Comparative Observation of Two Types of Limb Salvage Surgery on Limb Function and Quality of Life in Patients With Knee Joint Osteosarcoma

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Abstract

Background

We compared the effects of two surgical procedures on limb function and quality of life in patients with osteosarcoma in the knee.

Methods

This retrospective study evaluated the postoperative outcomes of patients treated with JPLS and JPRS for osteosarcoma around the knee between November 2000 and December 2019. All patients were followed up for at least one year. Patients' lower extremity function, knee function, and quality of life were evaluated during follow-up using the MSTS score, IKDC score, and SF-36 score.

Results

All 38 patients received a successful operation, and all incisions healed in one stage after surgery. At 12 months after the operation, the MSTS score in the prosthetic-replacement group (22.79±5.22) was lower than that in the joint-preservation group (27.05±1.62)(P=0.002). The IKDC score was lower in the prosthetic-replacement group (59.89±11.22) than in the joint-preservation group (76.84±9.42)(P <0.001). After 12 months, the SF-36 scores of physiological and social function in the joint-preserving group were higher than those in the prosthetic-replacement group (P <0.05), and there were no significant differences among the other indexes (P >0.05). Comparing the distribution of each item in the MSTS and IKDC scoring criteria between the joint-preservation and the prosthetic-replacement group revealed that the limb function, pain, satisfaction, support assistance, and the walking and gait of the joint preservation group were superior to those of the prosthetic-replacement group (P < 0.05). There was no significant difference in knee flexion between the two groups (P > 0.05). However, the joint preservation group was superior to the prosthesis replacement group in terms of pain, swelling, twisting, softening of the leg, movement downstairs, sitting up from a chair, kneeling, squatting, running straight forward, jumping up with the injured leg and landing, and quickly stopping or starting (P < 0.05).

Conclusion

Compared with joint-prosthesis replacement surgery, joint-preservation limb salvage leads to better joint function and quality of life. To improve the limb function and quality of life of patients with long-term survival osteosarcoma, joint-preservation limb salvage should be carried out according to the principles of Operation Indication, neoadjuvant and effective chemotherapy.

Background

Osteosarcoma (OS) is one of the most common primary malignant bone tumors, and 80% ~ 90% occur in the metaphysis of the long bones of the extremities, especially around the knee joint (distal femur and proximal tibia). Approximately 70% of osteosarcoma occurs around the knee[1]. With the wide application

of neoadjuvant chemotherapy and the rapid development of bone tumor surgery, limb salvage surgery has become the primary surgical treatment of OS[2]. Pathological changes in some osteosarcoma patients have mainly been found to be localized above the diaphysis or metaphysis, and these tumors do not break through the epiphyseal plate to invade the epiphysis when diagnosed. Therefore, the joint-preservation limb salvage (JPLS) treatment should be applied in clinical practice[3].

Compared with joint-prosthesis replacement surgery (JPRS), JPLS can preserve the ligaments and joint capsule of the patient as much as possible, which is beneficial to the recovery of the joint function. Simultaneously, long-term complications, such as limb shortening, prosthesis loosening, and infection, can be overcome, realizing the aim of biological reconstruction[4]. At present, with the improvement of survival and limb salvage rates of OS, both the recovery of limb function and the pursuit of high quality of life (Qol) are of importance. The modern medical model of society-psychology-biology-medicine has made the Qol an important index of Clinical Curative Effect Evaluation. Therefore, it is necessary to explore the Qol of patients.

To evaluate the clinical efficacy of JPLS, we retrospectively analyzed the lower extremity function, knee joint function, and Qol of 38 patients with osteosarcoma around the knee joint treated in our hospital between November 2000 and December 2019. We aimed to provide a scientific theoretical basis for evaluating the clinical application value of JPLS in limb function and quality of life.

Methods

Patients

All case data were obtained from 38 patients with osteosarcoma around the knee admitted to our hospital between November 2000 and December 2019. The patients were divided into two groups: the joint-preservation group (19 cases) and the prosthetic-replacement group (19 cases), all patients were followed-up for at least one year. We retrospectively analyzed the case data and included 21 males and 17 females, aged 16 to 49 (28.35±9.57) years.

Inclusion and exclusion criteria

The inclusion criteria for this study were (1) patients who were pathologically confirmed to have primary osteosarcoma; (2) completed chemotherapy in strict accordance with the principle of neoadjuvant chemotherapy; (3) the primary site of OS is the distal femur and proximal tibia; (4) received surgical treatment, including limb salvage and total knee arthroplasty; (5) the follow-up period was minimally 12 months; (6) patients were mentally healthy and able to understand and complete the questionnaire independently or under the guidance of the doctor; (7) signing of informed consent and voluntary investigation. The exclusion criteria were (1) Involvement of heart, brain, kidney, blood, and other serious diseases; (2) incomplete case data.

Preoperative treatment

All 38 patients received a chemotherapy regimen consisting of cisplatin-ifosfamide-adriamycin we called DIA[5] for preoperative chemotherapy. We administered a course of ifosfamide and adriamycin in the first week and ifosfamide and adriamycin in the second week; 2 weeks apart, we administered a second course of chemotherapy in the fifth week. The drug doses were as follows: 120 mg/m^2 intravenous drip once; ifosfamide 2.0 g/m^2 daily intravenous drip, immediately, 6 hours, and 8 hours after treatment with mesna 1200 mg/m^2 intravenous drip for 5 days; adriamycin 30 mg/m^2 intravenous drip for 3 days.

Surgical Technique

Joint preservation limb salvage

The procedure was performed under epidural or general anesthesia. The patient was placed in a supine position with a pneumatic tourniquet applied at the thigh base. An incision of 30 cm in length was made in the medial parapatellar region before the knee, and the skin, subcutaneous tissue, and fascial layer were incised layer by layer, from the space between the right rectus femoris and vastus medialis. The distal and middle femurs were exposed from the medial patellar approach. The femoral shaft was transected about 11 cm from the articular surface of the femoral condyle, the distal end was lifted, the femoral vessels were sharply separated at the edge of the joint capsule, the tumor nutrient vessels were cut and ligated, the medial and lateral head of the gastrocnemius muscle, the medial and lateral collateral ligaments, the joint capsule, and the anterior and posterior cruciate ligaments were cut, and the distal femoral tumor segment was removed entirely. The tourniquet was loosened, the bleeding was stopped thoroughly, and the tumor bed was soaked with saline at 42°C. The removed tumor segment was fenestrated behind the intercondylar notch, the tumor tissue in the periosteum was thoroughly scraped, the medial plate and lateral plate of the distal femur with appropriate length were selected and placed inside and outside the tumor segment, and the screw holes were predrilled for future use. The tumor segment and steel plate were completely immersed in absolute ethanol for inactivation for 30 min. The bone cement was reconciled, placed into the tumor segment, and the two plates were placed in the appropriate position and screwed into screw fixation. The inactivated tumor segment was replanted, drilled in the plate, and several screws were used for fixation. The knee joint was reduced, was thoroughly irrigated with 3% hydrogen peroxide solution and saline, and the surgical incision was closed by suture layer by layer. A negative pressure drainage tube was indwelled, the wound was dressed sterile, and a plaster brace was fixed externally.

Of the 19 patients, 16 underwent tumor segmentectomy and replantation, three patients underwent microwave-inactivated tumor curettage combined with cement filling and internal fixation, 11 patients had intramedullary nail fixation, six patients had a plate fixation, and two patients had external fixator fixation.

Joint prosthesis replacement surgery

The procedure was performed under epidural or general anesthesia. The patient was placed in a supine position with a pneumatic tourniquet applied at the thigh base. A longitudinal incision of10 cm in length

centered on the fibular head was made, and the skin, subcutaneous tissue, and fascial layer were incised layer by layer to expose the fibular head while paying attention to protect the common gastrocnemius nerve. Three cm below the lower fibular head, the fibula was amputated. An anteromedial "S" -shaped incision was made in the knee, and the skin, subcutaneous tissue, and fascial layer were incised layer by layer. Then the calf patellar flap was freed to both sides to expose the tibia, and the joint capsule was incised, the tendon insertion point was cut outside the periosteum at the tibial insertion point and everted. The medial and lateral tibial tumors were freed, the popliteal vessels were exposed and protected on the deep surface of the medial gastrocnemius muscle in the popliteal fossa. The medial joint capsule and the medial goose foot tendon insertion point were incised. The anterior spreading muscle was incised laterally and acutely freed outside the tibial periosteum, the length of the osteotomy of the proximal tibial tumor segment was measured and determined, the periosteum at the osteotomy was dissected, the tibial tumor segment was lifted retrogradely using a wire saw, and the nerves and peroneal vessels of the anterior spreading and posterior tibial vessels were separated and protected on the deep surface of the soleus muscle. Along with the fibula, the tumor segment was removed entirely. The tibial medullary cavity was reamed, the cruciate ligament of the intercondylar notch was removed, the femoral medullary canal was located, the distal bone resection was 9 mm, the bone resection module was selected, the anterior and posterior condylar bone resection was performed in turn, and the prosthesis trial was tried and placed. Then we placed the medullary plug in the femoral medullary cavity, reconciled the bone cement, injected the bone cement into the femoral medullary cavity, installed the prosthesis of the corresponding model, placed the medullary needle in the tibia, and installed the connecting device. We then took a patch of the appropriate size to cover and fix on the tibial prosthesis's surface, excised the distal end of the medial gastrocnemius muscle, pulled it to the front, and covered the surface of the prosthesis. Finally, the tendon was sutured to the gastrocnemius muscle bundle, we sutured the joint capsule, sutured and closed the surgical incision layer by layer, indwelled the negative pressure drainage tube, and fixed it with a sterile dressing.

We performed 19 cases of tumor segmentectomy and artificial knee arthroplasty, including 17 cases of primary prosthetic joint replacement and 2 cases of secondary revision joint replacement.

Postoperative treatment

Antibiotics were routinely applied for 48 hours postoperatively to prevent infection. The time of drainage tube removal was determined by drainage volume < 50 ml/24 h. Patients in the JPRS group were bedridden for one week without using an external brace, and those in the JPLS group were bedridden for six weeks with the use of an external brace. In both groups, the stitches were removed 12-14 days after surgery, and postoperative chemotherapy was started. The dose and type of drugs were determined based on the postoperative tumor cell necrosis rate. In the JPRS group, full weight-bearing was possible after three months of postoperative crutches use. In the JPLS group, external fixation was removed eight weeks after surgery, knee functional exercising was started, and double crutches were used to get to the ground. Full weight-bearing in this group was possible after four months of crutches use.

Pain anteroposterior and lateral radiographic examinations were performed every three months for two years, then bi-annually for a further three years, and annually after that. All included patients who completed at least six postoperative DIA[5] chemotherapy courses.

Observation indicators

At 12 months after surgery, the lower extremity function was assessed using the Musculoskeletal Tumor Society (MSTS)[6], knee function was evaluated using the International Knee Documentation Committee (IKDC) Subjective Knee Score[7], and physical function, role physical, bodily pain, general health, energy, social function, role emotional, mental health, and health changes were evaluated using the Medical Study 36-item short-form health outcomes survey (SF-36) questionnaire[8].

Statistical analysis

Data are presented as mean ± standard deviation and were analyzed using SPSS 22.0 software (IBM, Armonk, NY, USA). The postoperative MSTS score, IKDC score, and SF-36 item scores were compared between the two groups using the independent sample t-test. The Mann-Whitney U test was used to compare each item of the MSTS and IKDC scores between the two groups. $P < 0.05$ was considered statistically significant.

Results

General Data

All patients received a successful operation, and no intraoperative abnormalities or serious complications occurred. The postoperative incisions healed on the first intention. The joint preservation group was followed up for 12-228 (63.26 ± 60.40) months, of which 4 cases underwent open reduction, ligation, and internal fixation due to inactivated bone fracture 2-9 months after the operation. One case underwent extended resection of the tumor twice due to soft tissue recurrence within 11 months after surgery. The above five cases were followed up for 12 months after the operation. The prosthesis replacement group was followed up for 12-121 (43.35 ± 22.49) months, of which two cases underwent knee prosthesis revision surgery due to prosthesis dislocation and loosening six and eight years after the operation. The follow-up at 12 months after surgery showed no abnormalities. There were no significant differences in age, gender, lesion site, disease course time, and surgical stage between the two groups ($P > 0.05$, Table 1).

Lower Extremity Function and Knee Joint Function

The MSTS score was lower in the prosthetic replacement group (22.79±5.22) than in the joint preservation group (27.05±1.62) ($P < 0.05$, Table 2). The IKDC score was also lower in the prosthetic replacement group (59.89±11.22) than in the joint preservation group (76.84±9.42) ($P < 0.05$, Table 2).

Quality of life (QOL)

At 12 months after surgery, the physical functioning and social functioning scores in the SF-36 scores of the joint preservation group were higher than those of the prosthesis replacement group ($P < 0.05$, Table 3), there were no significant differences in other indicators between the groups ($P > 0.05$, Table 3).

Comparison of MSTS and IKDC Score Items

The function, pain, satisfaction, support assistance, walking, and gait in the joint-preservation group were superior to those in the prosthesis-replacement group ($P < 0.05$, Table 4). There was no significant difference in sitting with a bent knee between the two groups ($P > 0.05$, Table 5), but there was a significant difference in other items ($P < 0.05$, Table 5).

Discussion

In recent years, with the improvement of the survival and limb salvage rates after neoadjuvant chemotherapy, considerations on improving limb function on the premise of complete resection of the tumor should be made. Joint-preservation limb salvage (JPLS) is an effective method for treating osteosarcoma of limbs in children and adolescents. It was first used in epiphysis-preservation limb salvage (EPLS) for malignant bone tumors in children[9]. Amitani *et al.* then proposed a limb salvage procedure that preserves the knee joint[10]. In a recent study, Takeuch *et al*. called it joint-preserving surgery (JPS)[11]. In the past decade, our team has been studying and improving this surgical approach [12-15], and because of the rise of the patient's age and the closure of the physis, we named it joint-preservation limb salvage.

In this study, 19 patients with OS who underwent arthrodesis with preservation of the joints were followed-up 12-228 (63.26 ± 60.40) months and had an MSTS score of 27.05±1.62 points. From 2009 until now, our team has committed to the clinical study of JPLS, fully confirming that joint-preservation biological reconstruction surgery after receiving neoadjuvant chemotherapy can achieve a good prognosis and limb function in patients[5]. During this period, other studies also reported a higher limb function score. Tsuchiya *et al.* classified osteosarcoma around the knee joint and then maximally preserved the epiphysis according to the size of the extent of tumor invasion of the epiphysis. Twenty patients obtained good limb function and a lower local recurrence rate after joint-preserving surgery by different means[6]. Chen *et al*. performed a joint-sparing hemicortical resection and biological reconstruction in six patients with high-grade osteosarcoma, and the postoperative MSTS score was as high as 97.7%[16]. Their team preserved the anterior and posterior cruciate ligaments, as well as one of the collateral ligaments on both sides, and argued knee stability was the reason for the higher MSTS score. Wong *et al*. applied computer navigation technology to achieve accurate bone resection and preserve the epiphysis as much as possible. They applied a special tumor prosthesis to repair neoplastic bone defects in four patients aged 6 to 14 years, of whom one died of lung metastasis five months after surgery, and the remaining three patients were followed up for 26, 45.7, and 52.3 months, with an MSTS limb function score of 30[17].

At present, most studies[12,16-18] have confirmed that under the premise of ensuring that tumor resection meets the requirements of safety, the implementation of JPLS will not reduce patients' survival rate or increase the postoperative recurrence rate and the occurrence of complications. On the contrary, it brings better limb function. Therefore, we argue that the reconstruction concept of JPLS should be prioritized in clinical practice under strict adherence to effective neoadjuvant chemotherapy.

The contents of JPLS include epiphysial-preservation tumor segment bone resection and bone defect repair, and because the used tumor segment bone has the advantages of lower rejection, low price, and good bone healing, we generally use inactivated tumor segment bone to repair bone defects.At present, the main modes of bone inactivation in the tumor segment are liquid nitrogen freezing [19], hypertonic saline [20] external radiotherapy[21], and alcohol[13]. Sung *et al*. experimentally demonstrated that 95% of alcohol can completely kill tumor cells without interfering with osteogenesis and effectively preserves joint function[22]. A pilot study by our team in ten patients with OS treated with JPLS and using 99% alcohol resulted in one patient dying of local recurrence and multiple metastases 13 months after surgery, three patients dying due to multiple metastases 9, 12, and 24 months after surgery, and three patients required reoperation due to inactivated bone fractures, with a mean International Society of Limb Salvage (ISOLS) graft score of 31 (87%) and a mean Musculoskeletal Tumor Society (MSTS) functional score of 23 (77%) at the last follow-up[12]. In this study, 19 patients with osteosarcoma around the knee joint were treated with alcohol-inactivated bone replantation and microwave-inactivated replantation. Four patients underwent open reduction, internal fixation with an embracing fixator due to inactivated bone fracture 2-9 months after surgery, one patient underwent extended resection of the tumor due to two soft tissue recurrences within 11 months after surgery, and five patients were followed up for 12 months after surgery without abnormalities.

We found that the MSTS limb function score in the joint preservation group was higher than that in the prosthesis replacement group, consistent with a previous study by Chen *et al.* [15]. In their MSTS function evaluation of 90 osteosarcoma patients, the biological reconstruction and joint preservation scores (25.0 ± 3.3 and 25.1 ± 3.6) were significantly higher than the mechanical reconstruction and joint resection scores (23.4 ± 3.7 and 23.1 ± 3.4, $P < 0.05$). San-Julian and Vazquez-Garcia retrospectively analyzed the data of patients who underwent bone tumor arthrotomy over 30 years and found that joint preservation resulted in a higher MSTS score than joint fusion and prosthesis implantation in the long run.[23] Kensaku *et al*. investigated patient satisfaction after JPLS and JRLS and found that MSTS and TESS scores were significantly higher in the JPLS group, indicating that these patients were more satisfied with limb function.[24]

At present, the evaluation of the quality of life of patients with OS undergoing different surgical methods mainly involves the difference between limb preservation and amputation [25-28], and there are few surveys and studies on the quality of life after joint preservation. Therefore, in this study, we applied the SF-36 to observe patients' quality of life after different limb preservation methods. Xu *et al.* found no significant difference in patients' quality of life with various limb salvage methods.[14] However, we found that the joint preservation group's physical function and social function scores were higher than

those of the prosthesis replacement group, indicating that the physical function and social function related to the quality of life of the joint preservation group were better. These data are consistent with the study results by Kensaku *et al*.[29], who investigated the SF-36 scores in 62 patients with osteosarcoma after limb preservation. The physical functioning domain of the SF-36 score is a measure of whether a patient's health status prevents regular physical activity, which can also reflect limb motor function. Social functioning is used to measure the impact of physical and psychological problems on the quantity and quality of social activities and to evaluate the effect of health on social activities. Therefore, JPLS results in better long-term efficacy and life satisfaction than JPRS, which provides a scientific basis for future related research.

Previous studies have found good knee range of motion and function after joint preservation [30,31], and to further explore the knee function status after JPLS, our study also added the IKDC score to evaluate the postoperative joint function and movement. The IKDC score provides a comprehensive evaluation of the subjective symptoms and objective signs of the knee system and applies to various knee conditions. In the past, the IKDC score was mainly applied to the assessment of ligament and tendon injuries, particularly for anterior cruciate ligament injuries and defects [32,33], and has not been used to evaluate knee joint function after limb salvage for bone tumors. We showed that the IKDC score of the joint-preservation group was higher than that of the prosthesis-replacement group. Further analysis of the differences in each item of the IKDC score between the two groups showed that, except for the sitting with a bent knee item, the joint-preservation group scores were superior for completing various daily movements and sports conditions, confirming that patients after JPLS could almost live and exercise like healthy subjects. Gerhard *et al*.[34] found in the long-term follow-up of 30 patients with Ewing sarcoma that 83% of the patients were able to perform regular sports activities, and the weekly sports time depended on the type of surgery, with the joint preservation group scoring higher in terms of sports time and activity scores than those in the prosthesis reconstruction group. Therefore, biological reconstruction could lead to performing high-impact sports. In this study, by analyzing the effect of knee joint function on daily life and movement using the IKDC score, we have obtained a deeper understanding of the effect of JPLS on limb function status. Furthermore, the postoperative efficacy evaluation of JPLS is limited to joint function and the stability and movement ability of the knee joint should be focused on.

This study has some limitations, such as a non-uniform follow-up time and small sample size, resulting in potential errors in scale scores. In addition, this study did not systematically analyze the complications and prognosis of JPLS, and the study subjects only involved surviving patients with osteosarcoma, lacked functional evaluation of dead patients, which may have biased the overall efficacy evaluation of JPLS.

Conclusion

In this study, JPLS can improve the postoperative limb function of patients with osteosarcoma, obtain a better knee joint function and a more satisfactory quality of life than JPRS, and should, therefore, be promoted in clinical practice. In evaluating postoperative efficacy in patients with osteosarcoma, it is

recommended to use a combination of multiple evaluation indicators to comprehensively reflect the clinical efficacy.

Abbreviations

JPLS:Joint-preservation limb salvage.JPRS:Joint-prosthesis replacement surgery.

Declarations

Acknowledgements

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Authors' contributions

ZWH did the study, analyzed the data, and wrote the manuscript. WZB,MingX,KaiZ,XCY were involved in the design, data management, and analysis of the study. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this article.

Ethics approval and consent to participate

This study has been approved by the Ethic Committee of the 960th Hospital of the People's Liberation Army[(2020) Scientific Research Ethics Review No. (74)].Written in formed consent was obtained from all patients included in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1 General Data of 38 patients

General Date	Joint Preservation	Prosthetic replacement	*P* Value
age			
30 year old	8	13	
≥30 year old	11	6	0.103
sex			
male	12	9	
female	7	10	0.328
tumor location			
femur	14	13	
tibia	5	6	0.721
duration of disease			
≤14 months	6	9	
≥14 months	13	10	0.319
Enneking stage			
a	15	16	
b	4	3	0.670

Table 2 Comparative features between two groups

Comparative features	Joint Preservation	Prosthetic replacement	*P* Value
	Mean ± SD	Mean ± SD	
Postoperative **MSTS** score	27.05±1.62	22.79±5.22	**0.002**
Postoperative **IKDC** score	76.84±9.42	59.89±11.22	**0.000**

Table 3 SF-36 score between two groups

Postoperative SF-36 score	Joint Preservation	Prosthetic replacement	*P* Value
	Mean ± SD	Mean ± SD	
Physical Functioning	69.21±10.51	50.78±18.65	**0.001**
Role-Physical	72.36±26.21	51.31±48.21	0.103
Bodily Pain	80.42±21.02	65.34±25.00	0.052
General Health	77.63±22.56	66.05±20.92	0.110
Vitality	76.31±12.23	68.15±21.62	0.161
Social Functioning	93.42±17.86	69.73±23.68	**0.001**
Role-Emotional	84.21±20.39	75.43±38.23	0.383
Mental Health	72.00±14.42	75.36±20.53	0.562
Reported Health Transition	77.63±20.23	64.47±25.43	0.086

Table 4 Comparison of MSTS Score Item Distribution

Observation items	Items	Joint Preservation	Prosthetic replacement	*P* Value
Function	Partial disability	0	3	**0.005**
	Intermediate	1	2	
	Recreational restriction	3	6	
	Intermediate	11	8	
	No restriction	4	0	
Pain	Intermediate	0	1	**0.000**
	Modest	0	5	
	Intermediate	4	10	
	None	15	3	
Emotional acceptance	Accepts	0	1	**0.002**
	Intermediate	1	2	
	Satisfied	0	5	
	Intermediate	11	10	
	Enthused	7	1	
Supports	2 cane crutches	0	1	**0.004**
	1 cane crutch	0	1	
	Brace	0	3	
	Intermediate	2	2	
	None	17	12	
Walking	Inside Only	0	1	**0.000**
	Intermediate	0	2	
	Limited	0	4	
	Intermediate	4	8	
	Unlimited	15	4	
Gait	Minor HACP	0	1	**0.016**
	Intermediate	0	4	
	Minor cosmetic	3	3	

	Intermediate	9	9
	Normal	7	2

Table 5 Comparison of IKDC Score Item Distribution

Observation items	Items	Joint Preservation	Prosthetic replacement	*P* Value
Highest activity without pain	Very strenuous activities	4	0	**0.000**
	Strenuous activities	5	0	
	Moderate activities	8	8	
	Light activities	2	9	
	Unable to perform any of the above activities due to knee pain	0	2	
Highest activity without swelling	Very strenuous activities	3	0	**0.000**
	Strenuous activities	8	0	
	Moderate activities	7	8	
	Light activities	1	11	
Highest activity without instability	Very strenuous activities	3	0	**0.000**
	Strenuous activities	9	0	
	Moderate activities	6	8	
	Light activities	1	11	
Highest level of activity	Very strenuous activities	2	0	**0.000**
	Strenuous activities	5	1	
	Moderate activities	10	3	
	Light activities	2	13	
	Unable to perform any of the above activities due to knee	0	2	
Ascending stairs	Not difficult at all	16	3	**0.000**
	Minimally difficult	2	8	
	Moderately difficult	1	7	
	Extremely difficult	0	1	
Descending stairs	Not difficult at all	18	5	**0.001**
	Minimally difficult	0	8	
	Moderately difficult	0	5	
	Extremely difficult	1	1	
Kneeling	Not difficult at all	9	1	**0.001**

	Minimally difficult	8	8	
	Moderately difficult	1	4	
	Extremely difficult	0	4	
	Unable to do	1	2	
Squatting	Not difficult at all	9	1	**0.001**
	Minimally difficult	6	8	
	Moderately difficult	3	1	
	Extremely difficult	1	5	
	Unable to do	0	4	
Sitting with bent knee	Not difficult at all	4	3	0.303
	Minimally difficult	10	8	
	Moderately difficult	4	5	
	Extremely difficult	1	3	
Rising from chair	Not difficult at all	18	4	**0.000**
	Minimally difficult	1	11	
	Moderately difficult	0	4	
Running straight ahead	Not difficult at all	14	0	**0.000**
	Minimally difficult	4	5	
	Moderately difficult	0	4	
	Extremely difficult	1	2	
	Unable to do	0	8	
Jumping and landing	Not difficult at all	5	0	**0.000**
	Minimally difficult	12	5	
	Moderately difficult	2	4	
	Extremely difficult	0	2	
	Unable to do	0	8	
Stopping and starting	Not difficult at all	6	0	**0.000**
	Minimally difficult	13	5	
	Moderately difficult	0	4	

	Extremely difficult	0	2
	Unable to do	0	8

Supplementary Files

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