CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 399, pp. 184–196

Scoring Systems in Total Knee Arthroplasty

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For assessment of total knee arthroplasty outcome, various scoring systems have been introduced. The current study assessed the interobserver correlation of four commonly used total knee arthroplasty outcome scores. One hundred eighteen total knee arthroplasties were investigated by two independent observers, using the Hungerford score, the Hospital for Special Surgery score, the Knee Society score, and the Bristol score. Each score consisted of three subscores: pain, knee, and function. For the highest interobserver correlation was computed for the Bristol score (interobserver correlation coefficient, 0.88). For knee range of motion, flexion contracture, and extension lag there was high interobserver correlation (interobserver correlation coefficient > 0.8 each). For walking distance and walking aids, there also was a high interobserver correlation (interobserver correlation coefficient > 0.7 each). For clinical assessment of total knee arthroplasty, pain should be measured on a four-step system, the knee should be assessed by measurement of range of motion, extension lag, and flexion contracture, and function should be measured on a separate score assessing walking distance and walking aids.

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Received: October 16, 2000.

Revised: May 14, 2001; September 23, 2001.

Accepted: October 4, 2001.

It is common to assess total arthroplasty outcome on the basis of scoring systems. The total outcome may be presented on a numerical point scale. Alternatively, a category system may be used. Scores with a category system frequently use the terms excellent, good, fair, or poor.[1,14,15,22,25,20,32,40,45,46,49] The lack of uniformity among analysis methods and the use of different terminology have been identified as problems.[3,4,7,8,12,26] For total hip replacement, outcome results were inconsistent, often giving contrary measures of success in the same patient.[7] Galante[12] suggested that a system for evaluating the results of hip surgery ideally should provide objective parameters that can be measured in a reproducible manner by independent observers.

The current study was designed to evaluate four commonly used scoring systems for knee arthroplasty: the Hungerford score, the Hospital for Special Surgery score, the Knee Society score, and the Bristol score. The study identifies variables proving high interobserver correlation which could be recommended for assessment of total knee arthroplasty.

MATERIALS A

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Pain	Pain
Knee	Mediol
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	Knee a
	Flexior
	Extens
	Flexion
	Extens
	Range
Function	Muscle
	Walkin
	Stairs
	Walkin
	Transfe
	Chair
	Giving
	Total

[1]Knee score of the Knee S
[2]Function score of the Kne

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MATERIALS AND METHODS

A series of 118 total knee arthroplasties in 92 patients, 58 women and 34 men, who had followup of their total knee arthroplasty at the authors' institution were included in the study. The average age of the patients at followup was 70 years (range, 43–87 years). The average followup was 9.8 years (range, 2–17 years).

All patients were evaluated by two experienced orthopaedic surgeons (CMB and MN). Four commonly used total knee arthroplasty evaluation systems were used: the Hungerford score,[18] the Hospital for Special Surgery score,[35] the Knee Society score,[20] and the Bristol score.[28] Each observer completed all four scores for each patient independently. All data were recorded in a database. Statistical calculations were started once data acquisition was completed. The individual results were not discussed before completion of the patient examination forms. Total score outcome was computed in points using the individual numerical scale, which ranged from 50 points (Bristol score) to 200 points (Knee Society score). Statistical analysis included the global Friedmann test to compare the mean total point outcome. The individual scores were compared pairwise by the Wilcoxon test with post hoc Bonferroni correction. The results of the Bristol score were doubled and the function score and knee score of the Knee Society score were analyzed independently to achieve a maximum of 100 points for each score. Additionally, the results were categorized as excellent, good, fair, or poor outcome according to the individual score instructions. For each score, the total number of cases rated excellent or good by both observers and the total number of cases rated fair or poor by both observers were summarized. All four scores were divided additionally into three subscores: subscore pain, subscore knee, and subscore function.

The subscore pain consisted only of the variable pain in all four scores. The subscore knee contained variables such as mediolateral and anteroposterior stability, knee alignment, flexion contracture, extension lag, and range of motion (ROM). The subscore function included variables such as muscle strength, walking distance, ability to climb stairs, use of walking aids, transfer activity, chair, and giving way. The interobserver correlation was calculated for all variables using the nonparametric. Kendell Tau correlation coefficient (interobserver correlation coefficient) (Tables 1–5). All analyses were done using the SPSS statistical software

TABLE 1. Interobserver Correlation Coefficient for Subscore Variables and for Total score Outcome

		Interobserver Correlation Coefficient			
Subscore	**Variables**	*Hungerford Score*	*Hospital for Special Surgery Score*	*Knee Society Score*	*Bristol Score*
Pain	Pain	0.74	0.84	0.62	0.88
Knee	Mediolateral stability	0	0.38	0.07	
	Anteroposterior stability			0.53	
	Knee alignment	0.28	0.41	0.54	0.22
	Flexion contracture	0.93	0.93	0.93	
	Extension lag		0.85	0.87	
	Flexion contracture				0.84
	Extension lag				
	Range of motion	0.89	0.87	0.87	0.87
Function	Muscle strength	0.65	0.48		
	Walking distance		0.73	0.73	0.73
	Stairs		0.70	0.63	0.71
	Walking aids		0.79	0.81	0.81
	Transfer activity		0.42		
	Chair				0.76
	Giving way				0.54
	Total	0.65	0.82	0.48[1] 0.78[2]	0.84

[1]Knee score of the Knee Society score

[2]Function score of the Knee Society score

TABLE 2. Hungerford Score With Subscores

Score	Points	Interobserver Correlation Coefficient
Total score	100	0.65
Subscore pain	40	0.74
Frequent rest pain; Severe pain with any activity, necessitating nonweight-bearing status		
Analgesics stronger than aspirin required; Cannot do routine activities because of knee pain	0	
Common rest pain; Moderately severe pain with almost any activity; Heavy dependence on weightbearing assistance devices; Unable to work because of pain; Unable to do most work because of pain; Unable to do housework or even simple activities	10	
Less frequent rest pain; Routine activities moderately restricted; May require mild or narcotic analgesics	20	
Performs most routine activities with slight or tolerable pain; Slight or tolerable pain; Occasional mild, nonnarcotic analgesics or antiinflammatory medications	30	
No discomfort with routine activity; Excessive activity provokes discomfort; Rarely takes analgesic or antiinflammatory medication	35	
No pain with any activity	40	
Subscore Knee	50	
Mobility		0.89
1–30°	0	
31–60°	5	
61–90°	10	
91–105°	20	
>105°	25	
Flexion contracture		0.93
5–15°	−5	
15–30°	−10	
30–45°	−15	
>45°	−20	
Stability		0
0–5°	10	
5–15°	5	
>15°	0	
Varus or valgus deformity		0.28
0–5°	15	
6–10°	10	
11–15°	7	
16–20°	3	
>20°	0	
Subscore Function	10	
Quadriceps strength		0.65
>75%	10	
50–75%	5	
<50%	0	

TABLE 3. Hospita

Score
Total score
Subscore pain
No pain at anytime
No pain on walking
Mild pain on walking
Moderate pain on walking
Severe pain on walking
No pain at rest
Mild pain at rest
Moderate pain at rest
Severe pain at rest
Subscore Knee
Range of motion
1 point for each 8°
Instability
None
Mild: 0°–5°
Moderate: 6°–15°
Severe: 16° or more
Flexion deformity
None
A few degrees
5°–10°
11° or more
Alignment
Each 5° varus/valgus
Extension lag
5°
10°
15°
Crutches
One cane
One crutch
Two crutches
Subscore Function
Walking
Walking and standing unli
Walking distance of 5–10
Walking 1–5 blocks and si
Walking less than 1 block
Cannot walk
Stairs
Climbing stairs
Climbing stairs with suppo

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0	0.65
)	0.74
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	0.28
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	0.65
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TABLE 3. Hospital for Special Surgery Score With Subscores

Score	Points	Interobserver Correlation Coefficient
Total score	100	0.82
Subscore pain	30	0.84
No pain at anytime	30	
No pain on walking	15	
Mild pain on walking	10	
Moderate pain on walking	5	
Severe pain on walking	0	
No pain at rest	15	
Mild pain at rest	10	
Moderate pain at rest	5	
Severe pain at rest	0	
Subscore Knee	38	
Range of motion		0.87
1 point for each 8°	≤ 18	
Instability		0.38
None	10	
Mild: 0°–5°	8	
Moderate: 6°–15°	5	
Severe: 16° or more	0	
Flexion deformity		0.93
None	10	
A few degrees	8	
5°–10°	5	
11° or more	0	
Alignment		0.41
Each 5° varus/valgus	−1	
Extension lag		0.85
5°	−2	
10°	−3	
15°	−5	
Crutches		0.79
One cane	−1	
One crutch	−2	
Two crutches	−3	
Subscore Function	32	
Walking		0.73
Walking and standing unlimited	12	
Walking distance of 5–10 blocks and standing ability intermittent (< 1/2 hour)	10	
Walking 1–5 blocks and standing ability up to 1/2 hour	8	
Walking less than 1 block	4	
Cannot walk	0	
Stairs		0.70
Climbing stairs	5	
Climbing stairs with support	2	

(continues)

TABLE 3. Hospital for Special Surgery Score With Subscores (*Continued*)

Score	Points	Interobserver Correlation Coefficient
Transfer		0.42
Transfer activity	5	
Transfer activity with support	2	
Muscle strength		0.48
Excellent		
Cannot break the quadriceps power	10	
Good		
Can break the quadriceps power	8	
Fair		
Moves through the arc of motion	4	
Poor		
Cannot move through the arc of motion	0	

TABLE 4. Knee Society Score Including the Knee Score and the Function Score

Score	Points	Interobserver Correlation Coefficient
Total score	200	
Subscore pain	50	0.62
None	50	
Mild or occasional	45	
Stairs only	20	
Walking and stairs	40	
Moderate	20	
Occasional	10	
Continual	0	
Severe		
Subscore Knee	50	0.48
Range of motion		0.87
One point for each 5°	≤25	
Anteroposterior stability		0.53
<5 mm	10	
5–10 mm	5	
>10 mm	0	
Mediolateral stability		0.07
<5°	15	
6°–9°	10	
10°–14°	5	
>15°	0	
Flexion contracture		0.93
5°–10°	−2	
10°–15°	−5	
16°–20°	−10	
>20°	−15	

(continues)

TABLE 4. Knee

Score
Extension lag
<10°
10°–20°
>20°
Alignment
5°–10°
0°–4°
11°–15°
>15°
Subscore Function
Walking
Unlimited
>10 blocks
5–10 blocks
< 5 blocks
Housebound
Unable
Stairs
Normal up and down
Normal up; down with r
Up and down with rail
Up with rail; down unat
Unable
Walking aids
Cane
Two canes
Crutches or walker

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RESULTS

Total Score Outcom

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TABLE 4. Knee Society Score Including the Knee Score and the Function Score

Score	Points	Interobserver Correlation Coefficient
Extension lag		0.87
<10°	−5	
10°–20°	−10	
>20°	−15	
Alignment		0.54
5°–10°	0	
0°–4°	3/°	
11°–15°	3/°	
>15°	20	
Subscore Function	100	0.78
Walking		0.73
Unlimited	50	
>10 blocks	40	
5–10 blocks	30	
< 5 blocks	20	
Housebound	10	
Unable	0	
Stairs		0.63
Normal up and down	50	
Normal up; down with rail	40	
Up and down with rail	30	
Up with rail; down unable	15	
Unable	`0	
Walking aids		0.81
Cane	−5	
Two canes	−10	
Crutches or walker	−20	

package (SPSS for Windows, Version 8.0, SPSS, Chicago, IL).

RESULTS

Total Score Outcome

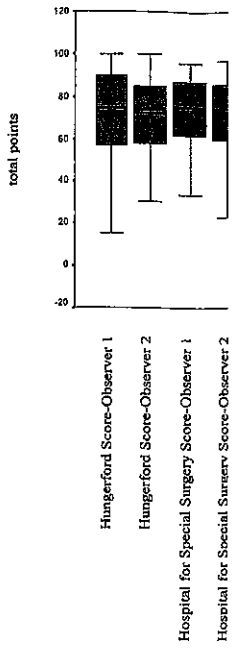
The median total score outcome, as averaged for both observers and for all the knees, was 74 points (range, 15–100 points) for the Hungerford score, 75 points (range, 23–97 points) for the Hospital for Special Surgery score, 58 points (range, −17–92 points) for the knee score of the Knee Society score, 50 points (range, −10–100 points) for the function score of the Knee Society score, and 71 points (range, 21–98 points) for the Bristol score (Fig 1). The global Friedmann test revealed significant differences among the mean total score outcomes ($p < 0.001$). Both components of the Knee Society rating system (knee score and function score) revealed significantly lower total score outcomes ($p < 0.05$, each).

Interobserver Correlation for the Total Point Outcome

The mean differences in points between Observer 1 and Observer 2 of the total score outcome were 14.1 points for the knee score of the Knee Society, 8.8 points for the Hungerford score, 7.2 points for the function score of the Knee Society score, 4.2 points for the Bristol score, and 3.9 points the Hospital for Special Surgery score.

TABLE 5. Bristol Score With Subscores

Score	Points	Interobserver Correlation Coefficient
Total score	50	0.84
Subscore pain	15	0.88
No pain	15	
Mild or occasional pain	12	
Moderate pain restricting activity	6	
Severe pain disturbing rest	0	
Subscore Knee	15	
Movement		0.87
1 point for each 12°	≤ 10	
Fixed flexion contracture or extension lag		0.84
None	3	
A few degrees	2	
Up to 15°	1	
16° or more	0	
Maximum varus/valgus		0.22
None	2	
up to 15°	1	
16° or more	0	
Subscore Function	20	
Mobility		0.81
No aids	5	
1 cane sometimes	4	
1 cane always	3	
2 canes	2	
2 crutches or frame	1	
Chairbound or bedridden	0	
Walking		0.73
Unlimited	5	
1/2 to 1 mile	4	
Up to 1/4 mile	3	
100 to 200 yards	2	
A few steps	1	
Cannot walk	0	
Stairs		0.71
Climbs stairs normally	3	
One at a time	2	
Only with help	1	
Cannot climb stairs	0	
Chair		0.76
Rises not using arms	2	
Rises using arms	1	
Cannot rise from chair	0	
Giving way		0.54
No giving way	5	
Feels insecure	3	
Gives way	2	
Does not support weight	0	



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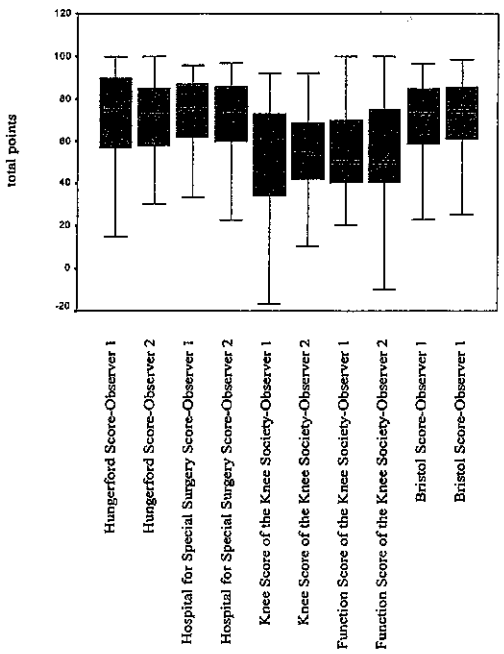

Fig 1. The total point outcomes for the Hungerford score, the Hospital for Special Surgery score, the Knee score and the Function score of the Knee Society score, and the Bristol score for Observer 1 and Observer 2 are shown. The boxplot indicates the median, the twenty-fifth, and seventy-fifth percentiles, and the adjacent values.

The interobserver correlation coefficient was 0.84 for the Bristol score, 0.82 for the Hospital for Special Surgery score, 0.78 for the function score of the Knee Society score, 0.65 for the Hungerford score, and 0.48 for the knee score of the Knee Society score (Tables 1–5). Figure 2 shows the different interobserver correlations for the scores tested.

Total Score Category Outcome

Evaluation of the scores' capability to distinguish an excellent or good result from a fair or poor result showed agreement in 112 cases between Observer 1 and Observer 2 for the Hospital for Special Surgery score. Accordingly, disagreement was seen in six cases. One hundred nine cases of agreement were recorded for the Bristol score, 103 cases for the function score of the Knee Society score, 96 cases for the Hungerford score, and 90 cases for the knee score of the Knee Society.

Interobserver Correlation of the Subscore Variables

Evaluation of interobserver correlation for the subscore variable pain revealed an interobserver correlation coefficient of 0.88 (Bristol score), 0.84 (Hospital for Special Surgery score), 0.74 (Hungerford score), and 0.62 (Knee Society score).

Variables of the subscore knee with a high interobserver correlation were ROM (interobserver correlation coefficient, 0.9 for all scores), flexion contraction (interobserver correlation coefficient, 0.9 for the Hungerford score, for the Hospital for Special Surgery score, and for the Knee Society score), extension lag (interobserver correlation coefficient, 0.9 for the Hospital for Special Surgery score and for the Knee Society score; interobserver correlation coefficient, 0.8 for the Bristol score).

For the subscore function, variables with high interobserver correlation were walking distance (interobserver correlation coefficient, 0.7 for the Hospital for Special Surgery score, for the Knee Society score, and for the Bristol score), the variable walking aids (interobserver correlation coefficient, 0.8 for the Hospital for Special Surgery score, for the Knee Society score, and for the Bristol score), chair (interobserver correlation coefficient, 0.8 for the Bristol score), stairs (interobserver correlation coefficient, 0.7 for the Hospital for Special Surgery score, for the Knee Society score, and for the Bristol score). The complete results are summarized in Tables 1 through 5.

DISCUSSION

Outcome assessment has received new impetus during the past decade as emphasis has shifted from the area of expansion and technical development to assessment and accountability.[2] An outcome scale for total joint arthroplasty should be valid, reliable, and responsive.[23] For total hip replacements, studies investigated various scoring systems and showed measurable dis-

orrelation Coefficient

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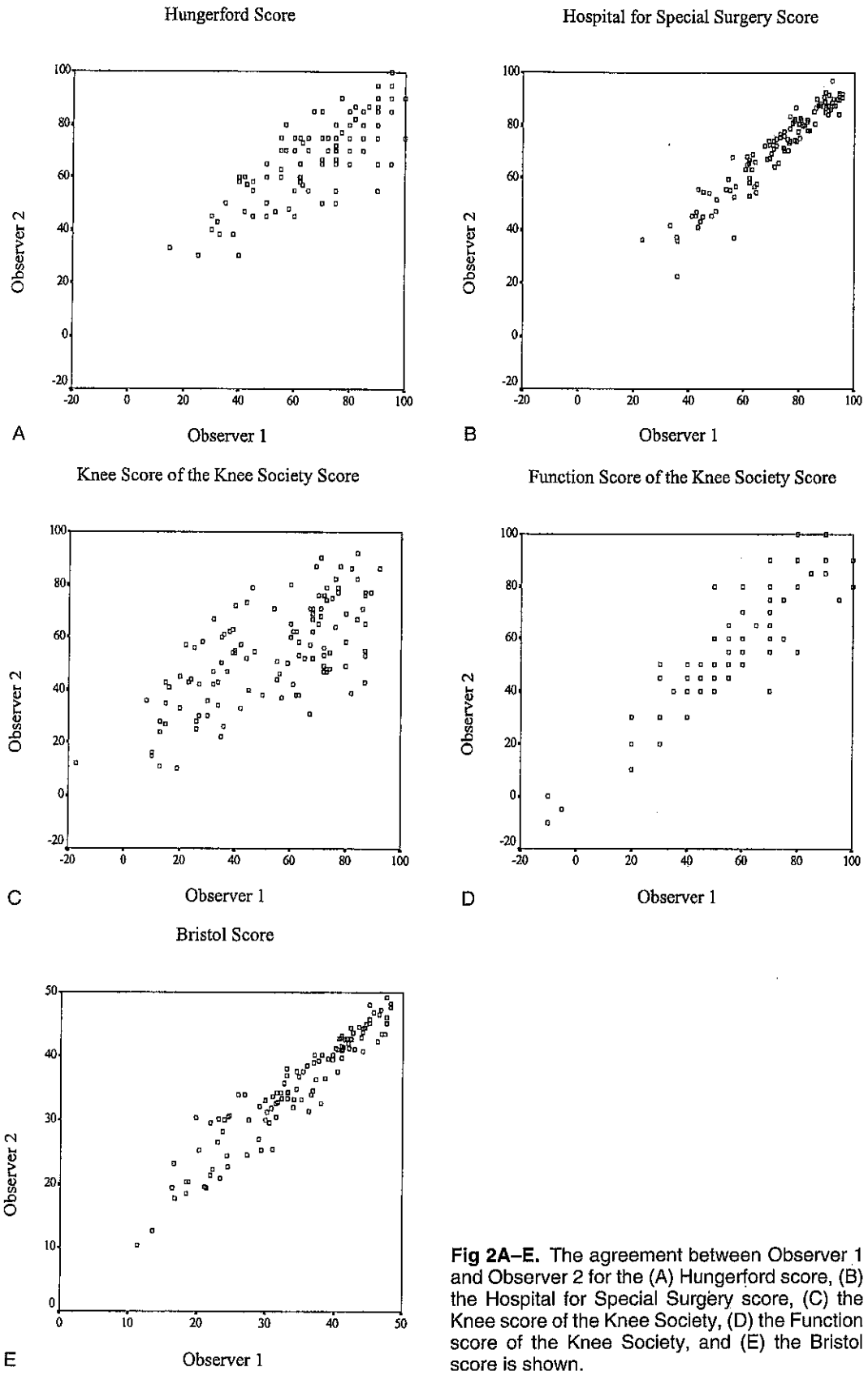

Fig 2A–E. The agreement between Observer 1 and Observer 2 for the (A) Hungerford score, (B) the Hospital for Special Surgery score, (C) the Knee score of the Knee Society, (D) the Function score of the Knee Society, and (E) the Bristol score is shown.

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crepancies in the outcome.[3,7,8] For total knee arthroplasty, the responsiveness of outcome scores was investigated by Kreibich et al.[23] Ryd et al[38] addressed the problem of interobserver variability of knee scores. They stated that the scores were unreliable but did not suggest alternatives. The four knee cores currently tested revealed considerable differences of total outcome. The median total score outcome ranged between 50 points for the function score of the Knee Society and 75 points for the Hospital for Special Surgery score. These results indicate that using different scoring systems makes it difficult to compare results of different studies reporting on outcome of total knee arthroplasty. These results are in concordance with studies done on the evaluation of scores for total hip arthroplasty.[3,8]

For assessment of total knee arthroplasty outcome, it is common to express the results in categories like excellent, good, fair, or poor.[1,14,15,22,25,30,32,40,45,46,49] In some studies these categories are even more simplified by summarizing excellent and good results and fair and poor results.[5,9,10,15,15,16,21,22,24,25,27,29,31–33,39] The current results show there was considerable disagreement between both observers when this simplification was applied especially for the Hungerford score and the knee score of the Knee Society. Gartland[13] stated that the practice of category classification has developed as a matter of convention rather than as a result of the scientific method. The results of the current study suggest that some scores have a poor capability to distinguish accurately between excellent or good results and fair or poor results, respectively. The Hospital for Special Surgery score and the Bristol score revealed the highest interobserver agreement for the category classification system.

For total score outcome, the Hospital for Special Surgery score and the Bristol score had the highest correlation. This might be explained by the subscore variables of the individual scores. Both scores include variables with high interobserver correlation (Tables 1–5). Figure 2 shows the different interobserver correlation of the five scores.

A weakness of the current study was having only two observers. For studies assessing the reliability of agreement of radiographic scoring systems multiple observer agreement was reported.[11,34,41–43,47,48] In clinical studies, repeated patient examinations by different observers using multiple evaluations systems may be problematic because of learning effects and decrease of patient cooperation.

Pain is a critical issue that relates to the success or failure of a total knee replacement. Pain was the most important variable in all scores. Pain had the highest interobserver correlation in the Bristol score (interobserver correlation coefficient, 0.9) and in the Hospital for Special Surgery score (interobserver correlation coefficient, 0.8). In the Bristol score, pain is assessed by a simple four-point scale (no pain, mild or occasional pain, moderate pain restricting activity, and severe pain disturbing rest). The Hospital for Special Surgery score also uses a four-point scale. The other scores assess pain using a more complex system. The Hungerford score uses a six-point scale, the Knee Society score uses a seven-point scale where many different factors are considered for a proper ranking. The results of the current study suggest that for a high interobserver correlation, pain should be assessed using the four-point scales of the Bristol score or the Hospital for Special Surgery score. Similar suggestions were made by Aichroth et al[2] who introduced a standard chart for assessment of the knee after reconstructive operations. For assessment of pain, four simple grades with no pain at best, severe pain at worst, and two categories between were suggested. However, there are two additional approaches that could provide evaluation of pain: a visual analog scale as described by Huskisson[19] or measurement of the relief of pain instead of its severity. Neither of these methods currently is used for assessment of results of total knee arthroplasty.

For the subscore knee, the variables ROM, flexion contracture, and extension lag revealed the highest interobserver correlation (Tables 1–5). All these variables were measured in the

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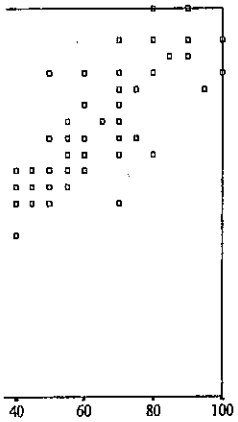

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ty, and (E) the Bristol

sagittal plane using a simple goniometer. The lateral malleolus of the fibula, the lateral femoral condyle, and the greater trochanter were clear landmarks for orientation and measurement. Similar results were reported for simple ROM measurements of the foot,[36] the wrist,[44] and for the knee.[38] Low interobserver correlations were seen for the variable knee alignment. A possible explanation may be the complicated measurement technique. A cord was required to measure the line from the center of the femoral head, to the center of the patellar, and to the center of the ankle. Additional use of a goniometer was difficult for one observer.

Determining the femoral head position clinically and assessing ROM using a goniometer may cause some inaccuracy. Ritter and Campbell[37] showed that the distance between the anterior iliac spines to be the only clinically significant factor related to the position of the femoral head center. Horton and Reckling[17] found that a marker placed just lateral to the palpable femoral pulse approximately 2 to 3 cm below the inguinal ligament is suitable as a guide to locate the center of the femoral head when determining the mechanical axis during total knee arthroplasty. Boone et al[6] showed that when more than one tester measures the same movement, increases in joint motion should exceed 6° for the lower extremity to determine improvement. With additional radiologic assessment accuracy probably would increase. However all scores applied in the current study assessed the knee alignment entirely clinically which may contribute to the low interobserver correlation.

The measurement of mediolateral knee stability revealed the lowest interobserver correlation of all variables tested (interobserver correlation coefficient values ranging from 0 to 0.4). As scores used steps of 5° for assessment of knee stability and a goniometer was required for proper measurement, it was difficult to test and to measure simultaneously.

The variables of the subscore function mainly revealed high interobserver correlation. The Knee Society score separates patients' general factors from knee related factors, whereas the other scoring systems combine both factors, and as such, may give a false impression of what is transpiring. As most of these variables were patient-dependent, a learning effect must be considered. Once estimated, the variables were easy to remember by the patients, which would result in a better interobserver correlation.

Uniform reporting would simplify interpretation of data and facilitate comparisons between results from different centers.[12] Orthopaedic surgeons should agree to a uniform method of evaluating and reporting the results of total knee arthroplasty. A system for evaluating the results of total knee replacement should provide objective parameters that can be measured in a reproducible manner by independent observers. Pain should be assessed on a four-step scale. The objective findings in the knee should include ROM, extension lag, and flexion contracture and evaluation of function should include walking distance and walking aides.

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From the Department of Or
University, Shimane, Japan
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Orthopaedics, Shimane Me
cho, Izumo, Shimane 693–8
Received: March 8, 2001.
Revised: September 10, 20
Accepted: October 11, 200