Clinical outcome and rate of complications after primary total knee replacement performed with quadriceps-sparing or standard arthrotomy

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We performed a prospective, randomised study to compare the results and rates of complications of primary total knee replacement performed using a quadriceps-sparing technique or a standard arthrotomy in 120 patients who had bilateral total knee replacements carried out under the same anaesthetic. The clinical results, pain scales, surgical and hospital data, post-operative complications and radiological results were compared.

No significant differences were found between the two groups with respect to the blood loss, knee score, function score, pain scale, range of movement or radiological findings. In contrast, the operating time ($p = 0.0001$) and the tourniquet time ($p < 0.0001$) were significantly longer in the quadriceps-sparing group, as was the rate of complications ($p = 0.0468$).

We therefore recommend the use of a standard arthrotomy with the shortest possible skin incision for total knee replacement.

In total knee replacement (TKR), the mini-incision and quadriceps-sparing approaches were developed to minimise soft-tissue damage and enhance early rehabilitation.¹⁻⁵ Tria¹ limited the medial parapatellar arthrotomy to the level of the superior pole of the patella and displaced the patella laterally without eversion. The early results indicated that there was reduced intra-operative blood loss, less pain, better early mobilisation and a shorter hospital stay. The accuracy of the alignment of the implant was found to be similar to that when using a standard incision.¹⁻⁶ We have undertaken a prospective, randomised study in patients undergoing bilateral TKR. A quadriceps-sparing technique was used on one side and a standard arthrotomy on the other. We compared the differences in the surgical parameters, positioning of the component, safety and the rate of complications in each group.

Patients and Methods

Between August 2004 and January 2005, 132 consecutive patients underwent primary bilateral TKR undertaken under the same anaesthetic. Each operation was undertaken by the senior author (YHK). A total of 12 patients were lost to follow-up leaving 120 in the study. There were 27 men and 93 women with a mean age at the time of the operation of

65.4 years (43 to 88). Their mean weight was 61.8 kg (46 to 90) and mean height 152.6 cm (134 to 189 cm). The mean body mass index was 28.1 kg/m² (19 to 36). The pre-operative diagnosis was osteoarthritis in 113 patients (94.2%), osteonecrosis in six (5%) and rheumatoid arthritis in one (0.8%). Epidural anaesthesia was used in 108 patients (90%) and general anaesthesia in 12 (10%). The mean follow-up was for 21.5 months (17 to 24). The study was approved by our institutional review board and all patients gave informed consent.

The senior author performed approximately 25 TKRs using the quadriceps-sparing approach before starting the present study in order to eliminate bias due to the learning curve.

Each patient underwent TKR using the quadriceps-sparing technique in one knee and a standard arthrotomy in the other. Randomisation determined which knee was done first using a sequential pool on the basis of a table of randomised numbers.

In the quadriceps-sparing group, all the procedures were performed through an anterior midline skin incision measuring ≤ 10 cm in length. The extent of any incision into the quadriceps tendon was limited to the level of the superior pole of the patella. Vastus medialis was not split. Any extension of the incision into the quadriceps tendon proximally was

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Table I. The mean knee and functional scores in both groups

	Quadriceps-sparing		Standard arthrotomy		p-value	
	Knee score	Functional score	Knee score	Functional score	Knee score	Functional score
Pre-operative	27 (5 to 35)	49 (5 to 55)	28 (7 to 33)	53 (15 to 58)	0.607	1.000
Post-operative						
3 months	85 (68 to 90)	76 (55 to 80)	83 (70 to 92)	73 (55 to 85)	0.3632	0.6728
1 year	90 (68 to 100)	81 (65 to 100)	91 (71 to 100)	82 (68 to 100)	0.2478	0.3158
1.8 years (1.4 to 2)	91 (71 to 100)	85 (85 to 100)	92 (76 to 100)	83 (81 to 100)	0.607	0.661

considered to be an iatrogenic split of the tendon. The suprapatellar pouch was not opened, the patella was not everted and the suprapatellar fat pad was not resected.

In the standard arthrotomy group, all the procedures were performed through a similar skin incision of the same length, with a standard medial parapatellar arthrotomy of the joint. The extent of the incision of the quadriceps tendon was 4 cm to 8 cm proximal to the level of the superior pole of the patella depending on the size of the patient. The mobile upper aspect of the skin incision was used to expose the proximal portion of the quadriceps tendon. The suprapatellar pouch was opened and the patella everted but the suprapatellar fat pad was not resected.

The anterior and posterior cruciate ligaments were excised in all knees. The Nexgen Legacy Posterior Stabilising prosthesis (Zimmer, Warsaw, Indiana) was implanted using cement in all knees. In the quadriceps-sparing group, the four-in-one minimal invasive surgery quadriceps-sparing instruments (Zimmer) were used. These allowed femoral and tibial bone cuts to be made from the medial side of the knee. In the standard arthrotomy group, the same instruments were used, but the femoral and tibial bone cuts were made from the front rather than from the side of the knee. In all cases, ligamentous balancing was performed. After pulsed lavage, drying and pressurisation, the cemented implants were inserted.

After surgery, an epidural block was maintained for two days. The patients received a basal level of analgesics and were allowed to increase this amount by using a self-administered patient-controlled analgesia pump.

The knees were splinted in 15° of flexion for the first 24 hours after the operation and then mobilisation was commenced using a continuous-passive motion machine. An active and passive range-of-movement programme and walking, taking weight as pain allowed, was begun on the second day. The patients used a walking stick for 12 weeks.

Clinical and radiological follow-up was undertaken at three months, one year and annually thereafter. This follow-up was performed by one of the authors (DYK) who was blinded to the type of arthrotomy used. Each knee was rated pre-operatively and post-operatively according to the Knee Society scoring (KSS) system.⁷ Patients evaluated their knee pain subjectively using a ten-point visual analogue scale, with 0 points indicating no pain and 10 severe pain.

The data collected for analysis were the operating time, tourniquet time, intra-operative blood loss, blood replacement during hospitalisation, the amount of drainage, the mean duration of drainage and the length of hospital stay. Homologous transfusion was performed when the haemoglobin level fell below 10.0 g/dl and the patient had symptoms including dizziness, headache and nausea. The drains were removed when the amount of drainage was less than 50 ml over 48 hours. Complications were recorded.

Standing and supine anteroposterior and lateral radiographs, and patellar skyline views were the basis for all pre-operative and post-operative assessment. Limb alignment, the position of the components and the presence and location of radiolucent lines at the cement-bone interface according to the recommendation of the Knee Society were assessed.⁷ The level of the joint line was determined pre- and post-operatively. The radiological measurements were taken using a picture archiving and communication system (PACS; Pixview Starr, Infinitt Co., Seoul, Korea). Three measurements were performed on each radiograph by an observer who was not an author.

Statistical analysis. This was done using a two-tailed *t*-test for continuous variables and a chi-squared contingency table for dichotomous variables. A *p*-value of ≤ 0.05 was considered to be significant.

It was calculated that at least 55 patients would be required in order to determine whether there was a significant difference (power, 0.8, $p < 0.05$) in the Knee Society score, surgical and hospital data, post-operative complications and radiological results between the two groups.

Results

Clinical findings. The mean pre-operative KSS was 27 points (5 to 35) in the quadriceps-sparing group and 28 (7 to 33) in the SA group ($p = 0.607$). The mean pre-operative functional score was 49 points (5 to 55) in the quadriceps-sparing group and 53 (15 to 58) in the standard arthrotomy group ($p = 1.000$). At the final follow-up the mean KSS was 91 points (71 to 100) in the quadriceps-sparing group and 92 points (76 to 100) in the standard arthrotomy group ($p = 0.667$). In the quadriceps-sparing group the mean functional score at the latest follow-up was 85 points and 83 points in the standard arthrotomy group ($p = 0.661$) (Table I). The post-operative pain scales in the two groups

Table II. Operative and hospital data (range) for both groups

	Quadriceps-sparing	Standard arthrotomy	p-value
Operating time (min)	95.6 (60 to 120)	89.5 (55 to 122)	0.0001
Tourniquet time (min)	62.8 (45 to 98)	54.5 (39 to 80)	<0.0001
Intra-operative blood loss (ml)	359.0 (100 to 950)	336.4 (120 to 1080)	0.400
Haemovac drainage (ml)	1112.5 (240 to 2920)	1076.2 (300 to 1630)	0.012
Duration of haemovac drains (days)	5.1 (2 to 6)	4.9 (2 to 7)	0.246
Length of skin incision (cm)			
Extension	10.5 (7.5 to 22.0)	10.8 (8.5 to 12.5)	0.288
Flexion	12.4 (10 to 14)	12.5 (10 to 15)	0.798

Table III. Mean radiological findings (range, SD) for both groups

	Quadriceps-sparing		Standard arthrotomy		p-value	
Knee alignment (valgus)(°)	5.5	(-3 to 9)	2.6	5.2	(-2 to 11)	2.2 0.1334
Femoral component position (°)						
Coronal plane	98.3	(95 to 101)	1.9	96.8	(93 to 98)	2.2 0.3524
Sagittal plane	2.7	(-3 to 9)	3.2	2.5	(-4 to 10)	2.4 0.7349
Tibial component position (°)						
Coronal plane	89	(95 to 91)	3	87	(82 to 95)	2.3 0.8923
Sagittal plane	87	(79 to 89)	2	85	(80 to 93)	2.2 0.9238
Patellar component angle (°)	5	(-9 to 18)	3.7	4.1	(-10 to 21)	4.8 0.2673
Tibial surface capping (%)	98	(90 to 105)	2.1	97	(91 to 105)	-2.5 0.7435
Joint line (cm)						
Pre-operative	16.1	(6 to 21)	4.3	16.3	(5 to 25)	4.1 0.8612
Post-operative	15.8	(8 to 24)	4.1	15.7	(9 to 23)	3.7 0.5134
Posterior condylar offset (cm)						
Pre-operative	24.1	(18 to 31)	2.2	24.9	(17 to 29)	3.1 0.6233
Post-operative	24.9	(21 to 32)	2.5	26.3	(17 to 31)	2.8 0.8112

at three months, one year, and a mean of 1.8 years (1.4 to 2) post-operatively were not significantly different ($p > 0.05$).

At the three-month follow-up the mean range of movement was 128° (110° to 135°) in the quadriceps-sparing group and 129° (108° to 140°) in the standard arthrotomy group. This difference was not significant ($p = 0.549$). At the final follow-up, the mean range of movement was 130° (110° to 150°) in the quadriceps-sparing group and 130.6° (110° to 145°) in the standard arthrotomy group, which again was not significant ($p = 0.531$). The range of movement was measured clinically with a protractor.

The mean length of the final skin incision with the knee in 90° of flexion was 12.4 cm (10 to 14) in the quadriceps-sparing group and 12.5 cm (10 to 15) in the standard arthrotomy group. This difference was not significant ($p = 0.798$, Table II). In the quadriceps-sparing group 31 (25.8%) knees had iatrogenic laceration of the quadriceps tendon approximately 2.5 cm in length because of excessive retraction to achieve adequate exposure.

The mean operating time and the tourniquet time were significantly longer in the quadriceps-sparing group ($p = 0.0001$, $p < 0.0001$ respectively; Table II). By contrast, the mean intra-operative blood loss, the mean amount of drainage, and the mean duration of the use of suction drains were not significantly different ($p > 0.05$) (Table II). The mean pre-operative haemoglobin and haematocrit values were 13.8 g/dl (11 to 16) and 38.9% (29.8% to 45.1%), respectively. The mean post-operative haemoglobin and haematocrit values at the time of discharge were 10.9 g/dl (9.1 to 13.9) and 32.8% (24.9% to 41.2%), respectively. The mean length of hospital stay for both groups was 12.9 days (7 to 15). All the patients were discharged directly to their homes.

A total of 16 quadriceps-sparing procedures (13%) and seven standard arthrotomy procedures (6%) were associated with an operative or post-operative complication ($p = 0.468$). In the quadriceps-sparing group, two knees (1.7%) had laceration of the popliteus tendon, two (1.7%) had palsy of the deep peroneal nerve, which

resolved spontaneously within five and six months and one (1%) had a partial avulsion of the patellar tendon. Five knees (4%) had notching of the anterior femoral condylar and one knee (1%) had a supracondylar fracture. This required open reduction and internal fixation by a plate and screws. One knee (1%) had a medial epicondylar avulsion fracture which was fixed by a screw. One knee (1%) developed a superficial infection which resolved after intravenous antibiotics for six weeks. Two knees (1.7%) developed a deep infection which resolved after open debridement and intravenous antibiotics for six weeks. One knee (1%) developed a deep vein thrombosis (DVT) in the calf vein. The patient was not treated for DVT and there were no further complications.

A total of 31 knees (25.8%) had laceration of the quadriceps tendon inadvertently 2.5 cm in length along the substance of the quadriceps tendon, proximally from the superior pole of the patella. The laceration of the quadriceps tendon did not affect the post-operative management.

In the standard arthrotomy group, two knees (1.7%) had anterior femoral notching. One (1%) sustained an undisplaced fracture of the posteromedial tibial plateau which was fixed by a screw, and two others (1.7%) had a medial epicondylar avulsion fracture, also fixed by screws. One knee (1%) developed a superficial infection which resolved after intravenous antibiotics for three weeks, and one (1%) developed a deep infection which resolved after open debridement and intravenous antibiotics for six weeks.

Radiological findings. These are summarised in Table III. There were no significant differences between the groups with regard to the position of the femoral and tibial components in the coronal and sagittal planes, the alignment of the knees, the patellar angle, the tibial surface area covered by the implants, the level of the joint line and the posterior femoral condylar offset ($p > 0.05$). No knee in either group had evidence of radiolucent lines around any component. There was no evidence of aseptic loosening of the femoral, tibial or patellar components, or patellar subluxation or dislocation in either group.

Discussion

Early reports of the use of a mini-incision and quadriceps sparing approach for TKR indicated that there was reduced intra-operative blood loss, less pain, better early movement, and a shorter hospital stay, with an accuracy of the alignment of the implant similar to that of TKR with a standard incision.¹⁻⁶ In our study, the early complication rate was significantly higher in the quadriceps-sparing group. Major complications included one superficial and two deep infections, two cases of palsy of the peroneal nerve, and one supracondylar fracture. We believe that the higher rate of complications in the quadriceps-sparing group was related to limited visualisation. Working through a small incision may cause more pressure on the

skin and soft tissues from stronger retraction. There may be more abrasion of the skin edges from reamers and rasps. This may result in more wound complications and infections. The operative and tourniquet times were significantly longer in the quadriceps-sparing group.

Considerable effort was made to preserve the quadriceps tendon in the quadriceps-sparing group, but no significant differences were found between the groups with respect to the knee score, pain scale, range of movement, hospital data or radiological parameters. We believe that because there were no short-term differences in these parameters the long-term results may also be similar.

It was very difficult to place a stemmed tibial component using the quadriceps-sparing approach and the quadriceps tendon was lacerated inadvertently in 31 knees (25.8%). Because the benefit of the quadriceps-sparing technique was negligible and the rate of complications higher, we suggest that a formal incision of the quadriceps tendon 2 cm to 4 cm proximal to the superior pole of the patellar should be an important part of the exposure.

A weakness of our study may be attributed to potential bias in the assessment of the clinical and radiological results, variables in the type of anaesthetic used and in the type of pathology encountered.

We routinely perform bilateral TKR under a single anaesthesia session unless patients have serious medical problems. To date we have experienced no major systemic complications such as fatal pulmonary emboli in a total series of more than 2000 patients treated in this way.

All patients in both groups favoured a short skin incision. Despite there being no differences in most of the clinical and radiological outcome parameters between the two groups, the operating time was longer and the early complication rate higher in the quadriceps-sparing group. We therefore recommend a standard arthrotomy with the shortest possible skin incision when performing TKR.

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