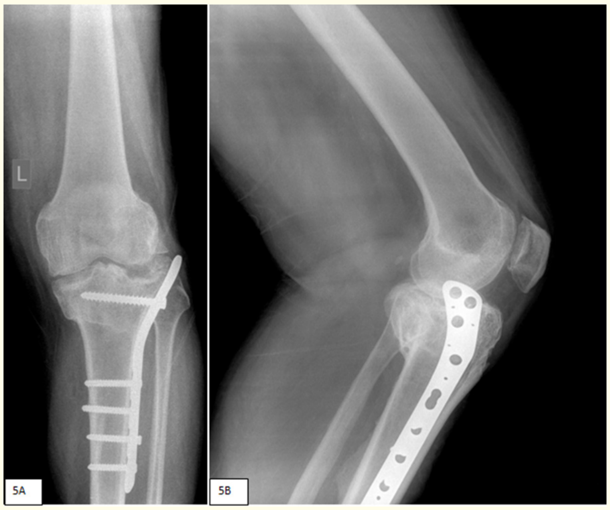

Figure 5a and 5b: Case 2 preoperative anteroposterior (AP) and lateral radiograph.

Surgery was performed as per the previous case; however, challenges during this case were the coexisting implant and the pre-existing fibrosis, ligament status, distorted intra- articular anatomy, possible deep-seated infection, joint line, and bone loss management. The proximal tibial surface was deformed intraoperatively. There were extensive adhesions and fibrosis due to the presence of the implant, which were carefully removed to avoid injury to the lateral structures. Bone registration was performed with the implant *in situ,* followed by removing the implant and osteophytes, balancing, and the virtual implant position was ascertained (Table 2; Figures 6a and 6b). Case was followed up to 18 months and clinical outcomes are elaborated in table 2.

Case 3

A 44-year-old man with no medical comorbidities, with a history of road traffic accident 2 years ago, and who underwent surgery of the lateral condylar plate presented with fixed flexion of 47.3 degrees with further flexion of up to 90 degrees with pain.

Figure 6a and 6b: Case 2 anteroposterior (AP) and lateral radiograph at 1-year follow-up.

The plate was removed one and half years prior due to infection. Routine protocol AP and lateral views were done. Blood tests were performed to rule out infection, and MRI scans of the knee and the quadriceps were performed to assess the status of the quadriceps muscle and ligament integrity.

In particular, there were multiple surgeries performed, and a history of infection and extensive fibrosis was anticipated. After anesthesia, the patient was assessed, and no extension was possible. A routine approach was taken, and all adhesions were carefully released. Flexion deformity was corrected up to 10 degrees. During surgery, this patient had undergone a quadriceps snip, as described by Abdel., *et al*. [4].

Surgery was performed similarly to the previous case; however, challenges during this case were the coexisting implant and the pre-existing fibrosis, ligament status, possible deep-seated infection, joint line, and bone loss management. The tibia and the femoral checkpoints were inserted as per the routine protocol, and femoral and tibial registrations were performed. The femoral and tibial cuts were performed as per the plan using the robotic arm technology. The final position of the implants and the results are elaborated in table 2. Final follow up was till nineteen months.

Results

At a mean overall follow-up of 16.3 months (range 12 to 19 months), mean knee society score improved from 67 to 144.3 and WOMAC score 53.6 to 4.6. Mean flexion gain was 6∘: mean preoperative flexion, 103∘ (0∘ to 110∘), vs. 115∘ (0∘ to 115∘) at final follow-up. No complications were observed in this series (Table 1 and 2).

	Case 1	Case 2	Case 3
Age(years)	40	55	44
Sex	M	M	M
BMI	21.4	23.2	22.8
Charlson comorbidity index	0 point	2 points	0 point
Time from fracture to TKA (days)	310	2554	360
Preoperative ROM (degrees)	20°-110°	0°-110°	45°-90°
Final ROM (degrees)	0°-120°	0°-120°	5°-105°
Preoperative Knee Society Score (points)	90	97	14
Final Knee Society Score (points)	140 (Twelve months)	148 (Eighteen months)	145 (Nineteen months)
Preoperative WOMAC score	61	48	52
Final WOMAC score	6 (Twelve months)	4 (Eighteen months)	4 (Nineteen months)

Table 1: Demographic data of patients with post-traumatic arthritis of the knee.

Discussion

In the above-mentioned cases, TKA had provided a better result; however, it was inferior when used in conventional primary osteoarthritis of the knee.

The few available literature has shown approximately 20% complications in such cases [2-4]. To the best of our knowledge, literature is scarce for such cases that were managed by MAKO. We have tried to manage challenges in our three cases.

			Case 1	Case 2	Case 3
Preoperative-deformity	Varus		12.3°	10.2°	5°
	Flexion		18°	7°	45°
Final alignment	Varus		1°	0°	1°
	Flexion		0°	0°	1°
Intra operativegap balancing	Extension gap	Medial(mm)	18	19	13
		Lateral(mm)	20	19	16
	Flexion gap	Medial(mm)	14	15	12
		Lateral(mm)	18	17	14
Post-operativesoft tissue tension	Extension gap	Medial(mm)	19	20	18
		Lateral(mm)	20	20	19
	Flexion gap	Medial(mm)	20	20	19
		Lateral(mm)	19	21	18
Component Size	Tibia		3	4	3
	Femur		4	5	4
	Insert(mm)		9	11	9
Augment	Tibia stem(mm)		11 × 100	13 × 100	13 × 150

Table 2: Pre-operative and post-operativedata.

These cases have few inherent problems, such as post-traumatic joint fibrosis and lower limb misalignment induced by cartilage damage and pain. Cases 1 and 2, where TKA was completed within 12 months of trauma, achieved good outcomes.

Case 3 had fibrous ankylosis and previous multiple skin incisions and underwent surgery after 4 years, which is a reason for extrarticular stiffness that is extensor system dysfunction, similar to that reported by a previous study [2]. During surgery, this patient had undergone a quadriceps snip, as described by Abdel., *et al*. [4]. In all three cases, bone loss was managed with an extension rod in the tibia and a primary surface implant in the femur. There were many intraoperative challenges in these cases, and bone registration was also challenging. In all three cases, 32 registration points were obtained and within range. Once registration was done, an assessment of the deformity (intraarticular) was done, and the balancing was achieved on-screen, incorporating minimal bone cut with precision. In these types of cases, the senior surgeon believed that in manual positioning of the tibia, jigs could have been an issue, as the landmarks are distorted and might lead to malalignment. However, the navigation and robotics allowed for a precise and accurate proximal tibial cut position [6,7]. According to Parratte., *et al*. extensor avulsions were observed in 20% of cases in their series [2]. However, the bone cuts are made with MAKO without the subluxation of the tibia anteriorly, thus minimizing the risk for extensor system avulsion.

Conclusion

Robot-assisted surgery allows the surgeon to restore alignment even in patients with severe deformities. In this case series, we have illustrated how the robotic device corrected severe PTOA and flexion deformities in patients, which can be challenging in routine TKA.

Conflict of Interest

None.

Funding Source

This research did not receive any specific funding.

Ethical Approval

This study received ethical approval from the Ethics committee of hospital under the protocol number AIOR-LEO-011.

Informed Consent

Written informed consent was obtained from all patients and/or families.

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Volume 5 Issue 9 September 2022