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The functional outcome after tumor resection and endoprosthesis around the knee: a systematic review

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The evidence for the functional outcome of endoprosthetic replacement (EPR) after tumour resection has been from few cohort studies. A scoping search revealed no systematic review on patient reported outcome measures after EPR around the knee. The purpose of this study was to evaluate the functional outcome of distal femoral and proximal tibial EPR after tumour resection.

A systematic review was conducted using the PRISMA guidelines. The search identified 2560 articles from MEDLINE, EMBASE, CINAHL, and Web of Science. 36 studies satisfying the selection criteria were included for data synthesis. Pooled analysis was performed for homogenous studies. Narrative synthesis was performed for all the studies due to heterogeneity in methodological and statistical analysis.

Amongst the overall patient population of 2930, mean ages ranged from 18-66 years and the mean follow up periods in the studies ranged from 12 - 180 months. The weighted mean functional outcome was similar for patients who had DFEPR and PTEPR. The functional outcome scores of Rotating Hinge Knee implants (RHK) were significantly greater than that for Fixed Hinge Knee implants (FHK). The weighted mean functional outcome scores were higher after cemented fixation and after primary EPR procedures.

The current evidence suggests that functional outcome after EPR in the knee is good, and RHK implants are better than FHK implants. Functional outcome after primary EPR was significantly better than following revision EPR, and this underscores the importance of minimising complications at the primary surgery.

Keywords: Endoprosthetic Replacement; MSTS Score; TESS Score; RHK Implants, FHK Implants.

INTRODUCTION

Previous comparative studies in patients after endoprosthetic replacement (EPR) have suggested that patients had efficient gait patterns and were

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community ambulant after a reasonable period of follow up *(1, 3)*. In spite of the extensive tissue resection, many patients were as functional as patients who had primary total knee or total hip replacement surgeries *(4, 7)*.

The functional outcome measures previously reported for patients after limb salvage procedures include the Toronto Extremity Salvage Score (TESS); which is a Patient Reported Outcome Measures (PROM) and the Musculoskeletal Tumor Society Score (MSTS); which is a clinician reported outcome measure *(8)*. The MSTS and the TESS score reliability and validity has been tested in many studies conducted across diverse population groups *(9, 12)*.

Initially reported in 1996, the TESS score is a detailed questionnaire which utilized the framework of the International Classification of Functioning, Disability and Health Criteria in developing a detailed instrument for assessing patients with extremity tumors *(13)*. The construct validity of TESS score has been correlated with the MSTS score in previous studies and its use has been reported as a reliable measure that is able to detect changes in patients' performances serially over time *(14)*.

In a recent systematic review of the functional outcome in patients after treatment for extremity sarcoma, Kask et al. identified several functional outcome assessment methods in mostly non-randomized control studies. The review identified the validated TESS score as the most frequently reported measure *(15)*. Among the 31 retrospective and 6 prospective studies included in the review, only 3 were RCTs. This systematic review underscores the challenges involved in the conduct of surgical randomized control trials (RCTs).

The aim of this study is to systematically review the functional outcome in patients after resection of musculoskeletal tumors around the knee and EPR. The objectives are:

1. To determine the functional outcome of distal femoral EPR and proximal tibial EPR after resection of tumors.

2. To determine the effect of the type of articulation mechanism on the functional outcome of EPR around the knee.

3. To determine the effect of the intramedullary fixation technique on the functional outcome of EPR around the knee.

PATIENTS AND METHODS

The systematic review was conducted in accordance with recommended guideline by Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) 16 and our review protocol was registered on PROSPERO prior to study selection (#2019:CRD42019131313). The PRISMA flow diagram is shown in Figure 1.

Search Strategy

The search included widely used large databases such as MEDLINE, EMBASE, Web of Science, Cinahl. Manual review of included study references was performed to enable the inclusion of as many articles as possible for screening. The search of grey literature such as conference proceedings, working documents and backward reference of eligible articles was also conducted to include relevant studies.

The electronic database searches included Medical Subject Heading (MeSH) terms and Boolean operators. The Medical Subject Heading (MESH) terms were combined with Boolean operators to expand the search for key words; distal femoral or proximal tibial endoprosthesis, with a focus on functional outcomes.

The search terms included: "knee," "endoprosthesis," "megaprosthesis" , "prosthesis," "limb salvage," "functional outcome", "MSTS", "TESS", "distal femoral," and "proximal tibial". All the databases were searched from inception to May 2019 in order to enable the inclusion of a wide array of articles and reduce bias.

Search Strategy and Flow Diagram

(tumor OR tumors OR tumor OR tumors OR neoplasm OR neoplasms OR cancer OR cancers OR oncologic OR oncological OR sarcoma OR sarcomas OR metastasis OR metastases OR metastatic OR benign* OR malign*) AND

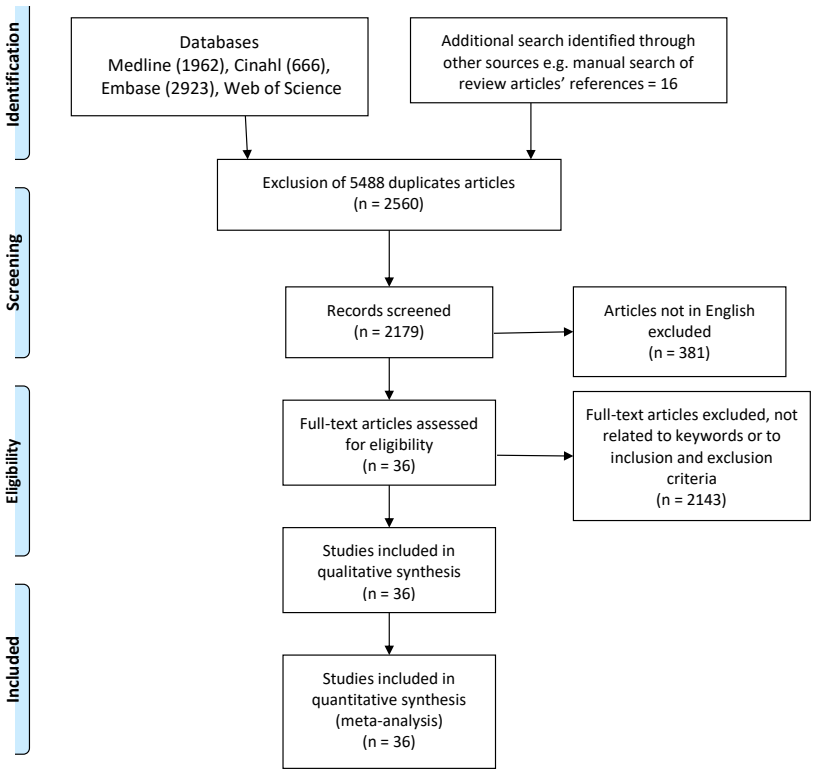

Figure 1. — PRISMA Flow diagram.

(replacement OR replacements OR reconstruction OR reconstructions OR endoprosthesis OR endoprostheses OR endoprosthetic OR prosthesis OR prostheses OR prosthetic OR arthroplasty OR arthroplasties OR megaprosthesis OR megaprostheses OR megaprosthetic OR implant OR implants) AND ((knee OR knees) OR (proximal tibia) OR Distal femur))).

The inclusion and exclusion criteria included patients with extremity musculoskeletal tumours undergoing resection and reconstruction with adult endoprosthesis around the knee. The study excluded patients with expandable prosthesis because the functional outcome in expandable EPR is affected by the age of the patient, and the amount of remaining growth in paediatric patients requiring expandable EPR.

Also, the study excluded patients with non-malignant conditions because the pathophysiology in patients with EPR following tumour resection is different compared to patients with nonmalignant conditions. To ensure reliability of the review, studies in revision arthroplasty not related to EPRs, and studies focused on allograft prosthetic composites were excluded. This is because the complications and functional outcomes for these techniques are different from EPRs.

The study included articles with outcome tools such as overall survival of the patients, implant survival rates, complications, MSTS score, TESS scores, range of knee flexion, and extension lag. The studies that did not use these tools to measure outcome were excluded.

The initial search the databases provided 8032 citations. Manual search and backward referencing of review articles yielded additional 16 articles. After screening for duplicates, 5488 studies were excluded leaving 2560 studies. Articles not written in English Language (381 articles) were excluded because of the challenges encountered with translation leaving 2179 articles. After reviewing the abstracts for these 2179 articles, 77 studies were eligible for full-text review.

Case reports, studies with less than 5 patients within a treatment arm, reviews, letters to the

editor, meeting abstracts, technique papers, revision procedures were excluded. 41 articles were finally excluded using the exclusion and inclusion criteria leaving 36 studies which were included in this review.

Thirty-one of these articles consisting of 1996 cases reported functional outcome results of DFR; 16 articles consisting of 934 cases reported functional outcome results of PTR.

The relevant studies' titles and abstracts were independently evaluated for inclusion by two of the authors according to the inclusion criteria. The manual evaluation and screening were performed by two authors to minimize selection bias.

The methodological quality of the studies included determined independently by two authors using the Methodological Index for Non-Randomized Studies (MINORS) (SLIM 2003) *(17)*.The MINORS utilizes eight predefined criteria to assess the quality of the studies. The results of the quality assessment in this study were reported as percentages for ease of comparison across studies as shown in Table I *(15)*.

Furthermore, the risk of bias in the included studies was evaluated using the Risk of Bias in Non-Randomized Studies - of Interventions (ROBINS-I) tool as shown in Table II. The ROBINS-I is an instrument developed by the Cochrane study group for assessing the risk of bias in the results of comparative non-randomized studies from health care settings *(18)*.

The demographic and clinical data extraction was performed by using a standardized extraction pro-forma, the data extracted were checked by three of the authors to minimize errors.

The mean MSTS and TESS scores were weighted according to the size of study population and the weighted mean determined for distal femoral and proximal tibial EPR. The weighted mean scores were determined for cemented EPR and cementless EPR. The weighted mean scores were determined for implants with rotating hinge and fixed hinge devices. The mean difference in the TESS and MSTS scores of; distal femoral and proximal tibial fixations; fixed hinged and rotating hinge knees were determined.

Pooled analysis was performed for homogenous studies. Narrative synthesis was performed for all the studies due to heterogeneity in methodological and statistical analysis.

All the data for included studies were entered into a spreadsheet. Data was analysed using IBM SPSS Statistics version 25.0. Descriptive statistics regarding patients' demographics were analyzed. The scores for groups across the studies were compared using means of the scores reported in the studies with t-tests or Mann-Whitney U after normality tests. Bivariate correlations were used to compare overall scores.

RESULTS

The included studies consist of 16 prospective comparative studies and 20 studies retrospective studies from prospectively maintained databases. The search did not yield any RCTs on functional outcome EPR. The percentage MINORS scores for all the included studies range from 46 - 94% (mean 72%). The MINORS scores for each study are presented in Table I.

The risk of bias due to confounding variables was generally low among the included studies. There was moderate risk of confounding variables in two studies. Yan et al for instance, included only patients with soft tissue sarcoma. The morphology of the lesion in soft tissue sarcoma may be more associated with destruction of adjoining soft tissues in the knee joint. This factor could affect the functional outcome after resection and EPR. Moreover, Toepfer et al compared the functional outcome in EPR after resection of malignant musculoskeletal tumors with EPR but did not report on the histological profile *(19, 20)*.

Nevertheless, the risk of selection bias was low, as most of the included studies consist of consecutive patients with tumors recorded in a prospectively maintained database. The risk of bias due to classification of the intervention was moderate in 8 studies and unclear in 2 studies. These studies did not indicate the type of implant used in the patients (i.e. RHK/FHK). The name of the manufacturers was also not indicated to enable the determination of the type of EPR.

Furthermore, the risk of bias in the measurement of outcome was moderate in most of the studies (29 studies) as only the physician reported outcome

Table I. — Minors scores in included studies

AUTHOR	STUDY TYPE	MINORS SCORE	% MINORS SCORE
Ahlmann et al. (35)	Retrospective	12	75
Albergo et al. (36)	Comparative	18	75
Asavamongkolkul et al. (37)	Retrospective	12	75
Barjaktarovic et al. (38)	Retrospective	11	69
Bickels et al. (4)	Comparative	12	50
Cho et al. (39)	Retrospective	13	81
Choong et al. (40)	Comparative	14	58
Gosheger et al. (22)	Retrospective	12	75
Guo et al. (41)	Comparative	14	58
Hillmann et al. (42)	Comparative	22	92
Ilyas et al. (43)	Retrospective	14	88
Kamal et al. (44)	Comparative	14	58
Kinkel et al. (34)	Comparative	11	46
Malawer et al. (45)	Comparative	21	88
Malo et al. (33)	Comparative	19	79
Mavrogenis et al. (32)	Retrospective	15	94
Morii et al. (46)	Comparative	14	58
Nakamura et al. (47)	Retrospective	10	63
Natarajan et al.(33)	Comparative	13	54
Niimi et al. (23)	Retrospective	13	81
Pala et al. (24)	Retrospective	11	69
Palumbo et al. (48)	Comparative	15	63
Puchner et al. (49)	Retrospective	11	69
Qadir et al. (50)	Retrospective	9	56
Rubio et al. (51)	Retrospective	12	75
Ruggieri et al. (52)	Retrospective	12	75
Schwartz et al. (53)	Retrospective	13	81
Sharil et al. (25)	Retrospective	11	69
Sharma et al. (54)	Retrospective	12	75
Toepfer et al. (19)	Comparative	14	58
Tsauo et al. (55)	Comparative	20	83
Tunn et al. (29)	Retrospective	15	94
Wilke et al. (56)	Comparative	20	83
Wunder et al. (26)	Comparative	19	79
Yan et al. (20)	Retrospective	12	75
Zhang et al. (57)	Retrospective	12	75

measure (MSTS) was reported. Seven studies evaluated both the MSTS scores, and patient reported outcome measure such as TESS, which reduced the risk of measurement of outcome bias. The risk of reporting bias was moderate in 7 studies and unclear in 10 studies, these studies did not include enough details for pooled analysis of all the outcomes of interest (Table II).

Table II. — Risk of bias as assessed by ROBIN-I

Author	Confounding bias	Selection bias	Classification of intervention bias	Attrition bias	Measurement outcome bias	Reporting bias
Ahlmann et al.	Low	Low	Moderate	Unclear	Moderate	Moderate
Albergo et al.	Low	Low	Moderate	Low	Moderate	Low
Asavamongkolkul et al.	Low	Low	Moderate	Unclear	Moderate	Moderate
Barjaktarovic et al.	Low	Low	Unclear	Low	Moderate	Low
Bickels et al.	Low	Low	Moderate RHK/ FHK Choice Not Clear	Low	Moderate	Low
Cho et al.	Low	Low	Moderate	Low	Moderate	Low
Choong et al.	Low	Low	Low	Low	Moderate	Low
Gosheger et al.	Moderate No Histology	Low	Low	Unclear	Moderate	Unclear
Guo et al.	Low	Low	Low	Low	Moderate	Low
Hillmann et al.	Low	Low	Low	Low	Low	Low
Ilyas et al.	Low	Low	Low	Low	Moderate	Low
Kamal et al.	Low	Low	Moderate Implant Type Not Stated	Low	Moderate	Low
Kinkel et al.	Low	Low	Low	Moderate >5% loss to follow up	Moderate	Unclear high loss to follow up
Malawer et al.	Low	Low	Moderate	Unclear	Moderate	Unclear
Malo et al.	Low	Low	Low	High >5% Loss to follow up	Low	Unclear high loss to follow up
Mavrogenis et al.	Low	Low	Low	Low	Moderate	Low
Morri et al.	Low	Low	Unclear	Moderate >5% Loss To Follow Up	Low	Unclear High Loss To Follow Up
Nakamura et al.	Low	Low	Low	Unclear	Moderate	Low
Natarajan et al.	Low	Low	Low	Low	Moderate	Low
Niimi et al.	Low	Low	Low	Low	Moderate	Low
Pala et al.	Low	Low	Low	Moderate >5% Loss To Follow Up	Moderate	Unclear
Palumbo et al.	Low	Low	Moderate Computer Navigation	Low	Moderate	Low
Puchner et al.	Low	Low	Low	Moderate >5% Loss to follow up	Moderate	Moderate (Pt With Incomplete Data Excluded)
Qadir et al.	Low	Low	Low	Unclear	Moderate	Moderate (Pt Tics Not Fully Stated)

Table II. — Risk of bias as assessed by ROBIN-I *part 2*

Rubio et al.	Low	Low	Low	Moderate >5% Loss to follow up	Moderate	Unclear
Ruggieri et al.	Low	Low	Low	Unclear	Moderate	Unclear
Schwartz et al.	Low	Low	Low	Low	Moderate	Low
Sharil et al.	Low	Low	Low	Unclear	Moderate	Unclear
Sharma et al.	Low	Low	Low	Low	Low	Low
Toepfer et al.	Low	Low	Low	Unclear	Low	Moderate
Tsauo et al.	Low	Low	Low	Moderate >5% Loss to follow up	Low	Low
Tunn et al.	Low	Low	Low	Unclear	Low	Low
Wilke et al.	Low	Low	Low	Low	Moderate	Low
Wunder et al.	Low	Low	Low	Moderate >5% Loss to follow up	Moderate	Low
Yan et al.	moderate sts only	low	low	unclear	moderate	moderate
Zhang et al.	low	low	low	unclear	moderate	moderate

The 36 studies reported on 2930 neoplastic lesions around the knee. The common histological diagnoses include osteosarcoma (66%), giant cell tumor (10%), and chondrosarcoma (7%).

The mean age ranged from 18 to 66 years. The 5 year patient survival ranged from 30 - 90% reported in 21 studies. The 5-year implant survival ranged from 53 - 97% reported in 25 studies.

Functional Outcome in Distal Femoral Replacement (DFEPR)

Thirty-one studies comprising 1977 cases of DFR were included for pooled analysis of MSTS scores. The weighted mean MSTS score was 78.7% (57-88). Five studies consisting of 213 cases of DFR were included for pooled analysis of TESS scores. The weighted mean TESS score was 80.3 (78-84).

Nine studies consisting of 444 cases of DFR were included for pooled analysis of range of flexion in the knee. The weighted mean flexion in the knee was 103 degrees (83-114). Five studies consisting of 306 cases of DFR were included for pooled analysis of extension lag in the knee. The weighted mean extension lag in the knee was 7.5 degrees (4-15).

Effect of Intramedullary Fixation Technique on the Functional Outcome of DFR (Cemented Vs Cementless)

Fifteen studies comprising 759 cases of cemented DFR implants and 6 studies comprising 884 cementless DFR implants were included for pooled analysis. The weighted mean MSTS scores were similar 79.7% and 78.6% for cemented and cementless implants respectively. (Table III)

The weighted mean flexion in degrees in was 100 and 92 degrees for cemented and cementless prosthesis respectively. The mean extension lag was 5.5 and 15 degrees for cemented and cementless implants respectively. The TESS scores were only reported for cemented implants.

Effect of Articulation Mechanism on the Functional Outcome of DFEPR (Fixed Hinged Vs Rotating Hinged)

In the evaluation of the effect of articulation mechanism on functional outcome, 2 studies comprising 166 cases were included in the pooled analysis. The weighted mean MSTS score was

Table III. — Functional outcome and method of fixation in patients with DFEPR and PTEPR

Author	Fixation Method	Mean MSTS %	Mean Tess	Mean Flexion (Degrees)	Mean Extension Lag (Degrees)
Ahlmann et al.	Cemented	76			
Asavamongkolkul et al.	Cemented	88			
Barjaktarovic et al.	Cemented	75			
Bickels et al.	Cemented	71			
Choong et al.	Cemented	71		83	
Guo et al.	Cemented	77			
Kamal et al.	Cemented	84			
Malawer et al.	Cemented	87			
Qadir et al.	Cemented	70			
Schwartz et al.	Cemented	87		110	7
Sharil et al.	Cemented	70		108	
Sharma et al.	Cemented	85	78		
Toepfer et al.	Cemented	57	80		
Yan et al.	Cemented	82			
Zhang et al.	Cemented	85		97	4
Gosheger et al.	Cementless	80			
Ilyas et al.	Cementless	69		90	15
Pala et al.	Cementless	85			
Rubio et al.	Cementless	77		94	
Ruggieri et al.	Cementless	76			
Wunder et al.	Cementless	77			

57.1% (50-73%) and 90.6% (90-91%) for fixed hinge and rotating hinge implants respectively. The TESS score was reported in only 1 study consisting of 56 cases of DFR. The mean TESS scores in this single study was 73 and 86 for fixed hinge and rotating hinge implants respectively

Functional Outcome in Proximal tibial replacement (PTEPR)

Sixteen studies comprising of 934 cases of PTR were included for pooled analysis of MSTS scores. The weighted mean MSTS was 76.9% (67-99%). Two studies consisting of 38 cases of PTR were included for pooled analysis of TESS scores. The mean TESS scores ranged from 79 - 85, the weighted mean TESS score was 80.7.

Furthermore, three studies consisting of 93 cases of PTR were included for pooled analysis of range of flexion in the knee. The weighted mean flexion in the knee was 89.9 degrees (77-94). Three studies consisting of 287 cases of PTR included for pooled analysis of extension lag in the knee. The weighted mean extension lag in the knee was 12.9 degrees (12-16).

Intramedullary Fixation Technique and Functional outcome PTR (Cemented vs Cementless)

Six studies comprising 270 cases of cemented PTR implants and 3 studies comprising of 219 cases of cementless PTR implants were included for pooled analysis. The weighted mean MSTS scores were similar, 77.9% (67-99%) and 76.9% (70-83%) for cemented and cementless implants, respectively. The mean flexion in the knee, the mean extension lag and the TESS scores were only available in cemented implants.

Effect of Articulation Mechanism on the Functional Outcome of PTEPR (Fixed Hinged Vs Rotating Hinged)

In the evaluation of the effect of articulation mechanism on functional outcome of PTR, 2 studies comprising 287cases were included in the pooled analysis. The weighted mean MSTS scores were 77.1% (76-81%) and 81.2% (80-86%) for fixed hinge and rotating hinge implants respectively. None of the identified studies reported the difference in TESS score between patients with the two types of hinge mechanism.

DISCUSSION

The evidence for functional outcome after resection and EPR is limited to single center cohort studies. The articulation mechanisms have undergone modifications to improve implant longevity, and the implant survival has been evaluated in few systematic reviews. However, these reviews have not adequately elucidated the functional outcome of patients in relation to the modifications.

This systematic review focused on the following 3 questions: (i) what is the functional outcome of distal femoral EPR and proximal tibial EPR after resection of tumors; (ii) what is the effect of the type of articulation mechanism on the functional outcome of EPR around the knee.(iii) what is the effect of the intramedullary fixation technique on the functional outcome of EPR around the knee

Functional outcomes of DFR and PTR

This systematic review identified more studies on DFR than PTR. Generally, previous reports on long term outcome of EPR have recorded more cases of DFR because of increased frequency of sarcoma in the distal femur *(2, 22)*.

In this study the weighted mean MSTS scores for DFR (78.7%) was similar to that of the PTR (76.9%). Moreover, the weighted mean TESS score for DFR (80.3) was similar to PTR (80.7). Three of the included studies reported that the difference was not statistically significant *(23-25)*. However, Wunder et al reported a statistical significance between the mean MSTS scores after DFR and PTR. ($p= 0.02$) 26.

Nevertheless, recent reports on the functional outcome of limb salvage surgery have revealed a positive correlation between MSTS and TESS. The minimal clinical important differences (MCID) of the TESS score has also been well documented in a recent study *(27, 28)*. Taking a cue from the recently determined MCID for TESS scores, there was no clinical significance between the functional outcome of DFR and PTR in this systematic review. Previous studies comparing other validated outcome scores in DFR and PTR have also reported similar findings. Tunn et al in a prospective cohort study, reported similar Reintegration to Normal Living Index (RNL) in 41 DFR and 27 PTR cases *(29)*.

This systematic review revealed that there may be better gait speed and faster return to normal daily activities with DFR compared to PTR. In this review the weighted mean flexion in the DFR (103 degrees) was greater than for PTR (90 degrees). Also, the PTR was associated with more extensor mechanism deficiency than the DFR (13 vs 7.5 degrees). Two of the included studies reported on the statistical significance between the range of movement after DFR and PTR. One of the included studies reported that the range of flexion after DFR was significantly better that after PTR.($p<0.001$) 25.

Furthermore, one study reported better MSTS scores in patients with less than 30 degrees extension lag compared to patients with more than 30 degrees extension lag 23. This difference in the MSTS scores between the two groups was statistically significant ($p< 0.01$).

The importance of range of flexion on gait and gait speed has been highlighted by previous studies on rehabilitation after knee joint replacement surgery. Rowe et al in a kinematic study reported that activities of daily living and gait speed correlate with the range of knee flexion *(30)*. More recently, Pua et al in a large longitudinal study, identified postoperative quadriceps strength and range of knee flexion as a good predictor of the gait speed after knee replacement surgery *(31)*.

Functional outcomes and effect of articulation mechanisms

In this systematic review RHK implants had better functional outcome scores compared to FHK. The weighted mean MSTS scores were better for RHK compared to FHK (mean difference of 33.5 and 4.1 for DFR and PTR respectively). The mean TESS score reported in a single study of 56 DFR was also greater for RHK implants (mean difference of 13).

Mavrogenis et al reported significantly better MSTS scores after RHK implantation ($p < 0.012$ CI 3.34-7.79) *(32)*. Moreover, Malo et al reported that the MSTS and TESS score were significantly better after RHK implantation ($p<0.006$ and $p<0.030$ respectively). This study compared generic functional outcome scores in RHK and FHK implants and reported that the Short Form-36 scores were also significantly better with RHK implants *(33)*.

This result is in agreement with the wider literature on the outcome of RHK EPR. Previous reports have demonstrated a reduction in complication rate from 46 - 3% over 10 yrs with the adoption of the RHK implants. There has also been a reduction in the rate of re-operation at 15 years by 52% with the use of RHK EPR *(1, 6)*.

Functional outcomes and effect of fixation methods

The weighted mean MSTS scores for cemented (79.7%) and cementless (78.6%) implants after DFR were similar. Equivalent results were recorded in patients requiring PTR (cemented 77.9% versus cementless 76.9%). However, patients with DFR achieved more knee flexion after cemented (100 degrees), compared to cementless (92 degrees) implants. Extension deficit was more pronounced after cementless implants. After resection and EPR, mobilization of patients may progress more rapidly because of the immediate fixation that the polymethylmethacrylate cement fixation achieves on the operating table. The fixation with cementless implants requires a period of osseointegration to allow solid fixation of the implants.

These results suggest that cemented implants may provide better movement and rehabilitation outcome in the post operative period. Previous studies have suggested that wider range of flexion may positively impact on gait and gait speed *(30, 31)*.

Complication profiles and the effects of revision procedure on functional outcomes

The most common complication in this review was type III (structural failure). Haijie et al. in a recent systematic review also identified Henderson Type III as the most common type of complication leading to revision. The authors reported similar complications rates between DFR and PTR 1.

This systematic review revealed a higher mean MSTS score after primary procedures. However, only one study established a statistically significant difference between the MSTS scores in primary and revision procedures *(34)*. Two other studies reported that this difference was not statistically significant *(23, 24)*.

The extensive dissection and bone loss associated with revision surgery usually increases morbidity, hence the reduction in the functional outcome score. The rehabilitation in revision procedures is even more challenging and so is the complication rate 2. These factors may translate to poorer functional outcome in patients needing revision surgery and require further evaluation in future studies.

Quality Assessment of Included Studies

The included studies had varying quality assessment rating but the average score for all studies was good (72%). The risk of bias using the ROBINS-I tool was generally low to moderate among studies included in this systematic review. The evidence from this systematic review would have been stronger with the inclusion of high quality RCTs. However, the database literature search did not reveal any RCTs on functional outcome EPR.

Strengths and limitations of the study

This systematic review which is the largest on the functional outcome of EPR around the knee utilized outcome measures with high levels of validity and reliability. Both the physician reported and patient reported outcome measures were identified and reported for DFR and PTR at an average follow up

period of 60 months which is a reasonable period for monitoring the progress of patients' functional outcome after EPR.

Despite the extensive data included, this systematic review has some limitations. The results were based on published articles with diverse study designs, institutions, and time span, which made generalization of the results difficult. Also, the variation in use of outcome measures and duration of followup did not allow direct comparison of surgical strategies. Furthermore, not all the 36 articles reported detailed data on locations, survival, complications, fixation method, and hinge mechanism.

Implication for Practice and Research

The functional outcome of EPR around the knee is good. There is a good correlation between the TESS and MSTS scores in patients after resection and EPR around the knee. The RHK implants have significantly better functional outcome compared to FHK implants. Cemented implants appear to have better functional outcome compared to cementless implants after DFR.

This systematic review identified the need for high quality randomized control trial on the functional outcome of patients after resection and EPR. The review also identified lack of unified database or registry for patients with EPR. Such national or regional registries can further improve the quality of evidence for future management of patients with Musculoskeletal tumors.

CONCLUSION

This study provides an overview of the functional outcome after DFR and PTR. The study indicates that the short term to midterm functional outcomes were reasonable. The RHK has better functional outcome compared to FHK implants. These results can aid patients and their clinicians in the decision-making process about operative intervention. Simultaneous recording of the MSTS score, the TESS and other patient reported outcome measures may result in better evaluation of the quality of life after limb-sparing surgery.

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