



STANDARDISING FUNCTIONAL ASSESSMENT AFTER LIMB SPARING SURGERY IN EXTREMITY SARCOMA - OBJECTIVE VS SUBJECTIVE SCORING SYSTEM

Oncology

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ABSTRACT

Introduction: While advances in reconstructive surgery and effective chemotherapy regimens for bone sarcomas, have facilitated limb preservation in extremity sarcomas, limited information exists regarding their functional outcome, most such data being from subjective analytical methods. Drawbacks of subjective scoring systems are difficulty in interpretation by patients and problem of undefined intermediate scores between defined variables. We have formulated an easy to apply, objective scoring system which will not be confounded by patient's age and differences in inter individual interpretation.

Objective: The primary objective of this study is to assess the functional outcome after limb salvage surgery in patients with extremity sarcomas using both subjective and objective methods of analysis. Correlation of objective with subjective score, influence of age, gender, pathology, radiotherapy, extent of soft tissue resection, bone resection, recurrent disease and rehabilitation on the scores & outcome were also assessed

Materials And Methods: The functional outcome of 54 patients with extremity sarcomas, both soft tissue and bone tumors, who underwent limb sparing surgery at our department between 2014-2016 were analysed using MSTS subjective scoring system and by an institution designed objective scoring system. Patients were assessed post operatively at 4th, 5th and 6th month. The mean scores were analysed for overall outcome and for different subsets.

Results: We observed a significant difference in outcome with adequate postoperative rehabilitation. There was no influence on outcomes due to gender, radiotherapy, pathology or recurrent status. Though there was no significant difference in outcome among various subsites of lower limb or among different compartments of thigh, resection of quadriceps and tibial resection resulted in inferior function.

Conclusion: This study revealed that objective scoring is feasible, providing a reproducible method to assess functional outcome with a strong positive correlation with subjective score. Together they complement each other for better assessment of functional status. Newer systems with combination of objective and subjective factors may be better for comprehensive analysis in the future.

KEYWORDS

Limb Sparing, Functional Outcome, Extremity Sarcoma, Objective Score

Introduction:

Limb salvage surgery is the treatment of choice in extremity sarcomas if no oncological considerations exclude this option. While the advances in reconstructive surgery like custom made & modular prostheses and effective chemotherapy agents for bone sarcomas have facilitated limb preservation in extremity sarcoma, limited information exists regarding their functional outcome. Most of the existing scoring systems for functional assessment are subjective and a standard objective scoring system is yet to be established. The primary objective of this study is to assess the functional outcome after limb salvage surgery in patients with extremity sarcomas using an objective score and compare it with existing subjective scoring system. Correlation of objective with subjective score, influence of age, gender, pathology, radiotherapy, extent of soft tissue resection, bone resection, recurrent disease and rehabilitation on the scores & outcome were also assessed.

Materials and methods:

Patients treated with limb sparing surgery for soft tissue sarcomas and bone tumors of extremity at our institution between 2014 and 2016 were included in the study. Patients with preoperative functional impairment not attributable to primary disease and those with significant comorbidities affecting performance status were excluded. Fifty four patients were eligible for the study. Postoperatively after 3 months of rehabilitation, functional assessment was done, once at end of the 3 months, then monthly once for 2 more times, using upper and lower extremity version of MSTS scoring system (subjective) and Institution designed (objective) scoring system. Comparisons were done and subsets analysed with SPSS – version 23 using Independent Sample Test for comparison between two groups, ANOVA for comparison among multiple groups and Pearson's correlation coefficient to compare between two scores; Subjective scoring system (MSTS Score) used in the study assigned numerical values (0-5) for

each of six categories: pain, function and emotional acceptance in upper and lower extremities; supports, walking and gait in the lower extremity; hand positioning, dexterity and lifting ability in the upper extremity. The objective scoring system was based mainly on the range of motion of joints of upper limb and lower limb. The scoring systems used for study are given in tables 1-4.

Table: 1 - MSTS functional scoring system for upper limb (subjective score)

Score	Pain	Function	Emotional acceptance	Hand position	Manual dexterity	Lifting ability
5	No pain	Not restricted	Enthused	Unlimited	No limitation	Normal load
4	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
3	Modest / non disabling	Recreational restriction	Satisfied	Not above shoulder/ no supination	Loss of fine movement	Limited
2	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
1	Moderate/ intermittent disabling	Partial occupational restriction	Accepts	Not above waist	Cannot pinch	Helping only
0	Severe/ continuously disabling	Total occupational restriction	Dislikes	None	Cannot grasp	Cannot help

Table: 2 - MSTs functional scoring system for lower limb (subjective score)

Score	Pain	Function	Emotional acceptance	Supports	Walking	Gait
5	No pain	Not restricted	Enthusied	None	Unlimited	Normal
4	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
3	Modest / non disabling	Recreational restriction	Satisfied	Brace	Limited	Limited
2	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate	Intermediate
1	Moderate/intermittently disabling	Partial occupational restriction	Accepts	One crane or crutch	Inside only	Major cosmetic
0	Severe/continuously disabling	Total occupational restriction	Dislikes	Two cranes or crutches	Not independent	Major handicap

Table 3:

OBJECTIVE SCORING FOR FUNCTIONAL ASSESSMENT OF UPPER LIMB

Wrist	Range of Movement (Compared to Normal Side)	Score	Grasp Strength % of Normal	Score
100%	5	100%	5	
75-99%	4	75-99%	4	
50-74%	3	50-69%	3	
25-49%	2	25-49%	2	
<25%	1	<25%	1	

Elbow	Flexion - Arc of Motion	Score	Stability	Score
>100%	2	Stable	3	
50-100%	2	Moderate Instability	2	
<50%	1	Grossly Unstable	1	

Shoulder	Active Forward Flexion	Score	Strength of Flexion	Score	Degree of Abduction	Score	Strength of Abduction	Score	Stability	Score
>150°	5	Grade 5	5	120-150°	5	Grade 5	5	No Instability	4	
120-150°	4	Grade 4	4	90-120°	4	Grade 4	4	No Instability	3	
90-120°	3	Grade 3	3	60-90°	3	Grade 3	3	Mild Instability	2	
60-90°	2	Grade 2	2	30-60°	2	Grade 2	2	Moderate Instability	1	
<60°	1	Grade 1	1	<30°	1	Grade 1	1	Severe Instability	1	

Table 4:

OBJECTIVE SCORING FOR FUNCTIONAL ASSESSMENT OF LOWER LIMB

Ankle	Frontal Motion (Inversion Plus Flexion)	Score	Sagittal Motion (Flexion Plus Extension)	Score
Normal or mild restriction (75% - 100% normal)	3	Normal or mild restriction (30° or more)	3	
Mild restriction (50-74% normal)	2	Mild restriction (15° - 29°)	2	
Marked restriction (<25% normal)	1	Marked restriction (<15°)	1	

Knee	Total Flexion	Range of Score	Extensor Lag	Score	Limb Length Discrepancy	Score
30-90°	3	<30°	2	Normal	3	
60-90°	2	30-60°	1	<2cm	2	
>90°	1	>60°	0	>2cm	0	

Heel	Stability Antero-Posterior	Score	Medio-Lateral	Score
<5mm	4	<5°	4	
5-10mm	3	6-9°	3	
>10mm	2	10-14°	2	
	1	>15°	1	

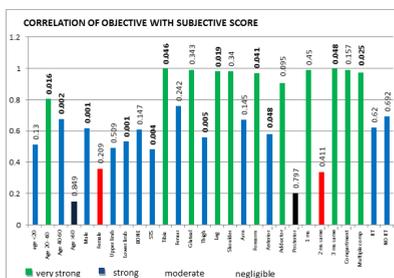
Heel	Range of Motion of Ankle	Score	Range of Motion of Ankle	Score	Range of Motion of Ankle	Score	Flexion Contracture	Score	
0-40	1	<10	1	None	0	None	0	None	5
40-70	2	10-30	2	<10	1	10-30	1	5-10	4
70-90	3	30-60	3	10-20	2	10-15	2	10-15	3
90-110	4	>60	4	>20	3	15-20	3	>20	2

Results:

Of the 54 patients in our study, 7 had tumor involving upper limb and 47 in the lower limb, predominantly thigh lesions (23 patients), most of which were anterior compartment tumours (12 patients). Majority of lesions were soft tissue sarcomas and 17 had bone tumors. Ten patients were in age group <20 years. Salvage of recurrent disease was done for 10 patients. Twenty two patients had received adjuvant RT of which 5 had received brachytherapy.

Analysis of correlation between objective and subjective scores (Fig 1) showed a very strong correlation [Pearson's coefficient (pc) > 0.70] in the following subsets of patients - Age group 20 - 40, gluteal muscle resection, leg muscles resection, tibial resection, adductor compartment lesions, single muscle resection, 3 muscles resection group, compartmental resection group and resection involving multiple compartments;

Fig 1

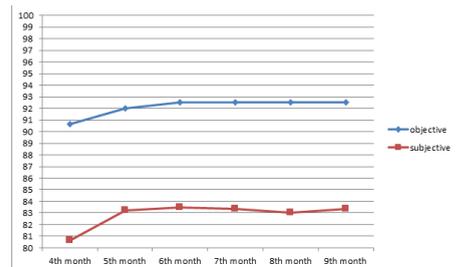


Correlation was strongly positive (Pearson's coefficient 0.40 - 0.69) in the following subsets: Age group <20 and 40-60, both Soft tissue sarcoma & bone tumor group, Upper limb & Lower limb lesions, High lesions, Femur resection group, resection involving anterior compartment, No RT & RT group and male patients. Correlation was moderate in female patients and 2 muscles resection group. Only two subsets showed negligible correlation between the two scores: Age >60 and resection involving posterior compartment (both statistically non significant).

Reproducibility assessment showed a very strong correlation between 1st & 2nd visit (pc 0.948; p .0001) and between 2nd and 3rd visit (pc 0.992; p .0001) in objective scoring system in three consecutive visits, which was better than subjective scores with Pearson's coefficient of 0.911 between 1st & 2nd visit and 0.903 between 2nd and 3rd visit.

With extended follow up for three more months, it was found that mean objective scores plateau beyond 6th post operative month. Also, subjective scores fluctuated in the later follow up visits (Fig 2)

Fig 2



On comparison based on age group, we noticed a difference in objective and subjective scores between age groups < 20 years and those in 40-60 years [statistically significant for objective score (p .007)]. The younger age group had better subjective and objective scores (Table 5). Comparison showed no statistically significant difference in either scoring systems between two genders.

Table 5:

VARIABLES	Mean Subjective score /30 (%)	Mean difference	P value	Mean Objective score / 40 (%)	Mean difference	P value
Age < 20	24.08 (80.26)	1.48	0.885	33.52 (83.8)	4.92	0.007
Age 40-60	25.56 (85.2)			38.43 (96.08)		
STS	25.55 (85.16)	3.35	0.06	37.52 (93.8)	3.35	0.002
Bone tumor	22.20 (74)			34.17 (85.43)		
Upper limb	23.07 (76.9)	2.11	0.48	36.5 (91.25)	0.49	0.75
Lower limb	25.18 (83.9)			36.99 (92.47)		
Compartment resection	22.8	0.2	0.98	34.5	2.6	1.00
Multiple compartments	23.00			37.1		

Both objective and subjective scores were better with soft tissue sarcoma group than bone tumors (Table 5). Limb salvage of upper limb lesions showed worse subjective and objective score than that of lower limb but this was not statistically significant (Table 5). Among lower extremity soft tissue sarcomas, there was no significant difference of mean scores between lesions of thigh (n = 23) and leg (n = 4). Gluteal lesions (n=2) had worse subjective and objective score compared to other two subsites (Table 6).

Table 6: Insignificant p value (>0.05) on comparing among the three subsets

SUBSETS	Mean Subjective score / 30	%	P value	Mean Objective score / 40	%	P value
Lower Limb Subsite						
Gluteal	24.50	81.67*		29.0	72.5*	

Thigh	25.63	85.43		38.16	95.4	
Leg	25.65	85.5		39.15	97.87	
Compartments of thigh						
Anterior	23.5	78.33 *		33.75	84.37 *	
Posterior	26.5	88.33		38.0	95	
Medial	26.6	88.67		39.0	97.5	
Number of muscles resected						
1	28.62	95.4 *		40	100 *	
2	24.81	82.7		35.87	89.68	
3	24.66	82.2		35.66	89.16	
Bone vs comp resection						
Compartment resection	22.8	76	0.76	34.5	86.25	0.88
Bone resection	22.2	74		34.2	85.5	
Bone tumor						
Femur	24.15	80.5	0.08	35.15	87.87	0.12
Tibia	19.6	65.33		32.87	82.17	
Recurrent Vs New Lesions						
Recurrent	24.12	80.4	0.5	36.58	91.45	0.5
New	25.25	84.16		37.99	94.97	
Rehabilitation						
Yes	28.61	94.97	0.001	38.61	96.5	0.002
No	20.51	68.37		34.88	87.2	
Adjuvant RT						
Yes	22.0	73.3	0.4	36.6	91.5	0.8
No	24.4	81.3		37.7	94.25	

The mean difference of objective and subjective score between compartment excision and resection of muscles involving multiple compartments was 2.6 and 0.2 respectively (Table 5), the scores being less for compartment excisions ($p > 0.9$).

Among various compartments of thigh, the mean subjective and objective scores were least for anterior compartment followed by posterior compartment and maximum with adductor compartment (Table 6). There was a fall in the subjective and objective score with increasing number of muscles excised in a single compartment of thigh eg., one muscle versus two muscles versus three muscles within a same compartment (Table 6). Single muscle resection resulted in maximal score whereas 2 or 3 muscles resection resulted in almost similar scores. Scores after bone resection were almost the same as that of compartment resection (Table 6) with a mean difference of less than 1. In bone tumors, femoral resection showed better mean objective and subjective score than tibial resection (Table 6). Resections involving nerve fare worse with lower subjective scores than resection of other components alone, with a mean difference of 3.7 versus bone resection, 4.3 versus compartment resection and 4.5 versus resection involving muscles of multiple compartments. This does not reach statistical significance, whereas the objective score is higher than that of bone resection (mean difference 2.8), compartment resection (mean difference 2.5).

Among the four predominant pathologies (MFH 25%, Osteosarcoma 15%, MPNST 12.5%, Fibromatosis 12.5%), osteosarcoma had the least objective (22.8) and subjective score (34.2).

Twenty soft tissue sarcoma patients (54%) received adjuvant RT. There was a mean difference of 2.06 in the subjective score and 0.87 objective score between soft tissue sarcoma patients who received RT and those who did not ($p > 0.4$) (Table 6). Twenty five percent of patients in this study had recurrent disease salvaged by limb sparing surgery. Recurrent lesions had lower objective and subjective score, but did not reach statistical significance ($p = 0.5$) (Table 6). Patients who adhered to 3 months of rehabilitation had a significant mean difference of 8.1 in subjective score and 3.8 in objective score which was higher than that of others who had not received adequate rehabilitation, both of which were statistically significant ($p = 0.002$) (Table 6).

Discussion:

Most of the established scoring systems for functional assessment of outcome after limb salvage are subjective and difficult to interpret in

some patients especially children^[1]. Subjective scores are also flawed by loss of reproducibility in the same patient at different times due to ill defined terms (like 'intermediate') designated for scoring between defined variables (Tables 1&2). Hence an objective scoring system was designed based mainly on the range of movements of major extremity joints. This had made evaluation of the limb function easy without being confounded by patient's age or literacy status. The score was reproducible without much interobserver difference. Range of movements has proven to correlate with functional mobility and quality of life, in study conducted by Marchese et al in patients with lower extremity sarcoma after limb-sparing surgery^[2]. They hypothesized that limited ROM in a patient who has undergone a limb-sparing procedure would directly impair the patient's functional mobility and that limitation in functional mobility would affect the patient's quality of life.

Comparing overall objective and subjective scores head to head, the former had very strong or strong correlation with latter in most of the subsets analysed. Only two subsets showed negligible correlation (Pearson's coefficient < 0.29) between the two scores: Age > 60 and resection involving posterior compartment of thigh, yet this was not statistically significant. Thus objective scoring system correlates well with the established subjective scoring system, indicating that this is a reliable and practically applicable alternative to the latter.

We noticed better reproducibility in objective scoring system in three consecutive visits with very strong correlation between 1st & 2nd and between 2nd and 3rd visit which was better than subjective scores. With extended follow up for three more months, it was found that mean objective scores plateau beyond 6th post operative month. This signifies that any efforts on improving the function (rehabilitation) should effectively be done in the early post operative period. Outcome is unlikely to improve beyond 6 months. Subjective scores fluctuated in the later follow up visits, reflecting its poor reproducibility, since pain and emotion component of the score are prone to fluctuate. Above findings ascertained the credibility of an objective scoring pattern in terms of reliability and reproducibility.

Age is an important factor in predicting outcome after limb sparing surgery^[3]. In this study, younger age group (< 20 years) had lower subjective and objective scores than elder group (40-60 years). This may be explained by predominance of malignant bone tumors in the former requiring bone resection and reconstruction. However, difference in subjective scores was not statistically significant since children had better emotional acceptance which compensated for the lower scores in other variables of MSTs scoring system. The significance of emotional acceptance was noted by Robert et al in their study where function was found to be significantly related to emotion in long-term osteosarcoma survivors. They found that association of emotional well-being, with physical function outweighed the impact of other variables in their model.

As a whole there was no influence of gender on the functional outcome analysed by both objective and subjective scores^[3].

Bone resection is an important predictor of functional outcomes following limb salvage surgery for lower-extremity soft tissue sarcoma. Soft tissue sarcoma patients showed a higher objective and subjective scores than patients with bone tumors. One of the common causes of fall in objective score in bone tumor arm was extensor lag, seen in 8 patients who underwent proximal tibial resection. Limb length discrepancy in lower limb was observed in 5 out of 17 persons. All the 5 patients had discrepancy of < 2 cm which was effectively corrected with boot raise. However, patients with custom made prosthesis reconstruction after bone resection had a reasonably good mean objective score (85.4%). These findings provide objective data from which patients undergoing custom mega prosthesis reconstructions of the lower extremity can expect efficient gait and active lifestyle.

Among the subsites of lower extremity soft tissue sarcomas, gluteal lesions had lower subjective and objective score compared to resections in thigh and leg. Gerrand et al, found significant variation in scores for gait handicap and limp, with lower scores for groin/femoral triangle^[4]. But those patients had femoral N resection contributing to poorer outcome. Difference noted in our gluteal muscles resection group is due to lower number of patients ($n=2$) with one patient having hip contracture reducing the mean objective score grossly.

The mean scores were less for compartment resection when compared to resection involving multiple compartments. The effect of resection of group of muscles, all with similar function, impacts greater on the outcome than resection of one muscle from each compartment with different function^[5]. In the latter group, other functional units will compensate for the function. Hence tumor involving multiple compartments does not necessarily predict poorer outcome than tumor confined to a compartment. Rather, the number of functional units left behind in each compartment determines the result.

The significance of extent of quadriceps resection and residual function is demonstrated in the following subset analysis.

Among various compartments of thigh, the mean subjective and objective scores were least for anterior compartment followed by posterior compartment and maximum with adductor compartment. This demonstrates the significance of quadriceps in lower extremity function. Lo et al in their study reported good functional outcomes only in the context of cases with residual quadriceps function. Analysing the effect of extent of soft tissue resection, we noticed a fall in the subjective and objective score with increasing number of muscles excised in a single compartment of thigh. Single muscle resection resulted in maximal score whereas 2 or 3 muscles resection resulted in almost similar lower scores. Studies have shown that smaller resections with loss of two or fewer components of the quadriceps, minimal impairment of function occurs in the absence of functional reconstruction, suggesting that functional restoration may not be warranted^[5]. Function of knee joint has shown to be progressively decreased with increasing number of quadriceps being resected^[6].

In bone tumors, femoral resection had better objective and subjective score than tibial resections. Bernthal et al have observed that proximal and distal femur reconstructions have better functional results compared to proximal tibia reconstructions. This probably reflects the effect of the reconstruction of the patellar tendon to the endoprosthesis.^[7]

Subjective and objective scores after bone resection were almost the same as that of compartment resection. This reflects the significance of musculoskeletal structures functioning as a unit in bringing out the outcome after resection of components.

Resection involving nerve (2 of our patients) fare worse by subjective score than resection of other components in our study, with a mean difference of 3.7 versus bone resection, 4.3 versus compartment resection and 4.5 versus resection involving muscles of multiple compartments, but did not reach statistical significance, whereas the objective score was higher than that of bone resection (mean difference - 2.8) and compartment resection (mean difference -2.5). Worse subjective score reflects alteration in walking and gait in lower limb and dexterity and lifting ability in upper limb after resection involving nerves, whereas bone resection and compartment resection produce significant decrease in range of movements reflected by lower objective scores than those with nerve resection. In a study conducted by Robert E. Turcotte et al on outcome in patients with popliteal sarcomas, they did not observe below-average functional scores when minor nerve branches of the sciatic nerve were sacrificed, whereas in a study by Davis et al on predictors of functional outcome after limb sparing surgery in lower extremity soft tissue sarcomas, patients with motor nerve resections were more disabled as reflected by low functional assessment score^[3]

Among the four predominant pathologies in our study (Malignant Fibrous Histiocytoma 25%, Osteosarcoma 15%, MPNST 12.5%, Fibromatosis 12.5%), Osteosarcoma group had the least mean subjective (22.8) and subjective score (34.2) reflecting the impact of bone resection and prosthetic reconstruction on subjective score in terms of gait & walking and on the objective score in terms of limb length discrepancy and extensor lag.

Radiation therapy did not have any significant effect on the functional outcome^[8]. Though detrimental effects of RT on functional outcome like post radiation fibrosis, joint stiffness, decreased tissue elasticity, delayed wound healing and swelling were proven in study by Robert et al^[9], these complications were not seen in our patients especially with adequate rehabilitation. Similar observation was made by Rikke Johansen et al who found that RT did not influence functional outcome in their patient group^[8]. Stinson et al evaluated the acute and long-term

effects of radiotherapy in relation to outcome and found that joint contracture was predicted by inclusion of a joint in the radiotherapy field and by radiotherapy treatment based on pre-1980 protocols^[10]; radiation fields longer than 35 cm and having a lower-extremity tumor were predictive of strength deficits and swelling^[10]. Davis et al showed that only preoperative radiotherapy had an early adverse effect on the clinical measures that might be considered in relation to the work of Stinson et al^[11]. All our patients who had radiation therapy received it as adjuvant therapy.

Patients with recurrent disease who comprised one fourth of the study group were successfully salvaged with no significant difference in scores compared to patients with new lesions. Though more soft tissue would require to be excised in recurrent disease, the resulting functional deficit depends on the residual functional musculoskeletal system rather than the recurrence status alone. Also early detection of recurrences may amount to smaller tumor burden which needs to be resected, thereby preserving adequate functional elements. Similarly patients with superficial recurrences can be salvaged by surgery without much loss of functional tissue, as observed by Gerrand et al in their study on influence of anatomical location on functional outcome, where resection of superficial tumors did not lead to significant change in MSTs score^[4].

Functional outcome after limb salvage not only depends upon the viable residual functional musculoskeletal unit, but also equally upon the effectiveness and adequacy of rehabilitation. The goal is to bring the patient as close as possible to independence in everyday life. Unlike many postsurgical patients, individuals who undergo limb sparing surgery are not transferred to rehabilitation centres; instead they must return as soon as possible to chemotherapy or radiation therapy. Shehadeh et al showed that adherence to a strict rehabilitation protocol after limb salvage surgery led to a relatively high level of functional outcome compared with other studies^[12-14]. Our patients who adhered to 3 months of rehabilitation had a significant difference in subjective and objective score than those who had not. Marchese et al who confirmed in their study, the importance of including ROM exercises in a comprehensive physical therapy program for children and adolescents with lower-extremity sarcoma.

Several other, unmeasured factors might influence postoperative functional outcome. Studies in other populations have suggested that social support, socioeconomic status and cognition are important determinants of outcome^[15-19]. These factors need to be explored in future studies.

CONCLUSION:

Objective scoring system proves to be a feasible and reliable method of functional assessment showing strong correlation with subjective score and with better reproducibility. The analysis of functional outcome after limb sparing surgery revealed a significant difference in outcome with postoperative rehabilitation. Radiotherapy, gender, pathology or recurrent status did not affect outcomes in our study. Resection of quadriceps components and tibial resection (because of quadriceps attachment) resulted in poorer score among lower extremity; these scoring systems complement each other for better assessment of functional outcome. Newer systems with combination of objective and subjective factors may be better for comprehensive analysis in the future.

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