Salunke's GCRI surgical technique for neopatellar ligament reconstruction using hamstring tendon in proximal tibia tumour megaprosthesis

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Aims

Reconstruction of soft tissues and preservation of the extensor mechanism integrity provide a major challenge following resection of the proximal tibia tumours. We propose a novel surgical technique for neopatellar ligament reconstruction using hamstring tendon in proximal tibia tumour cases. This study details the surgical technique, early clinical and radiological outcomes, and the potential long-term benefits of this innovative reconstructive approach following proximal tibia megaprosthesis implantation.

Methods

This study included 15 patients with proximal tibia tumours treated at orthopaedic oncology unit in Gujarat Cancer and Research Institute (GCRI), Ahmedabad, India. Surgical procedures included resecting the proximal tibia tumour, implanting a megaprosthesis, and using hamstring tendons to reconstruct the extensor mechanism by the neopatellar ligament. Autologous hamstring tendons (gracilis and semitendinosus) harvested from the ipsilateral leg were used and these tendons were braided together with a nonabsorbable suture and threaded through the remaining patellar tendon. The braided tendons were then secured to the holes in the tibial tuberosity of the proximal tibia megaprosthesis implant XLO (Ortho Life Systems, India) using nonabsorbable fibre wire sutures FiberWire (Arthrex, USA). The tension in the tendons was optimized and the sutures were tightened with the knee in full extension and the implant with neopatellar ligament were covered by medial gastrocnemius muscle flap. The mean follow-up period was 19 months (13 to 24), the mean age of the study group was 24.6 years (14 to 44), and it included 11 males and four females.

Results

The histopathological diagnosis was osteosarcoma (eight patients), Ewing's sarcoma (four patients), and giant cell tumours (three patients). The mean surgical duration was 3.2 hours (2.5 to 4.2) and the mean blood loss was 250 ml (150 to 450).Wound infection was found in three cases, which was managed with debridement and antibiotics. None of the patients had a local recurrence at the latest follow-up. The mean active knee flexion was 92° (85° to 105°), with an extensor lag of 4.6° (0° to 10°). The mean patella height preoperatively was 4.5 cm (4.3 to 5.1), with a patella tendon length of 4.7 cm (4.3 to 5.68). The mean preoperative patella height-to-patella tendon length ratio was 0.96 (0.89 to 1.02). Postoperatively (at 12 months), the mean patella tendon length was 4.4 cm (4.1 to 5.1), with a patella height-to-patella tendon length ratio of 1.04 (1 to 1.14). Follow-up radiological examinations showed that the neopatellar tendon had integrated satisfactorily, with no obvious signs of graft rupture or elongation.The mean Musculoskeletal Tumor Society score was 24 (22 to 27).

Conclusion

This study presents Salunke's Gujarat Cancer and Research Institute (GCRI) novel approach using hamstring tendons for neopatellar ligament reconstruction in proximal tibia

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megaprosthesis which successfully restores the knee's extensor mechanism. This technique provides an effective reconstructive option and preserving flexion, extension, and minimizing extensor lag. Additionally, the surgical steps are easily reproducible. Early radiological evaluations in this study demonstrated no evidence of patella alta or baja, though long-term follow-up is recommended.

Take home message

- Salunke's Gujarat Cancer and Research Institute (GCRI) Surgical technique using hamstring tendons for neopatellar ligament reconstruction in proximal tibia tumour megaprosthesis successfully restores the knee's extensor mechanism, allowing for improved function following tumour resection.
- The surgical steps are easily reproducible, allowing for standardization across surgical centers and provide a reliable reconstructive option, making it feasible for use in clinical practice for proximal tibia tumour cases.

Introduction

Historically, amputation was the primary treatment for limb sarcomas; however, the paradigm for treating limb tumours has shifted to include limb salvage surgery due to breakthroughs in chemotherapy, surgery, and radiation. These advances have boosted overall survival rates and drastically decreased the possibility of a local recurrence.[1,2]

Primary bone tumours frequently affect the knee joint, with the distal femur being the most affected, followed by the proximal tibia.[3] Reconstruction of soft-tissues and preservation of the extensor mechanism integrity provide a major challenge following resection of the proximal tibia.[4–6] Research on endoprosthetic reconstruction after proximal tibia resection has been published with the aim of achieving optimal knee function while minimizing challenges.[6–11]

With the aim of reconstructing the extensor mechanism, several techniques have evolved, including mesh reconstruction, bone grafting, direct attachment of the patellar tendon, only medial gastrocnemius muscle flap, and fibula transposition.[6–11] The patellar tendon's direct attachment may cause tendon elongation, tension mismatch, and patella alta, which can impair knee function. Donor site issues and restricted graft length may also result from fibula transposition. Furthermore, diminished strength, compromised function, and delayed recovery are potential consequences, regardless of the strategy. Complications continue to be a major issue, although each technique's success depends on careful surgical execution and patient-specific circumstances.

We propose an innovative surgical technique for neopatellar ligament reconstruction using the hamstring tendon in proximal tibia tumour cases. We evaluated the outcomes of the hamstring tendons (semitendinosus and gracilis) for reconstruction at a tertiary cancer centre.

Methods

This study was carried out at the orthopaedic oncology department in a tertiary cancer centre (Gujarat Cancer and Research Institute (GCRI), India) from 1 January to 30 June 2020. A total of 15 patients (11 males and four females) with proximal tibia tumours were included in our study. Proximal tibia megaprosthesis was performed for the following histopathological diagnoses: osteosarcoma (eight patients); Ewing's sarcoma (four patients); and giant cell tumour (three patients).

Following the clinical evaluation of the patient, conventional radiographs and MRI of the diseased leg were performed as a component of the radiological investigation (Figure 1a). All primary bone tumours were classified using the Enneking staging approach.[12]

Treatment decisions were guided by histological evaluation after core needle biopsy along the planned line of the upcoming skin incision. Neoadjuvant chemotherapy was given before surgery for sarcomas that include osteosarcoma and Ewing's sarcoma, and adjuvant chemotherapy was administered subsequently to surgery. Before surgery, patients with giant cell tumours received a monthly injection of zolendronic acid (4 mg in 100 ml of normal saline) for three months. Preoperative MRI was used to plan a tumour resection with an adequate margin of at least 2 to 3 cm from the tumour's distal growth. The extensor mechanism was reconstructed and proximal tibia megaprosthesis implantation was performed after tumour resection with wide oncological margins. We chose the ipsilateral hamstring tendon autograft procedure as it reduces the need for multiple incisions and lowers the risk of donor site morbidity. Contralateral tendon harvest may be a good substitute in situations when tumour proximity is an issue, but we did not need to do this in any of the cases in our study.

These patients were operated on with a medial approach for the knee joint and were followed up regularly to assess for the oncological and functional outcomes. The Insall-Salvati ratio[13] was used to evaluate patellar placement on lateral knee radiographs both before and after surgery (12 months of follow-up) (Figure 1). We obtained informed consent from the patients and received ethical committee approval from the GCRI.

Surgical technique

We planned to use hamstring tendons to reconstruct patellar tendon and propose a nomenclature as Salunke's GCRI Surgical technique in proximal tibia megaprosthesis. Upon placing the patient supine on the operating table, either general anaesthesia or spinal anaesthesia was administered (Table I). After painting and draping the surgical area, a skin incision was made using a medial approach for the knee joint and proximal tibia (Figure 1). The medial and lateral skin flaps were raised, and homeostasis was achieved using an electrocautery device.

The patellar tendon was properly detached from the proximal tibia during the procedure to ensure that it was safe from the tumour location. Likewise, a sufficient margin was preserved between the tumours and the hamstring tendon on the inside of the tibia, and these were thoroughly isolated. The semitendinosus tendon was then carefully dissected from its attachment on the tibia, ensuring enough soft-tissue encasing around the tumour (Figure 2). A nonabsorbable

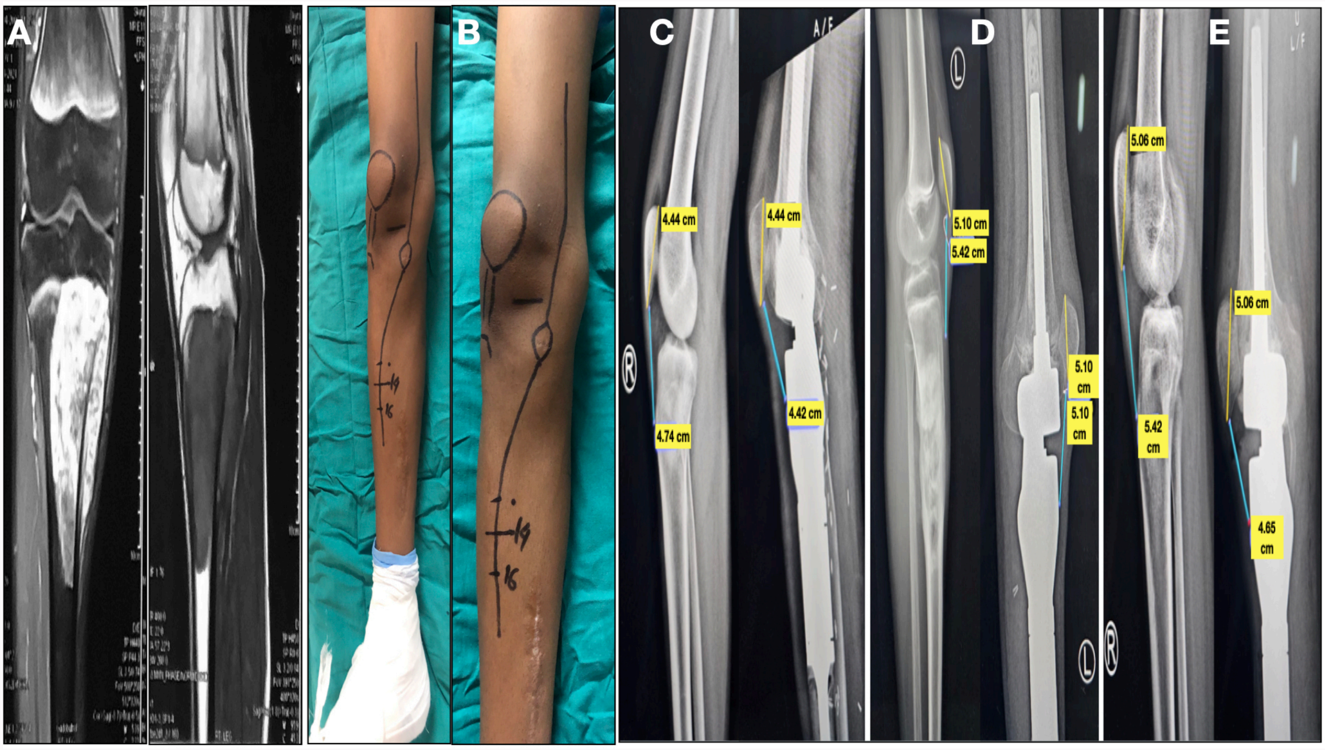

Fig. 1

a) A 17-year-old male patient with a proximal tibia osteosarcoma tumour; MRI of tibia showing a lesion. b) Supine positioning of the patient and a longitudinal incision on the anterior medial aspect of the knee, extending from the distal femur to the proximal tibia. c) The mean patella height preoperatively was 4.44 cm, with a patella tendon length of 4.74 cm. The preoperative patella height-to-tendon length ratio was 0.93, Postoperatively, the patella tendon length at 12 months was 4.42 cm, with the height-to-tendon ratio of 1.004. d) The mean patella height preoperatively was 5.1 cm, with a patella tendon length of 5.68 cm. The preoperative patella height-to-tendon length ratio was 0.89. Postoperatively, the patella tendon length at 12 months was 5.1 cm, with a height-to-tendon ratio of 1. e) The mean patella height preoperatively was 5.06 cm, with a patella tendon length of 5.42 cm. The preoperative patella height-to-tendon length ratio was 0.93. Postoperatively, the patella tendon length at 12 months was 4.65 cm, with the height-to-tendon ratio of 1.08.

Table I. Key steps of neopatellar tendon reconstruction using mastering tendon (semitendinosus and gracilis tendons) after resection of proximal tibia tumour.

No.	Step	Description
1	Patient positioning	Supine position on the operating theatre table
2	Skin Incision	Painting and draping, followed by skin incision using medial approach to proximal tibia and distal femur
3	Patellar tendon detachment	Raising medial and lateral flaps and detaching the patellar tendon form proximal tibia with safe soft-tissue margins
4	Hamstring tendon harvesting	Removal of semitendinosus and gracilis tendons using a tendon stripper
5	Tumour resection	Wide resection of tumour with 2 to 3 cm safe oncological margins based on preoperative MRI
6	Tibia megaprosthesis implantation	Bone reconstruction: reconstruction of bony defect with modular proximal tibia megaprosthesis
7	Neopatellar tendon reconstruction	Extensor mechanism reconstruction: braiding of semitendinosus and gracilis tendons, attachment to tibial tuberosity of the implant
8	Gastrocnemius muscles harvesting	Gastrocnemius muscles harvested and used to cover the neopatellar tendon and extensor mechanism reconstruction and proximal tibial implant
9	Prosthesis coverage	Raising and attaching a medial gastrocnemius flap to cover the prosthesis
10	Closure of soft-tissue and skin	Soft-tissue coverage of the tibia implant closure of the soft tissues in layers, including the quadriceps mechanism and skin closure
11	Postoperative care	Knee brace application, drain removal, quadriceps strengthening, partial and full weightbearing, and active range of motion exercises

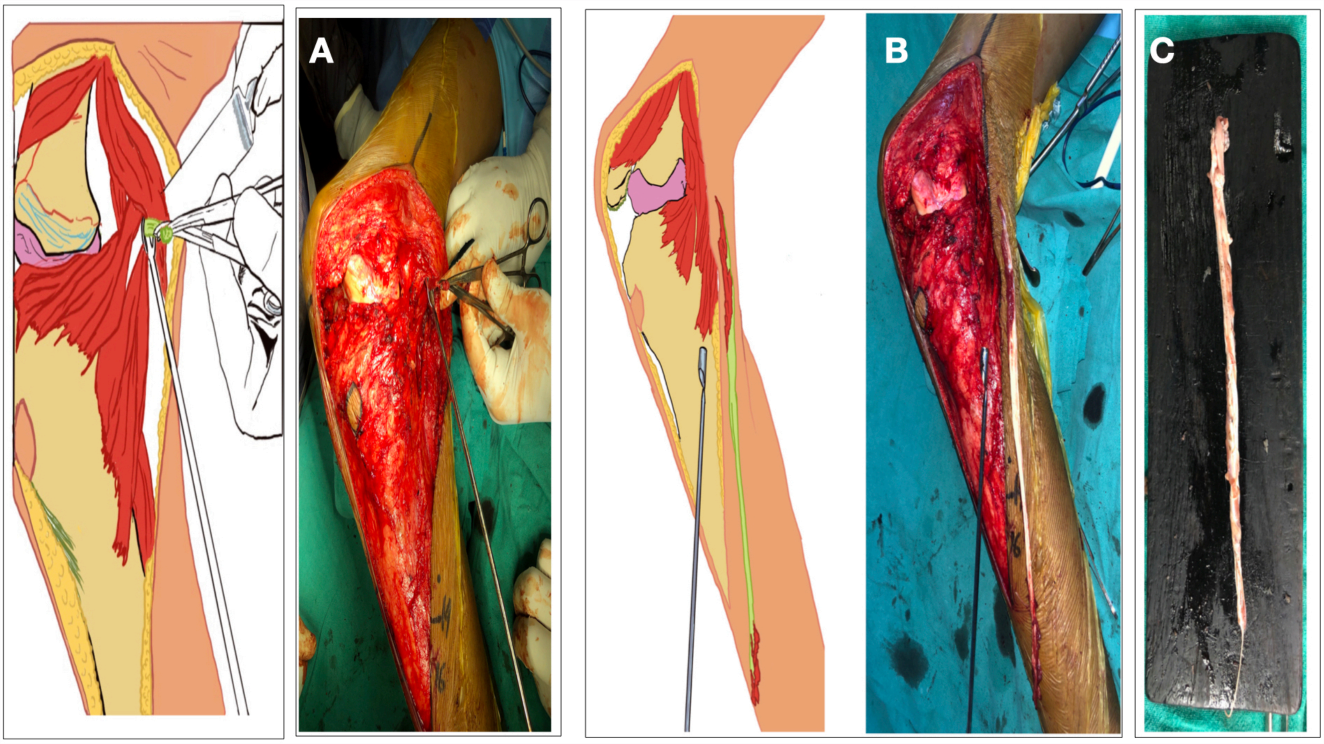

Fig. 2
Harvesting hamstring tendon (semitendinosus and gracilis tendon). a) The identification of the semitendinosus and gracilis tendons and first step of harvesting of tendon with tendon stripper. b) Harvested tendons and tendon stripper. c) The harvested tendon is prepped on a wooden board and remaining soft-tissue is removed.

suture was subsequently introduced through the tendon, and then the tendon was pushed through a tendon stripper to disengage it from its femoral attachment. The gracilis tendon was harvested using a similar procedure.

The neurovascular bundle was dissected from the tumour preserving a safe soft-tissue covering around the tumour. As per the preoperative MRI, the proximal tibia tumour bone tumour resection was performed with an adequate margin of at least 2 to 3 cm from the distal tumour extent (Figure 3a). The bony defect was reconstructed using a modular proximal tibia megaprosthesis implant (Figure 3b). The extensor mechanism was reconstructed utilizing the harvested semitendinosus and gracilis tendons.

The hamstring tendons were prepped on the operating table, and the excess soft-tissue was taken out. These tendons were braided together with a nonabsorbable suture and threaded through the remaining patellar tendon. The braided tendons were then secured to the holes in the tibial tuberosity of the proximal tibia megaprosthesis implant by XLO (Ortho Life Systems, India) using nonabsorbable fibre wire sutures FiberWire (Arthrex, USA) (Figure 3). The tension in the tendons was optimized and the sutures were tightened with the knee in full extension (Figure 4).

The modular proximal tibia prosthesis was assembled to match each patient's resection length. The implant comprised a 70 mm tibial component, a resection spacer (beginning at 35 mm with 10 mm increments), and a tibial stem (available in 10 to 12 mm sizes), side-specific femoral components for the right and left knee were used. All components of the megaprosthesis were manufactured by XLO(Ortho Life Systems). The implant and the neopatellar ligament were covered with a medial gastrocnemius flap. The skin was then closed in layers, and a negative suction drain was placed (Figure 5). A knee brace was used following surgery to keep the knee extended. The drain was removed three to four days following surgery after collection of less than 50 ml of fluid.

Quadriceps strengthening and partial weightbearing were started after the first week following surgery. Adjuvant chemotherapy began when the sutures were removed. Full weightbearing commenced four weeks after surgery, and active range of motion (ROM) exercises resumed 12 weeks following surgery.

Results

A total of 15 patients (11 males and four females) underwent neopatellar tendon repair with hamstring tendons at our hospital after a resection of a proximal tibia tumour. The mean age of the study group was 24.6 years (14 to 44; SD 9.56). The mean follow-up period was 19 months (13 to 24) (Table II).

This histopathological diagnosis included eight osteosarcomas, four Ewing's sarcomas, and three giant cell tumours. There were three stage IIA and nine stage IIB tumours, according to the Musculoskeletal Tumor Society (MSTS)[12] system of tumour staging. Following biopsy confirmation, all patients with osteosarcoma received neoadjuvant chemotherapy using the MAP protocol (methotrexate, doxorubicin, and cisplatin), which included high-dose methotrexate (12 g/m^2), cisplatin (120 mg/m^2 over two days), and adriamycin (75 mg/m^2 over three days), as per the institutional protocol. Following biopsy confirmation, neoadjuvant chemotherapy utilizing the VACM protocol

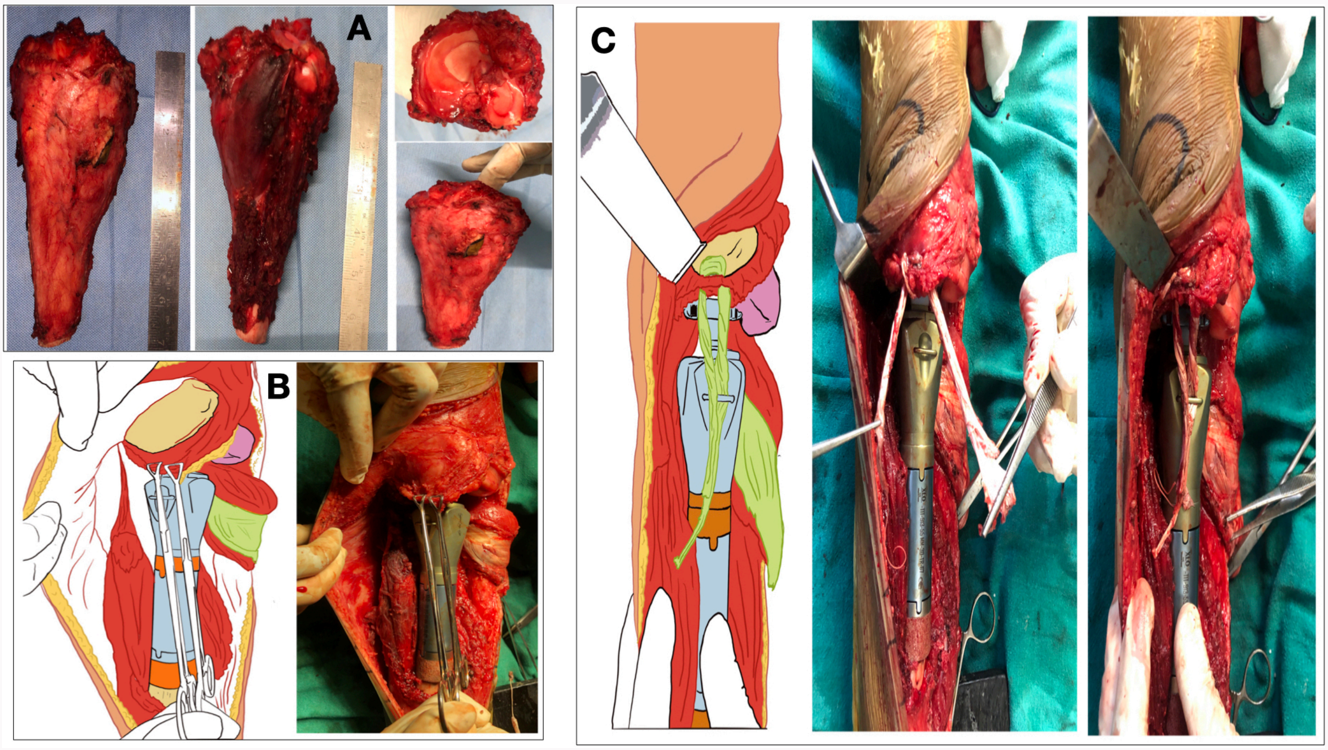

Fig. 3

a) Resected specimen of the proximal tibia tumour with a margin of healthy tissue. b) The megaprosthesis joint and soft-tissue around the knee after to resection of the proximal tibia and the preserved patellar tendon. c) The harvested tendons are routed through the remaining patellar tendon below the inferior pole of the patella using nonabsorbable sutures and passed through the slot in tibial prosthesis implant.

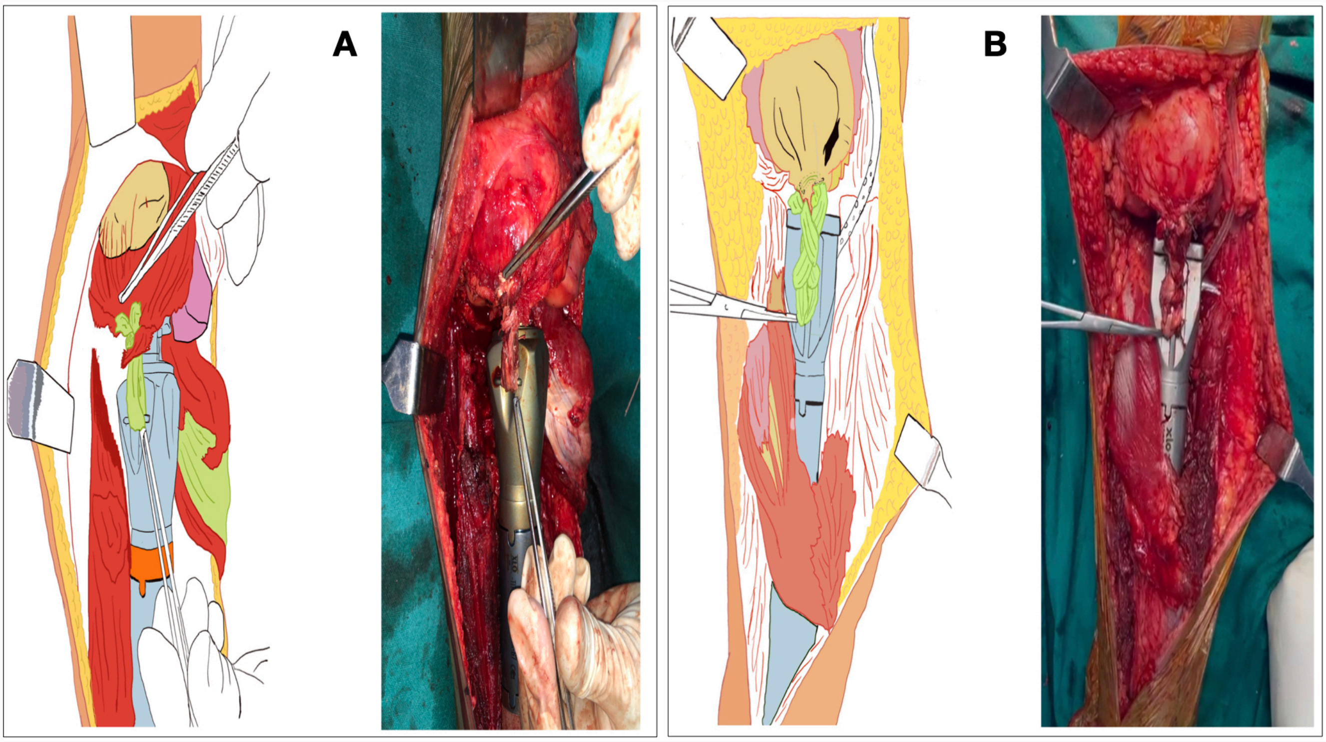

Fig. 4

a) Technique 1: the tendons being routed beneath the patella and tensioned to simulate the natural course of the patellar tendon and fixed through the tibial prosthesis slot. b) Technique 2: the braided and weaved tendons are fixed to the tibial prosthesis slot for fixation with nonabsorbable sutures.

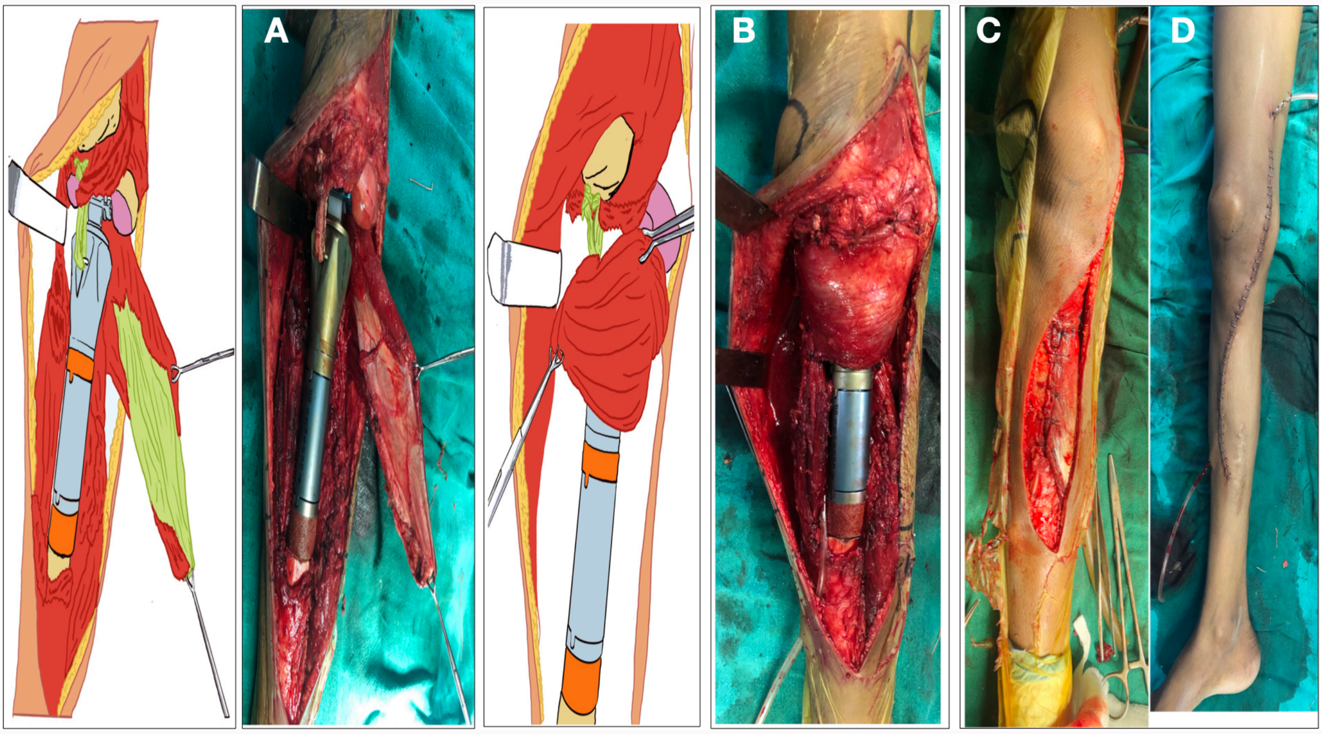

Fig. 5
a) Medial gastrocnemius flap is raised. b) Medial gastrocnemius flap is used for coverage of neopatellar tendon and proximal tibia megaprosthesis implant. c) Soft-tissue coverage of the tibia implant closure of the soft tissues in layers, including the quadriceps mechanism, and skin closure. d) Skin closure following placement of proximal tibia megaprosthesis implant.

Table II. Patient characteristics in current study.

No.	Age, sex	Diagnosis	Enneking stage	Active flexion, °	Extensor lag, °	Preoperative patella height, cm	Preoperative patella tendon length, cm	Preoprative patella height to patella tendon ratio	Patella tendon length at 12 mths, cm	Ratio patella height to patella tendon ratio at 12 mths	MSTS score	Follow-up, mths
1	27, M	Osteosarcoma	IIB	95	5	4.44	4.74	0.93	4.42	1.004	23	18
2	19, M	Osteosarcoma	IIB	90	10	5.1	5.68	0.89	5.1	1.00	24	22
3	21, M	Osteosarcoma	IIA	90	5	5.06	5.42	0.93	4.65	1.08	27	17
4	16, F	Ewing's sarcoma	IIB	90	3	4.69	5.0	0.93	4.1	1.14	26	24
5	39, M	Giant cell tumour	N/A	100	7	4.7	5.1	0.92	4.6	1.02	25	21
6	28, M	Ewing's sarcoma	IIA	85	5	4.3	4.5	0.95	4.1	1.04	24	20
7	14, M	Ewing's sarcoma	IIB	90	5	4.4	4.4	1.00	4.2	1.04	26	23
8	18, F	Osteosarcoma	IIA	95	5	4.5	4.6	0.97	4.3	1.04	23	24
9	22, M	Osteosarcoma	IIB	90	0	4.5	4.5	1.00	4.4	1.12	27	15
10	16, F	Ewing's sarcoma	IIB	90	3	4.4	4.7	0.93	4.2	1.04	22	20
11	44, F	Giant cell tumour	N/A	100	0	4.6	4.8	0.95	4.6	1.00	25	13
12	17, M	Osteosarcoma	IIB	105	0	4.5	4.7	0.95	4.3	1.04	23	17
13	41, M	Giant cell tumour with pathological fracture	N/A	90	10	4.4	4.4	1.00	4.2	1.04	26	14
14	25, M	Osteosarcoma	IIB	85	6	4.8	5.00	0.96	4.5	1.06	24	18
15	21, M	Osteosarcoma	IIB	90	5	4.4	4.3	1.02	4.4	1.00	25	19

MSTS, Musculoskeletal Tumor Society; N/A, not available.

(vincristine, adriamycin, cyclophosphamide, and methotrexate) was administered for Ewing's sarcoma as per the institutional protocol. After 12 weeks, MRI evaluations and surgery were performed.

Table III. A questionnaire was prepared and used for measuring patient satisfaction.

Question	Very Satisfied 😊	Satisfied 🙂	Neutral 😐	Dissatisfied 😕
How do you feel with the appearance of your knee?				
How confident do you feel with the stability of your knee?				
How is your ability to walk independently?				
How is your ability to perform activities of daily living?				

Patients had surgery following chemotherapy, and adjuvant chemotherapy was administered as needed. A thorax contrast-enhanced CT scan and bone scan were performed every three months for the first two years, and then every six months thereafter until the end of the follow-up period.

Surgical technique, reconstruction techniques, and complications

En bloc removal of the proximal tibia, with surgical margins was performed in all patients, which was confirmed with final histopathological assessment. Autologous hamstring tendons (gracilis and semitendinosus) harvested from the ipsilateral leg were used in the reconstruction technique. There was a mean blood loss of 250 ml (150 to 450) and a mean surgical duration of 3.2 hours (2.5 to 4.2). Three cases of wound infection which were successfully managed with debridement and antibiotics. These infections occurred within six months of surgery and functional outcomes were assessed after debridement surgery. One patient had mild anterior knee pain that was successfully treated with anti-inflammatory medications and physiotherapy.

Clinical and radiological assessment functional outcomes

The knee's function was assessed using flexion, extension, and extensor lag. In terms of the clinical outcomes, the 15 patients had stable knee joints with a mean active knee flexion of 92° (80° to 105°), with an extensor lag of 4.6° (0° to 10°).

Preoperative patella height and tendon length were evaluated to assess initial joint alignment and structure (Figure 1c, Figure 1d, and Figure 1e). The mean patella height preoperatively was 4.58 cm (4.3 to 5.1; SD 0.24), with a patella tendon length of 4.78 cm (4.3 to 5.68; SD 0.39). The mean preoperative patella height-to-tendon length ratio was 0.96 (SD 0.04), with values ranging from 0.89 to 1.02. Postoperatively, the patella tendon length at 12 months had a mean of 4.4 cm (4.1 to 5.1; SD 0.26), with the height-to-tendon ratio increasing slightly to 1.04 (1 to 1.14; SD 0.04). Follow-up radiological examinations showed that the neopatellar tendon had integrated satisfactorily, with no obvious signs of graft rupture or elongation.

The mean MSTS score was 24 (22 to 27), which indicates good to excellent function in 80% of patients; we calculated the score at the latest follow-up (minimum 12 months of follow-up) of the patients as per our hospital record database. A custom questionnaire was prepared and was used for measuring patient satisfaction, and 92% of patients said they were satisfied with their experience of the surgery (Table III). Patients were able to walk independently, returning to previous activity levels. Substantial improvements in quality of life and independence in function were reported by the patients, indicating the successful outcome of the reconstruction technique. We conducted a literature review and found various techniques, which include biological (allografts or autologous muscle, tendon) and non-biological methods (synthetic mesh, dacron tape, or trevira tube) for patellar tendon reconstruction (Table IV).[9,14–33]

Oncological outcomes

A total of 12 patients (eight with osteosarcoma and four with Ewing's sarcoma) received adjuvant chemotherapy as per the institutional protocol. Three individuals with osteosarcoma had distant metastases and died of the disease, and none of the patients had a local recurrence at the latest recent follow-up, while 12 patients were disease-free. Three patients had distant metastases affecting both lungs at 14, 17, and 18 months after surgery and were treated with palliative chemotherapy.

Discussion

In this study, we describe a novel surgical technique for neopatellar ligament reconstruction following proximal tibia resection. We used the semitendinosus and gracilis tendons for reconstruction, which resulted in improved knee ROM and MSTS scores. The use of autologous tendons presented several advantages, including cost-effectiveness, and minimizing the risk of foreign body reactions associated with polyprolene mesh or allografts. In the current study, all surgeries were performed by the same lead surgeon to maintain consistency and average surgical time. Blood loss was recorded and was comparable with our previous technique of direct attachment of patellar tendon to implant. None of the our cases exhibited patella alta or baja, and this was regularly monitored in follow-up radiographs. The findings highlight both the effectiveness of the procedures and the potential for minor postoperative adjustments in patellar alignment and tendon structure over time.

Following wide local excision of the proximal tibia, restoring the extensor mechanism is an important factor for achieving good functional recovery. A biomechanically stable, pretensioned extensor mechanism is essential for a good functional outcome. We previously used nonabsorbable sutures (FiberWire; Arthrex, USA) for direct attachment of the patellar tendon to the endoprosthesis, which restricted flexion while maintaining normal extension, resulting in delayed rehabilitation, which began eight weeks after surgery. The direct attachment of the patellar tendon can produce tension mismatch, and patella alta, all of which can compromise knee function.

Table IV. Review of literature for patellar tendon reconstruction techniques following proximal tibia tumour resection.

Study	Cases, n	Type of reconstruction	Surgical technique for extensor mechanism reconstruction	Mean ROM, extension lag °	Mean follow-up, mnths	Functional outcomes, mean score	Complications
Ebeid and Hassan (2023)[22]	55	Endoprosthesis	Patellar tendon secured to endoprosthesis with Ethibond surgical suture (polyethylene terephthalate) + medial gastrocnemius flap	a) 72.63 (SD 25.07) b) 15.09 (SD 15.38)	71.69 (49.76)	MSTS 26.5 (SD 2.22)	Hendersons complication a) Type 1: soft-tissue = four patients (7.4%) b) Type 4: superficial infection): = five patients (9.1%); deep infection = eight patients (14.5%)
Liu et al (2019)[23]	14	Endoprosthesis + mesh	Patellar tendon reconstruction by synthetic mesh (Bard crurasoft patch, 10 cm × 15 cm) + medial gastrocnemius flap	a) Active extension 1 57° (0° to 12°) b) Active flexion 105° (80° to 120°) c) Extension lag 1.57° (0° to 12°)	23.50 (14 to 37)	MSTS 23.57 (19 to 27)	N/A
Ichikawa et al (2015)[24]	9	Endoprosthesis	Mesh + medial gastrocnemius flap	a) Active flexion 97.5° (80° to 120°) b) Extension lag 5° (0° to 20°)	33 (20 to 50)	ISOLS 21 (18 to 26)	Infection in one case followed by amputation
Titus and Clayer (2008)[25]	10	Endoprosthesis	Cerclage wire	a) Active flexion 96° (70° to 110°) b) Extension lag 4°(0° to 20°)	48 (24 to 89)	a) MSTS 82.1% (46.7% to 93.3%) b) TESS 83% (75.8% to 90.5%)	a) Peroneal nerve palsy temporary, permanent b) Infections c) Postoperative adhesions
Biau et al (2007)[26]	26	Allograft prosthetic composite	Medial gastrocnemius flap	a) Active flexion 80.96° (0° to 130°) b) Extension lag 7.7°	128 (6 to 195)	N/A	Extensor mechanism rupture 23%
Ayerza et al (2006)[27]	34	Allograft	N/A	a) Flexion 110° (80° to 135°) b) Lag 6.5° (5° to 10°)	52 (24 to 136)	MSTS 26.6 (18 to 30)	N/A
Biau et al (2006)[28]	35	Endoprosthesis	Medial gastrocnemius flap + ligament augmentation	N/A	62 (6 to 343)	N/A	Extensor mechanism rupture 26%
Dominkus et al (2006)[29]	11	Endoprosthesis	LARS ligament + medial gastrocnemius flap	a) Extension lag 25°	44 (8 to 67)	a) TESS 81.8 (67 to 93) b) Enneking 83.3 (43 to 100)	Extensor mechanism rupture 27%
Shimose et al (2005)[30]	7	Endoprosthesis	Medial gastrocnemius flap + ligament augmentation	a) Extensor lag 15.5° (SD 7.6°)	32.1 (8 to 83 months)	N/A	Extensor mechansism rupture 42%
Kollender et al (2004)[31]	7	Endoprosthesis	Medial gastrocnemius flap + Goretex	a) Extension lag < 20°	58 (29 to 83)	MSTS 29 (26 to 30)	N/A
Gosheger et al (2001)[9]	7	Endoprosthesis	Medial gastrocnemius flap + Trevira tube	a) Knee flexion 85.5° (70° to 100°) b) Extension lag 7.5°	31.6 (9 to 78)	MSTS 78.2 (43% to 100%)	N/A
Grimer et al (2000)[32]	50	Endoprosthesis	N/A	a) Flexion 104° (0° to 140°) b) Extensor lag 30°	N/A	Overall MSTS 77%	N/A
Eckardt et al (1991)[33]	20	Endoprosthesis	Medial gastrocnemius flap	N/A	N/A	N/A	N/A
Current study (2024)	15	Endoprosthesis+ Ipsilateral hamstring tendon	Medial gastrocnemius flap + eoligament augmentation	Active knee flexion 92° (80° to 105°), with an extensor lag of 4.6° (0 to 10°)	19 (13 to 24)	MSTS 24 (22 to 27)	Wound infection (3 cases) were managed with debridement and antibiotics

ISOLS, International Society of Limb Salvage Score; LARS, ligament advancement reinforcement system; MSTS, Musculoskeletal Tumor Society; N/A, not available; TESS, Toronto Extremity Salvage Score.

To date, no standard method for extensor mechanism reconstruction has been established. We performed the review of literatutre for various techniques of patellar tendon reoconstruction following megaprosthesis surgery.[9,14–33]

According to Ebeid and Hassan,[22] a patellar tendon stabilized with medial gastrocnemius flaps achieved a mean flexion of 72.63°, with a MSTS score of 26.5; however, soft-tissue and infection complications were observed. In their 2019 study, Liu et al[23] used a synthetic mesh with a gastrocnemius flap, obtaining a mean MSTS score of 23.57 and an active flexion of 105°. Titus and Clayer[25] used a cerclage wire support to reach 96° flexion; nevertheless, infections and peroneal nerve palsy occurred in certain individuals.

Biau et al[26] reported a high rates of extensor mechanism rupture (up to 26%) in allograft prosthetic composite and endoprosthetic techniques with gastrocnemius flap restoration. The use of the ligament advancement reinforcement system (LARS) by Dominkus et al[29] resulted in high functional scores, but substantial rupture rates. Using a combination of neoligament augmentation and ipsilateral hamstring tendon with medial gastrocnemius flap, the current study found an average knee flexion of 92° and an extension lag of 4.6°, with a MSTS score of 24.

The fibula transposition can cause donor site problems, including common peroneal nerve palsy. Ichikawa et al[24] noted an infection-related amputation using mesh and gastrocnemius flaps and the mesh may increase chances of implant wear due to fibres dispersed in the soft-tissue area. With relatively mild wound infections treated with debridement and antibiotics, our current approach demonstrated fewer complications compared with previous studies, suggesting the possibility of benefits in maintaining function while decreasing extensor mechanism challenges.

Autologus tendons have been used for reconstruction of the anterior cruciate ligament (ACL) and posterior cruciate ligaments. Intra-articular reconstruction with a biological graft is the preferred treatment for a ruptured ACL. The clinical effectiveness of ACL repair is influenced by a variety of factors, including the graft material itself, graft fixation, graft placement, and rehabilitation following reconstruction. Hamstring tendons have been used for ACL reconstruction, and authors such as Järvela et al,[18] Cadambi and Engh,[19] Rajani et al,[20] and Sheth et al[34] have used them for reconstructing patellar tendons in knee arthroplasty cases. Minimizing infection risks and optimal soft-tissue coverage is achieved by a medial gastrocnemius flap. Grimer et al[21] reported that infection rates dropped from 36% to 12% with the use of a gastrocnemius flap.

To properly care for and monitor total and unicompartmental knee arthroplasties, radiological evaluation is essential.[35] Decisions on additional follow-up or surgical intervention are guided by the thorough assessment of radiographs, which aids in identifying any problems both after surgery and over time.[36] For all total knee arthroplasty patients, proper radiographs and lifetime follow-up are indispensable. In the current study, the preoperative patella height-to-tendon length ratio mean 0.96 (0.89 to 1.02) and postoperatively, the height-to-tendon ratio increased slightly to 1.04 (1.00 to 1.14). This subtle increase in ratio suggests that there was no patella alta or baja. The Insall-Salvati index needs to be calculated at long-term follow-up to evaluate changes in patellar positioning or neotendon adaptation.

Radiological examinations with the above index and clinical assessments of extensor function were used to infer patellar tendon integration. Direct healing may not occur at the tendon–metal interface, and in future we plan to assess this patellar tendon implant integration around the implant surface with an ultrasound method. The ultrasound should be performed at two weeks following surgery, at six to eight weeks, six-monthly for first two years from the index surgery, and thereafter yearly until five years of follow-up. This ultrasound method and radiological assessment of patella height to tendon ratio can be a method for assessment of the potential for rupture, and extensor lag issues in future studies.

This study presents a novel Salunke's GCRI approach of neopatellar tendon reconstruction using hamstring tendons in proximal tibia megaprosthesis. This method preserves flexion and extension while reducing extensor lag, and offers an efficient reconstructive option; the surgical procedures are also readily replicable. This new surgical technique provides a balanced approach with fewer complications and satisfactory functional results compared with previously published reconstruction techniques. However, whichever approach is used, there is always a chance of decreased strength, impaired function, and postponed healing. While each technique's success depends on precise surgical execution and patient-specific conditions, complications remain a major concern. We recommend a multicentre study comparing various reconstructive techniques, because the current study's limitations include a small patient population and the absence of comparison groups.

In conclusion, this study presents a novel approach to neopatellar ligament reconstruction following proximal tibia resection, utilizing the ipsilateral semitendinosus and gracilis tendons. This technique provides an effective reconstructive option for addressing oncological concerns, and supports knee joint stability and function, preserving flexion, extension, and minimizing extensor lag. Additionally, the surgical steps are easily reproducible. Early radiological evaluations in this study demonstrated no evidence of patella alta or baja, though long-term follow-up is recommended. To further validate Salunke's Gujarat Cancer and Research Institute (GCRI) Surgical technique using hamstring tendons for neopatellar ligament reconstruction in proximal tibia tumour megaprosthesis, a multicentre comparative study is suggested.

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Supplementary material

Video showing Salunke's Gujarat Cancer and Research Institute (GCRI) technique using hamstring tendons for neopatellar ligament reconstruction in proximal tibia tumour megaprosthesis

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