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Proprioception After Unicondylar Knee Arthroplasty Versus Total Knee Arthroplasty

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Proprioception was measured in 2 groups of patients after successful knee arthroplasty. Twenty-eight patients had total knee arthroplasty and their results were compared with an age matched group of 10 subjects who had undergone unicondylar knee arthroplasty. The threshold to detection of passive motion was quantified as a measure of proprioception. The degree of preoperative arthritis was objectively classified according to Resnick. The anterior cruciate ligament and posterior cruciate ligament were present and preserved in all the patients who had undergone unicondylar knee arthroplasty. The anterior cruciate ligament was sacrificed and posterior cruciate ligament retained in 15 of the patients who had total knee arthroplasty and the anterior cruciate ligament and posterior cruciate ligament were sacrificed in 13 of the patients who had total knee arthroplasties. There was no difference in threshold to detection of passive motion among any of the 3 groups. Maintaining the anterior cruciate ligament and posterior cruciate ligament did not impart improved proprioception in unicondylar knee arthroplasty nor did maintaining the posterior cruciate ligament impart improved proprioception in total knee arthroplasty.

Maintaining the posterior cruciate ligament during total knee arthroplasty has been thought to impart certain biomechanical advantages including more physiologic rollback, improved efficiency of the extensor mechanism, stability, and better proprioception.[2,9,10,12,13] Maintaining the anterior cruciate ligament and posterior cruciate ligament, as in unicondylar knee arthroplasty, may be advantageous in reproducing more physiologic motion and more normal walking patterns.[12,14,19] The proprioceptive contribution of the retained cruciate ligaments has been hypothesized as playing an instrumental role in improved postoperative function.[16] Whether the anterior cruciate ligament or posterior cruciate ligament retains its mechanical or proprioceptive role in the osteoarthritic knee, however, is uncertain.[1,15,21] This study quantifies whether a difference in proprioceptive ability could be detected between total knee arthro-

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plasty compared with unicondylar knee arthroplasty.

MATERIALS AND METHODS

All unilateral unicondylar knee arthroplasties performed between the years 1988 and 1994 by the Medical College of Pennsylvania, Allegheny Campus, Department of Orthopedic Surgery were retrospectively reviewed. The Miller-Galante Unicompartmental Knee Prosthesis (Zimmer, Inc, Warsaw, IN) was placed in all patients. Subject inclusion criteria included those individuals between the ages of 50 and 80 with a good clinical result. A good clinical result was defined as a range of motion (ROM) of at least 5° to 90° with no instability or significant pain. Only those patients with osteoarthritis or traumatic arthritis were included. Subjects with a peripheral neuropathy, cerebral vascular accident, insulin dependent diabetes mellitus, or rheumatologic disorders were excluded. Preoperative radiographs were also evaluated for the presence of significant preoperative knee deformity. Those patients with a preoperative varus or valgus deformity of greater than 15° or a flexion contracture greater than 15° were excluded from the study to avoid selection bias. Intraoperatively, all patients were noted as having anterior and posterior cruciate ligaments intact. The unicondylar knee arthroplasty group was compared with a previously reported group of patients who had total knee arthroplasty with and without posterior cruciate ligament retention. This group was composed of posterior cruciate ligament retaining and sacrificing total knee arthroplasties performed between the years of 1990 and 1993 by the University of Pittsburgh, Department of Orthopedic Surgery. All patients who had total knee arthroplasty had either the Insall-Burstein II (IB II; Zimmer, Inc) as the posterior cruciate ligament sacrificing design or the Miller-Galante (MG II; Zimmer, Inc) as the posterior cruciate ligament retaining design. All patients signed an informed consent form approved by the review boards of Tulane University and the University of Pittsburgh. The degree of arthritis in the preoperative and nonoperative knee was graded radiographically by the criteria of Resnick and Niwayama[20] (Table 1). Before proprioception testing, all subjects underwent clinical evaluation with completion of the Knee Society rating score.

Once the pretesting evaluation was complete, the subjects were instructed about the proprioception testing device (Fig 1) and its purpose as well as the testing format and patient expectations. This apparatus had been validated on a number of test groups of normal subjects and patients after knee ligament injury and surgery.[18] Subjects were then tested using the proprioception testing device. The proprioception testing device was controlled and operated by a direct control system. This consisted of a motor, which rotated the device at a constant angular velocity (0.5°/second), and an optical encoder that measured angular displacement of the knee in degrees. Proprioception is mediated by mechanoreceptors such as Ruffini end organs which are most specifically stimulated by slow, steady change in position. They respond with a change in the rate of impulses elicited. The impulse generation persists even when a stimulus ends, conveying conscious awareness of joint position. This

TABLE 1. Degenerative Grading Scale Based on Resnick and Niwayama's Criteria[11,20]

Grade 0 (no degenerative joint disease)	No arthritic changes
Grade 1 (minimal degenerative joint disease)	Minimal narrowing of joint space, mild sclerosis, no appreciable changes
Grade 2 (moderate degenerative joint disease)	Moderate narrowing of joint space, osteophyte formation, no bony collapse, moderate subchondral sclerosis, intraarticular osseous bodies, moderate bony aberration
Grade 3 (severe degenerative joint disease)	Marked joint space narrowing to obliterated joint space, bony collapse, severe subchondral sclerosis, intraarticular osseous bodies, marked deformity or angularity, severe bony aberration

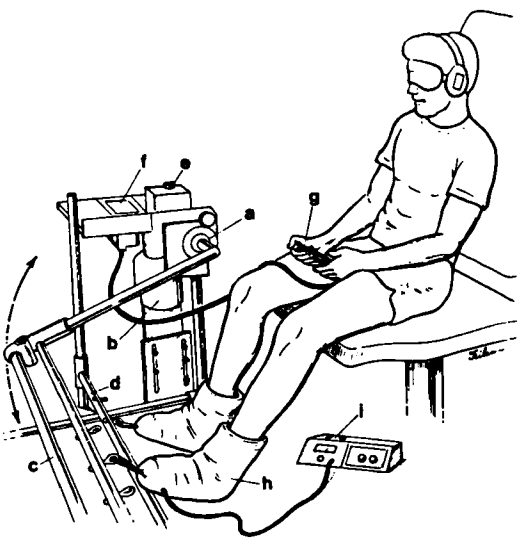

Fig 1. Proprioceptive testing device: (a) rotational transducer; (b) motor; (c) moving arm; (d) stationary arm; (e) control panel; (f) digital microprocessor; (g) hand held disengage switch; (h) pneumatic compression boot; and (i) pneumatic compression device. The threshold to detect passive motion is assessed by measuring the angular displacement until the subject senses motion in the knee.

is in contrast to rapidly adapting receptors in which the number of impulses rapidly declines to 0 with stimulus removal. These slowly adapting receptors are most appropriately examined with a slow constant angular velocity such as 0.5° per second.[3,4,18] The test retest reliability of the proprioception testing device had been previously established at r = 0.92.[2] The subjects were blindfolded and subjected to low intensity white noise to control for visual and auditory sensory input. To control for cutaneous sensory input, pneumatic boots were used to secure the lower extremities to the testing apparatus. The subjects were then tested for threshold to detect passive motion.

The tested extremity was positioned on the proprioception testing device's moving bar which measured angular displacement. Subjects were positioned in such a way to neutralize cutaneous compression or sensation. The threshold to detection of passive motion was tested from starting positions of 15° knee flexion (near terminal ROM) and 45° knee flexion (mid ROM). The proprioception testing device moved the knee randomly into flexion or extension at a constant angular velocity from the 2 starting positions. The subject signified the detection of passive motion by pressing a remote switch. After 2 practice trials, 3 randomized runs of the threshold to detection of passive motion were subsequently recorded with flexion and extension from the 2 starting positions. One-way analysis of variance with repeated measures was completed for the involved and uninvolved threshold to detection of passive motion mean comparisons. A value of $p < .05$ was considered significant.

RESULTS

Ten patients with the unicondylar knee replacement, 15 patients with the posterior cruciate ligament retaining total knee replacement, and 13 patients with the posterior cruciate ligament sacrificing total knee replacement met all inclusion criteria and were evaluated. There were 10 males and 18 females with a mean age of 69 years among the total knee arthroplasty group. There were 3 males and 7 females with a mean age of 65 years in the unicondylar group. A majority of the knees that underwent total knee arthroplasty had Grade II arthritis whereas the opposite nonoperative knees were mostly Grade I. Among the unicondylar knee replacement group, there was an even distribution of Grade II and Grade III arthritis in the knees that underwent arthroplasty whereas the opposite nonoperative knees had mostly Grade I arthritis (Table 2). After grading the preoperative arthritis, it became apparent that the posterior cruciate ligament sacrifing total knee replacements were used in the more arthritic involved knees whereas the posterior cruciate ligament retaining total knee replacement was placed in less arthritic knees (Table 3).

There was no statistically significant difference between posterior cruciate ligament retaining total knee arthroplasty, posterior cruciate ligament substituting total knee arthroplasty, or unicondylar knee arthro-

TABLE 2. Preoperative Arthritis Scores for Patients Who Had Total Knee Arthroplasty and Unicondylar Knee Arthroplasty

Joint Tested	Arthritis Grade 0	1	2	3
Operative knee (total knee arthroplasty)	0	0	17	11
Nonoperative knee (total knee arthroplasty)	0	17	7	4
Operative knee (unicondylar knee arthroplasty)	0	0	5	5
Nonoperative knee (unicondylar knee arthroplasty)	0	5	4	1

plasty in proprioception as measured (Table 4). When comparing proprioception in the operative knee with the nonoperative knee, there was no statistically significant difference revealed. To determine whether proprioception in unicondylar knee arthroplasty may be better in patients with less severe degenerative changes, patients with less severe arthritis preoperatively (Grade II) were compared with those with more severe preoperative arthritis (Grade III). Again, no statistically significant difference was seen in proprioception.

TABLE 3. Preoperative Arthritis Grade

Prosthesis Type	Arthritis Grade 1	2	3
Cruciate retaining (MGII)	0	11	4
Cruciate sacrificing (IBII)	0	4	9
Unicondylar	0	5	5

DISCUSSION

Whether retaining 1 or both cruciate ligaments imparts more proprioceptive input in knee arthroplasty remains a question. Authors whose studies address the unicondylar knee arthroplasty have reported that their patients had a more normal feeling knee joint when compared with the total knee arthroplasty.[8,17] Preservation of the cruciate ligaments and patellar surface were thought to be responsible for this increased joint awareness.[17,22,25] This has been suggested by some authors as contributing to the near normal walking pattern seen in the patient who underwent unicondylar knee arthroplasty.[12,14,19] Proponents of posterior cruciate ligament preservation in total knee arthroplasty think that major advantages include more normal kinematics and gait when compared with total knee arthroplasty in which the posterior cruciate ligament is sacrificed.[2] Proprioception has been hypothesized as playing a role

TABLE 4. Proprioception in Unicondylar Knee Arthroplasty Versus Total Knee Arthroplasty With and Without Anterior Cruciate Ligament

Prosthesis	Threshold to Detect Passive Motion (mean ± standard error) 15° Flexion	15° Extension	45° Flexion	45° Extension
Unicondylar knee arthroplasty (n = 10)	1.6 ± 0.19	1.4 ± 0.32	1.9 ± 0.32	2.0 ± 0.40
MGII (n = 15)	2.4 ± 0.50	1.9 ± 0.39	2.8 ± 0.66	2.3 ± 0.50
IBII (n = 13)	2.4 ± 0.50	1.5 ± 0.17	2.5 ± 0.67	2.3 ± 0.90
p	0.361	0.455	0.642	0.891

in obtaining these advantages.[12] Other investigators found no discernible difference between unicondylar knee arthroplasty and total knee arthroplasty.[7] Cameron and Jung[7] found that patients who underwent a unicondylar knee arthroplasty in 1 knee and a total knee arthroplasty in the other could not tell the difference between the 2 knees after 1 year. Even when asked about stair climbing, the patients had no preference of 1 knee over the other.

Proprioceptive input from the cruciate ligaments has been strongly suggested by a number of studies.[3,4] Their contribution, however, may be limited in the aged population.[1,15,21] Joint position sense has been shown to steadily decline in the normal knee with aging.[5,23,24] Degenerative changes in the knees further decrease proprioception.[5,15,23] Schultz et al[21] established histologically that mechanoreceptors were present in the human cruciate ligaments. There was, however, a very low population of mechanoreceptors in the ligaments harvested during total knee arthroplasty. Alexiades et al[1] also established neurologic degeneration of the posterior cruciate ligament with arthritis. The lack of mechanoreceptors in the degenerative cruciate ligaments may explain why no significant difference in proprioception between the 3 groups was found. The fact that the contralateral nonoperative knees with very early stages of degenerative arthritis (Grade I) did not perform significantly better than the postoperative knees suggests that proprioceptive loss occurs very early in the degenerative process as has been suggested by others.[5,24] Berman et al[6] reported that the abnormal gait pattern characteristic in the degenerative knee also occurs early preceding the subsequent radiographic changes. This would explain the lack of any significant difference in proprioception in patients with early (Grade II) arthritis.

It could be hypothesized that proprioceptive function of the anterior cruciate ligament is maintained in the early stages of arthritis, but is lost at the point where severe arthritis is present.[3] Mechanoreceptors in the anterior cruciate ligament may have atrophied and become nonfunctional even though the ligament is grossly present and mechanically intact. This was not supported by the findings of this study. The patients with early (Grade II) arthritis preoperatively did not perform better than those with severe (Grade III) arthritis (Table 5). The proprioception scores were in fact slightly worse, but this was not statistically significant.

TABLE 5. Average Threshold to Detect Passive Motion in Unicondylar Knee Arthroplasty Versus Preoperative Arthritis Grade

Prosthesis	Preoperative Arthritis Grade		
	I	*II*	*III*
Unicondylar knee arthroplasty (n = 10)	—	2.08 (5)	1.37 (5)

Retaining the anterior cruciate ligament and posterior cruciate ligament in the unicondylar knee arthroplasty, or the posterior cruciate ligament alone in total knee arthroplasty did not result in improved performance in proprioception testing as measured in this study. Although retaining the anterior cruciate ligament or posterior cruciate ligament or both may improve kinematics and gait, maintenance of proprioceptive input is not supported by these results.

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