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Functional outcome after high tibial osteotomy: A study using individual goal achievement as the primary outcome variable

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Abstract—Functional outcome after high tibial osteotomy (HTO) was evaluated with respect to both improvement and goal achievement. Fifty-seven subjects, 32 men and 25 women, with a mean age of 55 years were examined with the Functional Assessment System (FAS) 6 and 12 months after surgery. The FAS is an evaluation system, specifically designed to monitor lower extremity dysfunction. It shows a profile with preoperative status, individual goal, and postoperative status. Statistically significant improvement was seen in 6/20 variables after 6 months, and in 10/20 variables after 12 months. When goal achievement was examined, the results were not as impressive. The treatment goal was not reached on the group level for almost all variables. On the individual level, only 20\N40% of the patients achieved the goal as a result of surgery in most variables. Exceptions were pain and leisure time/hobbies, where there was a high degree of goal achievement. It is possible that postoperative training was inadequate. The authors recommend a new randomized study, where patients who receive specific individual training related to the individual goal and functional profile are compared with a control group.

Key words: *goal achievement, osteoarthritis, outcome, rehabilitation, tibial osteotomy.*

INTRODUCTION

For several decades, high tibial osteotomy (HTO) has been the treatment of choice for osteoarthritis of the knee, especially in young and active subjects (1). A literature search in the Medline database yielded more than 50 studies on follow up after HTO. Most studies report positive effects in 60–90 percent of the cases.[1] The variables most often evaluated have been general improvement, pain, and walking ability, often expressed by vague terms such as excellent/good/fair or satisfactory, acceptable, *et cetera.* Some studies examined more specific aspects, such as cartilage regeneration, postoperative joint angles, joint space, radionuclide uptake, and basic gait parameters. A few studies have used functional scales like the HSS score, Knee score, Functional Knee score, and the Tegner-Lysholm score. No study more specifically evaluated variables related to physiotherapy or rehabilitation activities. The follow up time varies from a few months to 20 years. Many studies report a deterioration of knee function and a progression of the gonarthrosis with time. All studies are of the pretreatment/posttreatment type, where the authors report the difference between the preoperative and postoperative sta-

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[1]These studies are not listed in the references list, but a complete list can be obtained from the authors on request.

tus. Generally, the studies were designed to evaluate factors important for the orthopedic surgeon, but not necessarily to reflect the effect of physiotherapy or rehabilitation procedures. No study examined the degree of goal achievement. In the present study, outcome after HTO was evaluated with respect to both postoperative improvement and individual goal achievement with an evaluation instrument, the Functional Assessment System (FAS), which reflects function on impairment, activity (disability), and participation (handicap) levels.

The main indication for HTO is pain and angle deformity of the knee due to unicompartmental gonarthrosis. Most cases reported in the literature have medial gonarthrosis with varus deformity of the knee, but about 15 percent of the subjects have lateral gonarthrosis with valgus deformity. Two main treatments have been available: closed wedge osteotomy and dome (vault) osteotomy. Normally, the knee is overcorrected to 5–13 degrees of valgus in medial gonarthrosis, and the opposite in cases of lateral gonarthrosis. This overcorrection is important for the final result of the osteotomy (2,3). The biomechanical idea behind the operation is a reduction of the load on the affected compartment of the knee. In recent years, however, cadaver studies have revealed that the extremity alignment necessary to unload the medial compartment of the knee is about 25 degrees, and that the hypothesis on biomechanical unloading probably is seriously flawed (4). Another possible mechanism may be reduction of the intraosseous pressure. Some studies have shown cartilage regeneration after HTO (5).

Many reports have stressed the importance of outcome analysis for judgment of the effectiveness of treatment and rehabilitation. Outcome is an evaluation of observations associated with a study period with respect to factors that can be of interest after some kind of intervention. Outcome is not an absolute measure; rather, it is a measure of change, with the end point compared with the situation at the start of the study (6,7). Functional outcome must also be evaluated with respect to treatment goals and goal achievement. It is not enough to report an improvement. The most important factor to evaluate is whether or not the individual treatment goal or rehabilitation goal has been reached. The treatment goal must be individualized, and it must be appropriate and meaningful in terms of activities that are important for the patient with respect to age, sex, and activity level (8–14). For example, a young physically active person will have demands on life other than those of an older, inactive person, even if they have the same medical diagnosis and have obtained the same treatment. The goals must be determined with respect to individual needs and must provide the patients with a realistic view of what can be expected from the treatment. Thus, the therapist must set the goals in close collaboration with the patient. The goals must be expressed in terms of reduction of disablement, and they must be measurable (15–18). Whether a treatment is effective or not must be judged from the degree of goal achievement. Even if there is a statistically significant improvement, it is inadequate if the treatment goal is not reached.

In the present study, outcome after HTO has been evaluated with respect to postoperative improvement and individual goal achievement. The effects have been described on both group level and individual level. The evaluation was performed with the FAS, an instrument specifically designed for evaluation of lower extremity dysfunction (19–22). Prior to this, the FAS has been used to evaluate outcome (improvement and goal achievement) after hip arthroplasty and knee arthroplasty (23).

SUBJECTS AND METHODS

Subjects

Seventy-five consecutive patients, who were admitted to a county hospital for high tibial osteotomy, were evaluated with the FAS (see below). Six patients never had an operation. At 6 months control, 63 patients were available, and at 12 months postoperatively 57 patients, 25 women and 32 men, were available. Only the 57 patients who completed the follow up at both 6 and 12 months are reported in this study, i.e., the preoperative and both postoperative studies include the same patients. The mean age of this patient group was 54.8 years (SD=9.0; range 34–77 years). Patients and reasons for drop out are shown in **Figure 1**.

Indications for High Tibial Osteotomy

The indications used for high tibial osteotomy at the clinic were: medial gonarthrosis degree 1\N2 (Ahlbäck's classification), disabling pain, varus deformity of the knees, and age below 65 years.

Postoperative Treatment

The knee was immobilized in a plaster-of-Paris cast for six weeks. The patient was dismissed from the hospital with a home training program. After six weeks, the patient was taken back, and the plaster was removed. Six

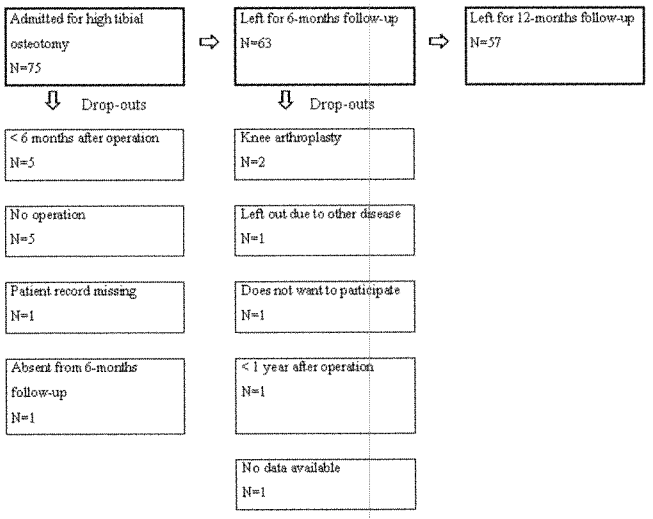

Figure 1.
Patients included in the study. The boxes show reasons for drop out.

weeks after the cast was removed, the patient had a second visit to the doctor to control knee mobility and gait. Then, the patient was normally transferred to a general practitioner. Only patients with some kind of complication were prescribed specific physical training. After six and twelve months the patients were seen by a physiotherapist at the hospital, and functional status was recorded with the FAS (see below).

The Functional Assessment System (FAS)

The FAS consisted of 20 variables, divided into five groups: hip impairment, knee impairment, physical disability, social disability variables, and pain. The variables were measured in a laboratory setting. The values were then transformed to a uniform, dimensionless score on a 5-point scale according to a key for every variable. Zero means no disability; four means severe disability or total lack of function. The scores were plotted onto a diagram, giving a disability profile. This procedure has been thoroughly described in an earlier paper (19). In that paper, there is also a brief key to the coding of the variables. The rating was done by a physiotherapist. A completed profile is included in the **Appendix**.

The 20 variables of the FAS arranged by functional group are:

Hip impairment variables:

1. Hip flexion
2. Extension deficit, hip
3. Abduction, hip
4. Adduction, hip

Knee impairment variables:

5. Knee flexion
6. Extension deficit, knee
7. Quadriceps muscle strength
8. Hamstrings muscle strength

Physical disability variables:

9. Rising from half-standing
10. Rising/sitting down
11. Step height
12. Standing on one leg
13. Stair climbing
14. Gait speed (m/s)
15. Walking aid

Social disability variables:

16. Communication/transport
17. Work/housekeeping
18. ADL functions, other
19. Leisure time/hobbies

Pain:

20. Pain

Originally, most variables included in the FAS were measured with some kind of instrument (e.g., goniometer, dynamometer, or stopwatch). A few variables have another character, for example evaluation of household activities, leisure time activities, etc. All measurements were then transformed to a uniform dimensionless disability score ranging from 0 to 4 (0=no disability; 4=severe disability). The scores were later transferred to a diagram showing a picture of total lower extremity dysfunction.

Active range of motion of the hip and knee was measured with a standard manual goniometer with long telescopic shanks. Muscle strength, tested as isometric extension and flexion forces in the knee, was measured with a strain-gauge dynamometer at 45 degrees of knee flexion and with the patient in a sitting position. Rising/sitting down was recorded as the lowest possible sitting height of a chair with adjustable height and without armrests. Rising

from a half-standing position was measured as the maximum number of times the patient could rise from a high chair during one minute, with a hip angle of about 135°. Step height was measured using a platform with different step heights, corresponding to ordinary stairs, bus and train stairs, and so on. The time standing on one leg was tested as the number of seconds the patient was able to stand on his or her affected leg. Gait speed was tested on a 65-meter indoor walkway. The social variables were evaluated by a personal interview of the patient. Pain was evaluated in a manner related to standard clinical evaluation of the indication for surgery.

Statistical Methods

Descriptive statistics and 2-sided *t*-test for pairwise comparison of data were performed according to standard procedures (24). Statistical computations were performed with a commercial statistics package for personal computers, Systat 6.0/Sygraph for Windows.

RESULTS

Discrepancy Between Goal and Preoperative Status

Mean scores were calculated for preoperative status and for the individual goals (**Figure 2**). For the hip variables there was, of course, no dysfunction. For the other variables (except for walking aid) there was an obvious difference between preoperative values and goal values in most variables. A Student's *t*-test revealed that this discrepancy was also statistically significant for all variables, except for walking aid and hip variables (**Table 1**). The discrepancy reflects possible gain from an operation. Where there is no difference, there is nothing to gain. **Figure 3** shows the percentage of the patients in which an improvement of at least one step on the scale was expected.

Improvement After Operation

Preoperative scores were compared with the scores six and twelve months after operation (**Figures 4** and **5**). The most impressive improvement six months after operation was found in the pain variable, where there was a reduction of 1.5 steps on the FAS scale. The Student's *t*-test revealed that the improvement was statistically significant for only six of the variables: extension deficit of the knee, communication/transport, work/housekeeping, ADL-functions, leisure time/hobbies, and pain. For the other variables the difference was not statistically significant (**Table 2**). At 12-months follow up, there was a further improvement in quadriceps muscle strength, raising up from half-standing, step height, and stair climbing (**Table 2**). However, the main picture is the same.

On an individual level 75–80 percent of the patients showed an improvement in the pain and leisure time/hobby variable at both 6- and 12-months follow up. For the variables of communication/transport, work/housekeeping, and

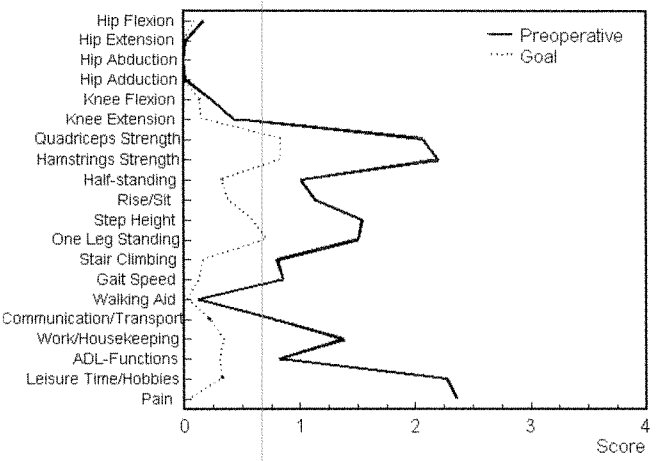

Figure 2.
Comparison of preoperative status and goal profile on group level.

Table 1.
Differences between preoperative status and goal.

Variable	*p*-value
1. Hip flexion	NS
2. Extension deficit, hip	NS
3. Abduction, hip	--
4. Adduction, hip	NS
5. Knee Flexion	<0.05
6. Extension deficit, knee	<0.001
7. Quadriceps muscle strength	<0.001
8. Hamstrings muscle strength	<0.001
9. Raising up from half standing	<0.001
10. Raising up/sitting down	<0.001
11. Step height	<0.001
12. Standing on one leg	<0.001
13. Stair climbing	<0.001
14. Gait speed (m/s)	<0.001
15. Walking aid	NS
16. Communication/Transport	<0.001
17. Work/house-keeping	<0.001
18. ADL functions, other	<0.001
19. Leisure time/hobbies	<0.001
20. Pain	<0.001

p-values from Student's *t*-test; --=insufficient data; NS=not significant.

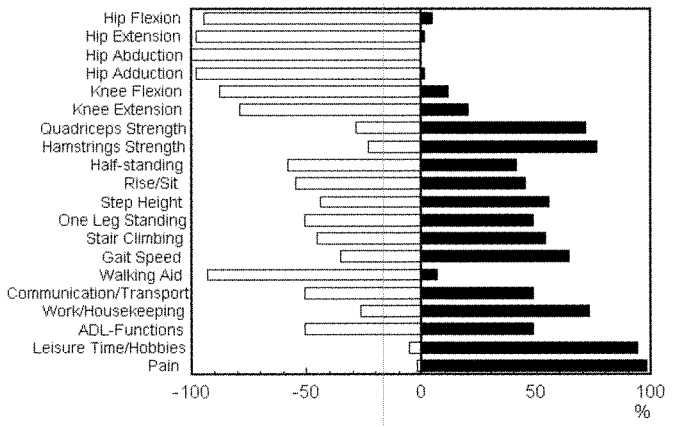

Figure 3.
Expected gain from surgery of at least one step on the scale. White bars on the left show patients who already were at the goal level before surgery. Black bars show patients with expected gain.

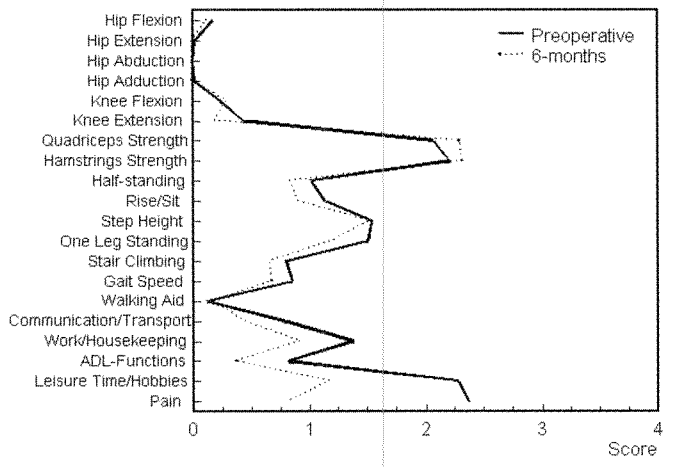

Figure 4.
Comparison of preoperative functional status and functional status six months after surgery.

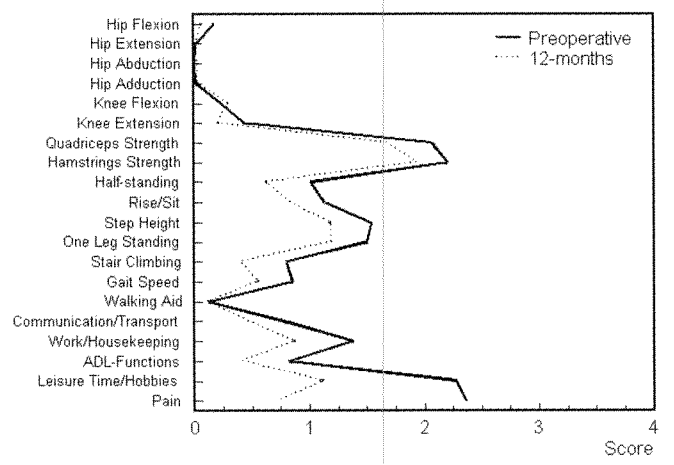

Figure 5.
Comparison of preoperative functional status and functional status twelve months after surgery.

Table 2.
Differences between preoperative status and 6 months postoperative status.

Variable	*p*-value 6 mo	*p*-value 12 mo
1. Hip flexion	NS	NS
2. Extension deficit, hip	NS	NS
3. Abduction, hip	--	NS
4. Adduction, hip	NS	NS
5. Knee Flexion	NS	NS
6. Extension deficit, knee	<0.05	NS
7. Quadriceps muscle strength	NS	<0.05
8. Hamstrings muscle strength	NS	NS
9. Raising up from half standing	NS	<0.05
10. Raising up/sitting down	NS	NS
11. Step height	NS	<0.05
12. Standing on one leg	NS	NS
13. Stair climbing	NS	<0.001
14. Gait speed (m/s)	NS	<0.01
15. Walking aid	NS	NS
16. Communication/Transport	<0.001	<0.01
17. Work/house-keeping	<0.001	<0.001
18. ADL functions, other	<0.001	<0.001
19. Leisure time/hobbies	<0.001	<0.001
20. Pain	<0.001	<0.001

p-values from Student's t-test; --=insuffificient data; NS=not significant.

ADL-functions, 35–45 percent of the patients showed an improvement. For most of the other variables, less than 30 percent of the patients were improved after surgery (**Figures 6** and **7**).

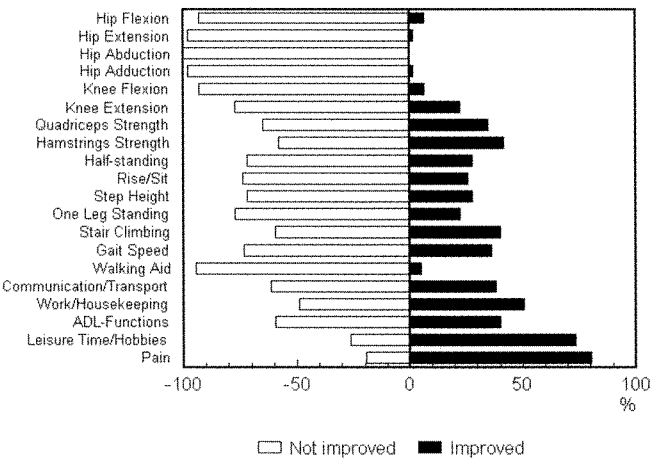

Figure 6.
Individuals with improvement of at least one step on the scale (black bars) at six months follow up. White bars indicate the proportion of patients with no improvement after surgery.

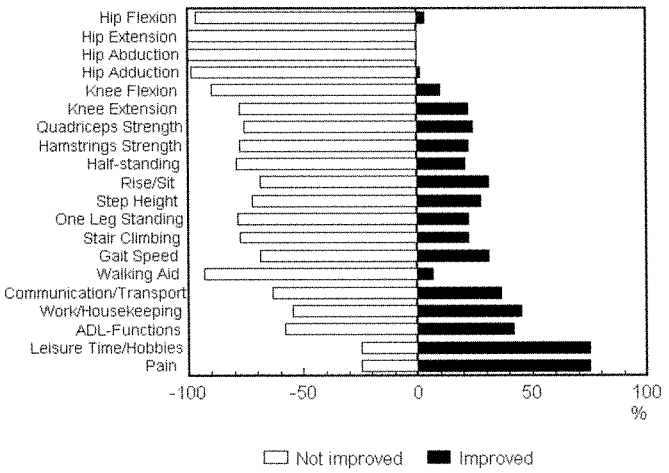

Figure 7.
Individuals with improvement of at least one step on the scale (black bars) at twelve-months follow up. White bars indicate the proportion of patients with no improvement after surgery.

Goal Achievement

There are big differences between the average function profile and the average goal profile six and twelve months after surgery (**Figures 8** and **9**). On the group level, the rehabilitation goal was not achieved in any variable. The Student's *t*-tests show that the observed differences were still statistically significant in all variables except for extension deficit of the knee, and ADL-functions (**Table 3**).

A high proportion of the patients had an acceptable functional capacity already before the operation, and only a minor portion of them experienced a gain of function. The variable showing the highest proportion of people

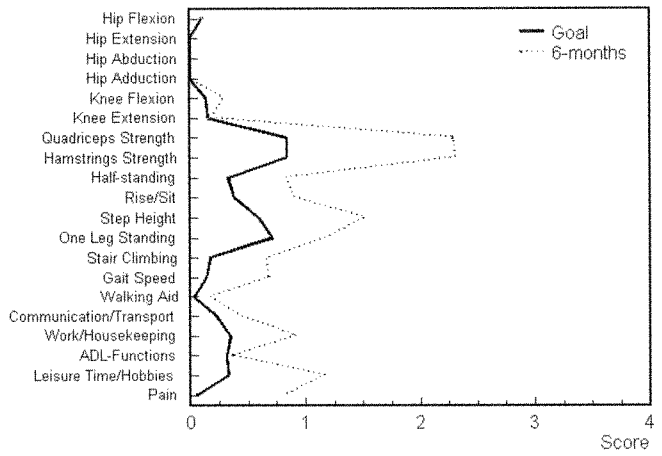

Figure 8.
Functional status related to goal six months after surgery. Mean values.

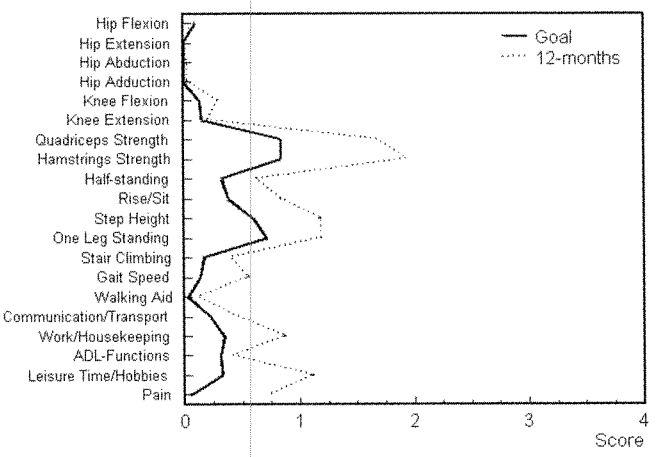

Figure 9.
Functional status related to goal twelve months after surgery. Mean values.

Table 3.
Differences between goal and 6 months and 12 months postoperative status.

Variable	*p*-value 6 mo	*p*-value 12 mo
1. Hip flexion	NS	NS
2. Extension deficit, hip	--	NS
3. Abduction, hip	--	NS
4. Adduction, hip	--	NS
5. Knee Flexion	<0.05	<0.05
6. Extension deficit, knee	NS	NS
7. Quadriceps muscle strength	<0.001	<0.001
8. Hamstrings muscle strength	<0.001	<0.001
9. Raising up from half standing	<0.001	<0.05
10. Raising up/sitting down	<0.01	<0.05
11. Step height	<0.001	<0.01
12. Standing on one leg	<0.01	<0.01
13. Stair climbing	<0.001	<0.01
14. Gait speed (m/s)	<0.001	<0.001
15. Walking aid	<0.05	<0.05
16. Communication/Transport	<0.01	<0.05
17. Work/house-keeping	<0.001	<0.001
18. ADL functions, other	NS	NS
19. Leisure time/hobbies	<0.001	<0.001
20. Pain	<0.001	<0.001

p-values from Student's *t*-test; --=insuffificient data; NS=not significant.

who achieved the goal as a result of the operation is pain. The results at 12-months follow up are very similar to those at 6 months (**Figures 10** and **11**).

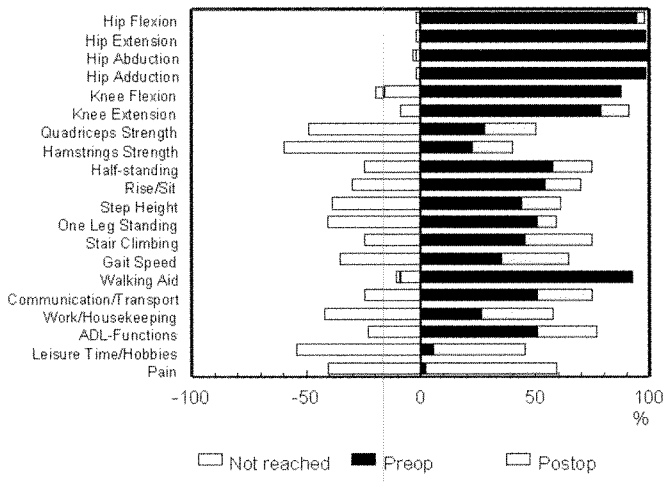

Figure 10.
Goal achievement after surgery at six-month follow up. White bars indicate subjects who never reached the goal. Black bars indicate subjects who were already at the goal level before surgery; gray bars indicate subjects who reached the goal as a result of surgery.

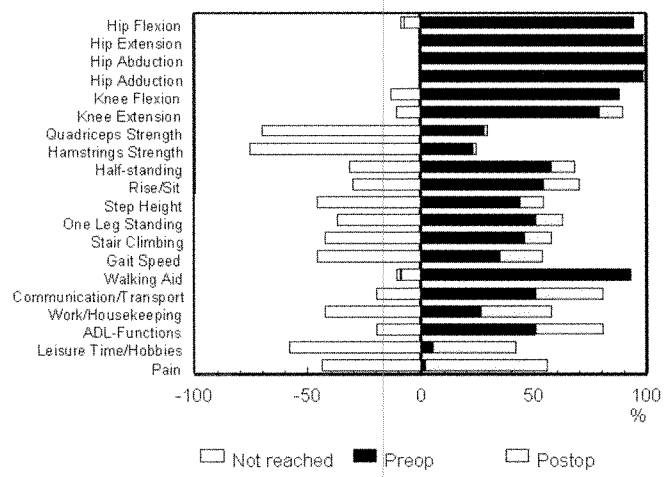

Figure 11.
Goal achievement after surgery at twelve-month follow up. White bars indicate subjects who never reached the goal. Black bars indicate subjects who were already at the goal level before surgery; gray bars indicate subjects who reached the goal as a result of surgery.

DISCUSSION

All changes or differences will become statistically significant, if the sample size is large enough. Statistical significance, however, is not the same as clinical relevance. In this paper we have focused on the individual rehabilitation goal as a criterion for clinical relevance. If, for example, the goal for a patient is the ability to tie his shoes, or to climb stairs, it does not matter much from a rehabilitation point of view if there is a statistically significant improvement of 10° of range of motion in the knee joint, if the patient still cannot perform these activities. Statistical significance is important, of course, but only if it is discussed together with clinical relevance, i.e., goal attainment on an individual level.

The present study is a follow up study after high tibial osteotomy. The evaluation was done in two ways, a) as a pre-/posttreatment study where improvement was recorded as statistically significant change, and b) as a study where goal achievement was the primary outcome criterion.

The primary aim of the study was to evaluate clinically relevant improvement after HTO, using individual goal achievement as a criterion of success, and with HTO as an example of application. In the literature, we found about 50 follow up studies concerning HTO. The outcome variables that were evaluated were mainly on an impairment level, and they were mainly chosen to fulfil the demands of orthopedic surgeons. Functional variables, such as rising from a chair, standing on one leg, stair climbing, communication/transport, work/housekeeping, and ADL-function, which are important from a rehabilitation and physiotherapy point of view, were not discussed in these studies. None of the studies used individual goal achievement as an outcome variable. Consequently, we have used a new approach to follow up and assess outcome when we used individual goal achievement as an outcome parameter. Many of the follow up studies report a positive result in 60–90 percent of the cases. When we used goal achievement as an outcome variable, we could not verify these positive results. Hence, the results obtained from a study are heavily dependent on what outcome variable we choose.

From a rehabilitation point of view, the individual patient's goals and expectations should be the primary outcome variable to assess (25). For this reason, it is important to formulate concrete, measurable goals, where individual goal achievement can be used to monitor the patient's progress. Such goals cannot be set by the patient himself, or by the therapist alone, but must be set by the patient and therapist in close collaboration in order to be realistic.

In the present study we have used the FAS as an evaluation instrument. The FAS is an instrument that has been designed for evaluation of lower extremity function, especially for patients with osteoarthritis of the hip and knee. This instrument reflects lower extremity function

not only on impairment level, but at activity (disability) and participation (handicap) levels as well. It has been thoroughly evaluated for different metric properties such as validity, reliability, discriminatory power, sensitivity, and specificity (19,21,22). The results are recorded as disability scores, which are plotted onto a diagram that shows a simple individual profile. Patient status can be recorded initially and at the end point. A goal profile can easily (and should routinely) be drawn. The pre- and postoperative profiles can be compared between themselves, and with the goal profile. In our opinion, the comparison between the end point profile and the goal profile constitutes the ultimate criterion for success.

In this study, there was a statistically significant improvement in 6 of 20 variables at 6-months follow up and 10 of 20 variables at 12-months follow up, but if the pre- and postoperative profiles are compared, the differences, except for pain and leisure time/hobbies, are quite small. Thus, if only statistical significance is considered, the results may indicate fairly good results. If, however, goal achievement is added as an outcome criterion, the results are less impressive. Except for pain and leisure time/hobbies, goal achievement as a result of surgery varied between 20 and 40 percent. Our results indicate that statistical significance is not enough. Goal achievement as a criterion for clinical relevance must also be considered.

Preoperatively there was quite a large discrepancy between initial status and goal. This discrepancy between the profiles indicates the theoretically possible gain to obtain from surgery. There was an obvious difference between the two profiles when the mean scores were examined, but on the individual level we can observe that no gain was to be expected for a high proportion of the patients in many of the variables (**Figure 2**, white bars). The exceptions were pain and leisure time/hobbies.

If, on a group level, the goal was reached, the postoperative profile and the goal profile at 6- and 12-months follow up would coincide. From **Figures 8** and **9** it is obvious that on the group level there is still a considerable difference between postoperative status and desired goal, and **Table 3** shows that this difference is also statistically significant. In **Figures 10** and **11** goal achievement as a result of surgery is shown in gray. Obviously, only a minority of the patients reached the rehabilitation goal as a result of surgery. The others either did not reach the goal, or they were at the goal already before surgery.

Pain is normally the main indication for HTO. It was also the variable where most gain was expected, and where most gain was obtained, both as statistically significant improvement, and as goal achievement. The mean improvement seen after 6 and 12 months was about 1.5 steps on the functional scale. Almost the same was observed for leisure time/hobbies. The close similarity between pain and leisure time/hobbies may indicate a close relation between pain and such activities.

Critical questions raised from this study are: Why was there so little functional improvement? and, Why did so little goal achievement come out of the treatment? The patients included in the present study were dismissed from the hospital without any specific training. Are the present postoperative training routines inadequate? Can better functional results be obtained by intensive physiotherapy, individually designed after the individual functional profile and goal profile? In a future study, the FAS should be used to compare randomized treatment groups, where one group receives standard treatment, and the other receives specific training related to the functional profile and goal profile.

CONCLUSIONS

The main improvements seen in this study were related to pain reduction and an increase in leisure time/hobby activity. On a group level there was a statistically significant improvement in many other variables, but when individual goal achievement was used as an outcome criterion, improvement was not impressive. We have focused on goal achievement as a criterion for clinical relevance, and we have highlighted the need for further studies on specific training based on the individual functional status and goal profile.

APPENDIX

Diagnosis: Osteoarthritis, left knee — Physiotherapist (sign): U.Ö.

Date: preop: 02-06-99; postop: 08-12-99

Euro-Quol / SF 36: pre op: ☐ post op: ☐ — Date op: 02-14-99

Functional Asessment System for lower extremity dysfunction

Variable	Score 0	1	2	3	4
1. Hip flexion	O□X				
2. Extension deficit, hip	O□X				
3. Abduction, hip	O□X				
4. Adduction, hip	O□X				
5. Knee flexion	O	□X			
6. Extensions deficit, knee	O	□X			
7. Quadriceps muscle strength		□	O	X	
8. Hamstrings muscle strength		□	O		X
9. Raising up from half-standing	□	OX			
10. Rising from/sitting down in a chair	□	O	X		
11. Step height	□	O	X		
12. Standing on one leg	□	O	X		
13. Stair walking	OX□				
14. Gait speed (m/s)	O□	X			
15. Gait aid	OX□				
16. Kommunication/transportation	O□	X			
17. Work/housekeeping	O□	X			
18. ADL-functions, other	O□	X			
19. Leisure time/hobby	O	□	X		
20. Pain	O	□		X	

X = Preoperative score O = Desired score (goal) □ = Postoperative score

The scale is a 5-grade scale with scores from 0 to 4.
0 = no reduction.
1 = pain at performance, or some reduction of performance.
2 = moderate reduction of performance, need for some kind of aid.
3 = severe reduction, need for technical aid or personal assistance.
4 = severe reduction with almost no ability, need for help with most tasks.

REFERENCES

1. Kettelkamp DB, Colyer RA. Osteoarthritis of the knee. In: Moskowitz RW, Howell DS, Goldberg VM, Mankin HJ, editors. Osteoarthritis. Diagnosis and management.Philadelphia: Saunders; 1984. p. 403–21.
2. Keene JS, Dyreby Jr JR. High tibial osteotomy in the treatment of osteoarthritis of the knee. The role of preoperative arthroscopy. J Bone Joint Surg Am 1983;65:36–42.
3. Keene JS, Monson DK, Roberts JM, Dyreby Jr JR. Evaluation of patients for high tibial osteotomy. Clin Orthop 1989;157–65.
4. Shaw JA, Moulton MJ. High tibial osteotomy: an operation based on a spurious mechanical concept. A theoretic treatise. Am J Orthop 1996;25:429–36.
5. Bergenudd H, Johnell O, Redlund-Johnell I, Lohmander LS. The articular cartilage after osteotomy for medial gonarthrosis. Biopsies after 2 years in 19 cases. Acta Orthop Scand 1992;63:413–6.
6. Bulstrode CJK. Outcome measures and their analysis. In: Pynsent PB, Fairband JCT, A, editors. Outcome measures in orthopaedics. London: Butterworth-Heinemann; 1993. p. 1–15.
7. Keith RA. Conceptual basis of outcome measures. Am J Phys Rehabil 1995;74:73–80.
8. Pörn I. An equilibrium model of health. In: Nordenfelt L, Lindahl BIB, editors. Health, disease, and causal explanations in medicine. Dordrecht: Reidel; 1984. p. 3–9.
9. Feinstein AR, Josephy BR, Wells CK. Scientific and clinical problems in indexes of functional disability. Ann Intern Med 1986;105:413–20.
10. Nordenfelt L. On the nature of health. Chapter 3: Towards a holistic theory of health. Dordrecht: Reidel; 1987. p. 35–104.
11. Lewthwaite R. Motivational considerations in physical activity involvement. Phys Ther 1990;70:808–19.
12. Talvitie U. Development of theoretical thinking and critical attitudes. Toward physiotherapy as the aim of developmental work research. Sjukgymnasten Vetenskapligt 1992;Suppl:12–9.
13. Guccione AA. Arthritis and the process of disablement. Phys Ther 1994;74:408–14.
14. Rothstein JM. Science and practice: examining outcomes. In: Dekker J, Oostendorp RAB, editors. Improving the quality of physical therapy. Amersfoort: Dutch National Institute for Research and Postgraduate Education; 1995. p. 17–23.
15. Echternach JL, Rothstein JM. Hypothesis-oriented algorithms. Phys Ther 1989;69:559–64.
16. Bennecom CAM, Jelles F, Lankhorst GJ. Rehabilitation activity profile\Ma brief research report on an application of the ICIDH in rehabilitation medicine. Eur J Phys Med Rehabil 1993;3:125–6.
17. Craik RL. Disability following hip fracture. Phys Ther 1994;74:387–98.
18. Dekker J. Application of the ICIDH in survey research on rehabilitation: the emergence of the functional diagnosis. Disabil Rehabil 1995;17:195–201.
19. Öberg U, Öberg B, Öberg T. Validity and reliability of a new assessment oflower-extremity dysfunction. Phys Ther 1994;74:861–71.
20. Öberg U, Öberg B, Öberg T. Concurrent validity of a new assessment of lower-extremity dysfunction. Eur J Phys Rehabil 1996;6:51–8.
21. Öberg U. Functional assessment system of lower-extremity dysfunction. Linköping University Medical Dissertations No 425. ISBN 91-7871-340-4, ISSN 0345-0082.
22. Öberg U, Öberg T. Discriminatory power, sensitivity, and specificity of a new assessment system. Physiotherapy Canada 1997;Winter:40–7.
23. Öberg U, Öberg T, Hagstedt B. Functional improvement after hip and knee arthroplasty: 6-month follow-up with a new functional assessment system. Physiotherapy—Theory and Practice 1996;12:3–13.
24. Armitage P, Berry G. Statistical methods in medical research. 3rd ed. Chapter 16: 4 Diagnostic tests and screening procedures. Oxford: Blackwell Scientific; 1994. p. 472–8.
25. Fuhrer, MJ. Postscript and commentary. In Fuhrer, MJ, editor. Assessing medical rehabilitation practices. The promise of outcomes research. Baltimore: Brookes; 1997. p. 433–49.

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