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## Interdependence of clinical and isokinetic results after bicondylar knee prostheses with special emphasis on quality of life results

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**Abstract** Nineteen patients were examined at an average follow-up of 2 years after total knee joint replacement without patella resurfacing. They were compared with 22 healthy subjects of the same age. Using the Hospital for Special Surgery (HSS) score the operated knee joints scored an average of 77 points, the contralateral side scored 87 points and the control group 97 points. In the SF-36 health questionnaire the patients showed highly significant deviations. Isokinetic measurements revealed a clear loss of isokinetic strength of more than 50% on average in flexion as in extension when compared to the control group and there were considerable asymmetries between the operated and the contralateral legs.

**Résumé** Dix-neuf patients ont suivis pendant une durée moyenne de 2 ans après une arthroplastie totale du genou sans implant rotulien. Ils sont comparés avec 22 sujets de même âge bonne santé. Utilisant le score HSS, les patients ont atteint environ 77 points, le groupe de contrôle 97 points. Les résultats des patients selon le questionnaire de qualité de vie SF-36 ont montrés des déviations hautement significatives. Les données isokinétiques révèlent une perte de force supérieure 50% en moyenne, s'agissant de la flexion et de l'extension, en comparaison avec le groupe de contrôle.

### Introduction

Clinical results as well as survivorship of knee joint endoprostheses have improved enormously during the last

two decades. Key words such as “minimal bone resection”, “reduced interface stress” and “unconstrained bicondylar knees” were ‘trendsetting’ for the change from hinged to bicondylar knee prostheses. Quality of life has been markedly improved [16] although there are still some unsolved problems. These symptoms of unknown origin are often related to the patella and are often simply described as “anterior knee pain” [4, 14, 15]. As a result of the reduced incidence of aseptic loosening and infections, patellar complications now represent the most frequent indication for revision operations [18]. The patella is ‘influenced’ by several well-known factors: soft tissue conditions, operative technique and the design of femoral and patellar components which have been shown to be of major importance [1, 4, 7, 12]. Yet there are indications that these factors play only a minor role in the development of patellar symptoms [8]. Therefore, the assessment of functional parameters that cannot be revealed by clinical or radiological examinations has gained importance. Clinical scores emphasize range of motion, stability and pain and do not include functional parameters which may themselves be responsible for persisting complaints. The role of the extensor muscles, especially of the vastus medialis and lateralis in patellofemoral pain, has already been investigated in patients without joint replacement and a predominance of lateral muscular strength has been shown to be responsible for some patellofemoral symptoms [3, 6]. After total replacement the influence of the soft tissues on patellar tracking and joint forces seems to be of special importance [10, 13].

### Materials and methods

Eight men and 11 women with a mean age of  $68.1 \pm 8$  years (range: 48–80 years) were studied. The mean follow-up was  $24.6 \pm 16.7$  months (range: 4–80 months). All the patients had received a Genesis-I-prosthesis (Smith & Nephew, Hamburg/Schnefeld, Germany) using a subvastus approach without patella resurfacing. All patients underwent our department's standard rehabilitation programme which mainly aims at restoring a good

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range of motion and proprioceptive abilities. It comprises 6–7 weeks as an in-patient (hospital and rehabilitation centre) and another 12–16 weeks of out-patient rehabilitation (2–3 times a week). No patient received specific strengthening exercises of the lower limb muscles. The patients did not show any radiological signs of loosening or mal-alignment, and 22 healthy volunteers (11 men and 11 women) with a mean age of 65.5±8 years (range: 51–82 years) served as our control group. The Hospital for Special Surgery (HSS) score was used for clinical assessment. The quality of life was assessed using a German translation of the SF-36 health questionnaire. This permits scoring of a set of eight scales (physical function, physical role limitations, bodily pain, health perceptions, vitality, social function, emotional role limitations and general mental health) displayed as a profile of health status concepts. It has been proved to be a reliable and valid measurement tool [5].

Isokinetic assessment of knee extensor and flexor muscles was made with a Cybex 6000 dynamometer (11779 Lumex; Ronkonkoma, N.Y., USA). After sufficient ‘warm-up’, measurements were recorded at angular velocities of 60°/s and 180°/s using the computer-based data acquisition system.

Statistical analysis was carried out using Microsoft Excel (Microsoft, USA) and the Statistical Package for Social Sciences for Windows, release 6.1.3 (SPSS, Munich, Germany) together with the two-tailed student’s *t*-test for unpaired samples and Mann, Whitney and Wilcoxon *U*-test (*P*=0.05). Pearson’s correlation coefficients were calculated for the determination of correlations.

**Results**

With the HSS score all the control subjects were rated as ‘‘excellent’’. The mean score was 97±2 (range: 92–100; Table 1). They all walked normally and the range of knee motion was at least 1250 in every subject. In the patient group only the operated knee joints were assessed. Eight were rated ‘‘excellent’’ (42.1%), four ‘‘good’’ (21.1%), five ‘‘fair’’ (26.3%) and two ‘‘poor’’ (10.5%). Patients achieved a mean HSS score of 77±12

**Table 1** HSS score results (maximum): comparison of control and patient groups (*t*-test)

Parameters	Control group (means ± SD)	Patient group (means ± SD)	Significance ( <i>P</i> -values)
HSS score (100)	97.18±2.16	76.84±12.41	<0.001
Pain (30)	29.32±1.72	23.42±7.62	<0.009
Function (22)	21.86±0.62	17.89±2.47	<0.001
ROM (18)	16.91±0.47	11.63±1.78	<0.001
Strength (10)	9.09±1.00	6.32±2.27	<0.001

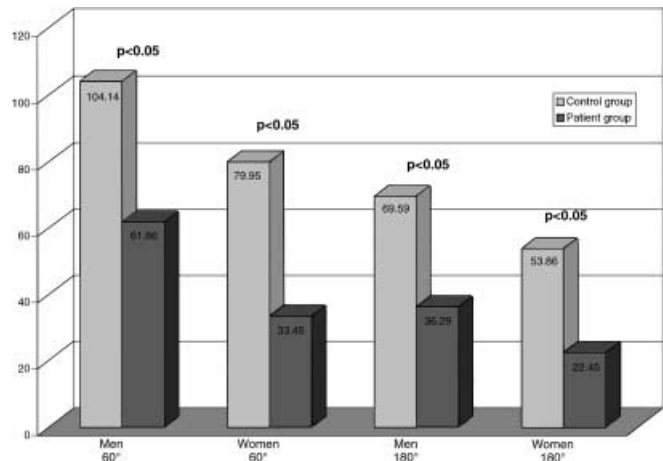
**Table 2** SF-36 health questionnaire results: comparison of control and patient groups (*t*-test; *n.s.* not significant)

Items	Control group (means ± SD)	Patient group (means ± SD)	Significance ( <i>P</i> -values)
Physical functioning	85.45±18.77	36.39±24.61	<0.001
Physical role limitations	80.68±35.30	22.06±35.61	<0.001
Bodily pain	86.50±18.91	47.33±29.28	<0.001
General health perceptions	67.50±15.58	46.59±28.13	0.012
Vitality	65.45±16.76	39.38±23.18	0.001
Social functioning	93.18±11.40	69.44±28.32	0.002
Emotional role limitations	86.36±86.36	58.82±45.73	0.039
General mental health	77.27±12.31	66.75±21.19	<i>n.s.</i>

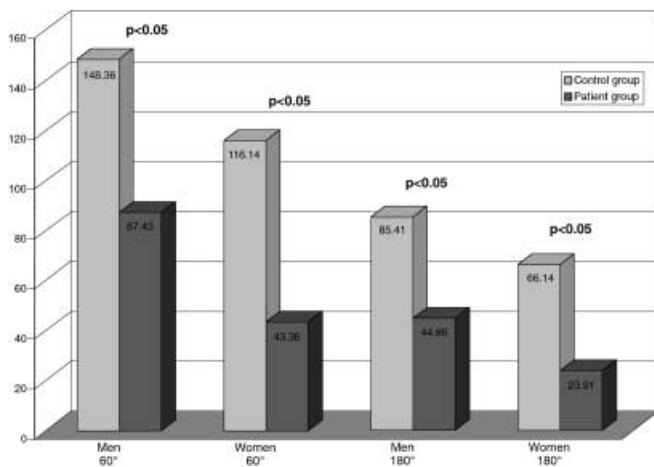
(range: 49–95). The average range of motion was 92° and this was statistically significant when compared with the control group. Apart from the stability category (all prostheses and control knee joints were stable), all the other items of the HSS score differed significantly between the two groups.

The results of the control group in the SF-36 health questionnaire were within the normal limits of an age-related population. As with the HSS score results the patient group showed highly significant deviations in SF-36 results (Table 2). Physical function, role limitations due to physical function and bodily pain were lower than in the control group, whereas assessment of general mental health did not differ significantly.

Peak flexion torques at 60°/s as well as at 180°/s in patients were significantly lower when compared to the controls (Figs. 1, 2). The patients reached only about 50% of normal flexion strength. The same difference was found with maximum isokinetic strength in extension at 60°/s as well as at 180°/s. Isokinetic peak torque values were higher at an angular velocity of 60°/s than at 180°/s. Isokinetic strength in absolute numbers was always higher in extensor muscles than in flexor muscles. The average flexion/extension ratios of maximum peak torque in patients were higher than in controls (Table 3). A statistically significant deviation was only found in women at 180°/s. Results at 60°/s were lower than at 180°/s.



**Fig. 1** Comparison of flexor muscles’ mean maximum peak torques in control and patient groups (Nm)



**Fig. 2** Comparison of extensor muscles' mean maximum peak torques in control and patient groups (Nm)

**Table 3** Comparison of flexion/extension ratios of maximum peak torques in control and patient groups (*t*-test; *n.s.* not significant)

	Control group (means ± SD)	Patient group (means ± SD)	Significance ( <i>P</i> -values)
60°/s Men	0.72±0.13	0.75±0.23	<i>n.s.</i>
60°/s Women	0.70±0.12	0.89±0.42	<i>n.s.</i>
180°/s Men	0.84±0.12	0.86±0.27	<i>n.s.</i>
180°/s Women	0.82±0.13	0.96±0.26	0.043

**Table 4** Pearson's coefficients of correlations between score results (HSS and SF-36) and isokinetic strength in flexion and extension at 60°/s

Items	Flexion	Extension
HSS: overall score	0.632	0.669
SF-36: physical functioning	0.651	0.619
SF-36: physical role limitations	0.525	0.576
SF-36: bodily pain	0.554	0.641
SF-36: general health perceptions	0.446	0.431
SF-36: vitality	0.400	0.484
SF-36: social functioning	0.391	0.482
SF-36: emotional role limitations	0.333	0.437
SF-36: general mental health	0.157	0.260

Concerning the angles of peak torque, male patients showed no statistically significant differences when compared to male controls. Female patients showed a significant reduction of the angle at peak torque of 10° on average in flexion at 180°/s. This means that peak torque in female patients occurs 10° earlier than in female controls. In extension at 60°/s female patients on average reach peak torque 13° later. The changes in angles of peak torque confirm the relative loss of extensor muscle strength.

Correlation analysis of isokinetic data and HSS score results, or isokinetic data and eight different SF-36 items, revealed statistically significant but low correlation coefficients (Table 4). Pearson's coefficient for cor-

relation between isokinetic strength and HSS score, physical function, role limitation due to physical function and physical pain ranged from 0.6 to 0.7. All other categories showed coefficients between 0.3 and 0.5.

## Discussion

Our clinical results and quality of life assessments reveal a distinct proportion of unsatisfactory results although radiological findings failed to reveal any problems. Definite restrictions of physical function and role limitation were found and these cannot be explained solely by social or psychological influences. For these reasons assessment of function parameters that cannot be measured by clinical or radiological examinations appears important. New assessment tools allow a detailed investigation of other factors influencing the knee joint, such as muscular coordination, strength, gait and proprioception.

Isokinetic testing in total knee replacement patients demonstrated the poorly understood nature of the extensor apparatus and the extensor muscles were definitely weak. The demonstrated decrease in quadriceps strength is a possible explanation for patients' symptoms relating to the patella.

When comparing patients with age-matched controls significant differences were found in maximum peak torque in extension as well as in flexion. Flexion/extension ratios tended to be higher in patients than in controls as peak extension torques were slightly more decreased than peak flexion torques. A statistical significance ( $P < 0.05$ ) could only be proved for women at 180°/s. The angles at peak torque in the patient group tended to be higher in extension and lower in flexion when compared to healthy volunteers. As before, statistical significance ( $P < 0.05$ ) was only found in two categories. These findings contribute to the relative loss of extensor muscle strength.

In clinical practice it should be remembered that low isokinetic peak torques are already present pre-operatively in osteoarthritic patients [3]. If no special rehabilitation programme is carried out, these deficits will remain after operation and may at least be partly responsible for persisting function deficits.

The clinical HSS score and the quality of life questionnaire SF-36 failed to predict isokinetic measurements. Therefore, isokinetic testing remains 'irreplaceable' in assessing muscle strength after total joint replacement.

Berman et al. [2] tried to explain the changes in the flexion/extension ratio by an increase of hamstring muscle activity when compared to the quadriceps muscles. They demonstrated that the flexion/extension ratio can be returned to normal with a special rehabilitation programme for quadriceps muscles. These measures also improve gait patterns. Although isokinetic data correlated directly with gait analysis results, their study revealed no direct impact on or correlation with clinical results. It appears that the implantation of an endoprosthesis and the gain in range of motion associated with this proce-

ture improves the capabilities of the hamstring muscles post-operatively. On the other hand, extension strength cannot be improved without a specific rehabilitation programme for the impaired quadriceps muscles.

Whittle and Jefferson [19] reported that function after prosthesis implantation very rarely returns to normal even though clinical results remain inconspicuous. In their study, gait patterns provided information about muscle function and this also showed deficits, especially in the extensor apparatus. They considered that this was mainly due to the pre-operative condition of the quadriceps muscle. Hsu et al. [9] also found extensor deficits which were identified by significant differences in flexion/extension ratios. Huang et al. [10] mentioned extensor deficits and also showed that prosthetic design had no major influence on results. Preservation of the posterior cruciate ligament or the use of mobile bearing platforms did not produce significant improvements. The persisting extensor weakness was related to anterior cruciate ligament resection as patients suffering from an anterior cruciate ligament rupture show similar functional quadriceps deficits. This also helps to demonstrate the pre-operative deficits that continue to exist postoperatively. An imbalance between the hamstrings and the quadriceps can result in anterior-posterior instability and thus contribute to patellofemoral complaints. Therefore, a special rehabilitation programme for the extensor group is necessary although isokinetic exercises for extensor muscles and the associated extreme retropatellar loads must be considered as a potential problem in respect to patellofemoral complications [11]. When considering the higher anterior shear forces in knee prosthesis patients following resection of the anterior cruciate ligament, exercise must be carefully controlled. Shear forces can only be reduced by starting with small flexion angles of about 20°. Reducing angular velocity in training has no significant influence on the shear forces [11]. On the other hand, Rodgers et al. [17] questioned extensor muscle training as they observed that flexion and not extension is improved by postoperative rehabilitation. Therefore a special pre-operative training of the extensor muscles appears advisable in order to change habits and to improve muscle deficits. In pre-operative planning any extensor muscle deficits might influence the surgeon's choice of surgical approach and the positioning of prosthetic components.

According to our findings, the extensor muscles play an important role in the overall postoperative results of total knee joint replacement. Therefore, quadriceps muscle function should be considered in the pre- and postoperative course as well as in operation planning and performance. The clinical and quality of life scores are incapable of predicting muscle strength in total knee arthroplasty.

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