

Transverse incision advantages for total knee arthroplasty

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**TRANSVERSE INCISION ADVANTAGES FOR TOTAL KNEE
ARTHROPLASTY**

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Running title: Transverse incision for TKA

1 **TRANSVERSE INCISION ADVANTAGES FOR TOTAL KNEE**

2 **ARTHROPLASTY**

3

4 **Introduction**

5 A longitudinal incision is commonly used for total knee arthroplasty (TKA) ¹.
6 However, there are three problems with this type of incision: first, a hypertrophic scar
7 with pain and itching; second, numbness at the distal lateral side of the knee joints; and
8 third, frontal knee pain while kneeling. According to these problems, the rate of the
9 neuropathy of the infrapatellar branch of the saphenous nerve has been reported to be
10 from 55 to 100 percent ^{2,3}. It causes incision-site problems, which leads to dysfunction
11 in daily life ^{4,5}. They have been thought to be difficult problems to resolve.

12 On the other hand, it is well known that transverse incisions provide better
13 cosmetic results for patients who undergo surgery for patellar fractures ⁶. This incision
14 is approximately parallel to the course of the infrapatellar branch of the saphenous
15 nerve, allowing the surgeon to better identify and preserve the nerve. If a transverse
16 incision can be safely used for TKA, this would satisfy the patients' desire for decreased
17 scar formation and increased kneeling motion. The purpose of this study was to
18 compare transverse and longitudinal incisions for TKA focusing on scar cosmesis, the
19 infrapatellar branch of the saphenous nerve, and kneeling.

20

21 **Patients and methods**

22 Among the 103 patients (110 knees) with primary TKA performed from April
23 2004 to July 2007, we evaluated 95 patients (101 knees) with follow-up for more than
24 two years. Scorpio NRG PS (Stryker, Kalamazoo, MI, USA) was used. Patients with
25 the following conditions were excluded: a previous surgery wound around the new one,
26 an apparent keloid constitution, skin diseases, bleeding tendency, diabetic disease
27 requiring insulin administration, nerve disorders, or cancer. All cases were performed
28 by the same surgeon (TO). Longitudinal incision was used for the first 40 knees, and a
29 transverse incision was used for the remaining 61 knees; the use of a transverse incision
30 for all TKAs began in 2006. Our institutional review board accepted the use of the
31 transverse incision. We also obtained informed consents regarding patients' rights
32 about the transverse incision from all candidates. There were no significant
33 differences in age, male-to-female ratio, preoperative diagnoses, and body mass indices.
34 There were no significant differences between the two groups in Knee Society Score
35 (KSS) and the femoro-tibial angle, which represents the degree of knee deformity. The
36 follow-up durations were 33.2 months for the transverse incision cases and 50.4 months
37 for the longitudinal incision cases (Table 1).

38 Air tourniquets were not used in any of the operations. The longitudinal
39 incisions were made at the midline, from three centimeters proximal to the upper end of

40 the patella to the tibial tuberosity (Fig 1A). The transverse incisions were made at a
41 ninety-degree knee flexion at the level of the lower end of the patella, along the skin
42 crease, and the medial and lateral ends were targeted around the medial and lateral
43 epicondyles (Fig 1B). Other than the incisions themselves, the surgical procedures for
44 both incisions were basically the same. Careful attention was paid not to injure the
45 infrapatellar branch of the saphenous nerve, when it could be observed (Fig 2). The
46 arthrotomy was performed using a medial parapatellar approach. With an
47 intramedullary guide, we first cut the tibial bone, and then the femoral bone. Without
48 using any tools for minimally invasive surgery (MIS), bones were cut with
49 ordinary-sized cutting guides (Fig 3A and 3B). Wounds were subcutaneously sutured
50 using 3-0 Vicryl (Johnson and Johnson, NJ, USA), leaving the superficial skin layer
51 unsutured to maintain the blood supply to the wound margins. The same postoperative
52 treatments were given to both groups.

53 The evaluation criteria included: operation time, blood loss during the
54 operation, complications and KSS one year after the surgery. As for the wounds, we
55 examined the wounds for complications and measured wound lengths and widths one
56 year after the surgery. The Manchester Scar Scale (MSS)⁷ was used for an objective
57 cosmetic evaluation. For evaluation of the wound conditions, two doctors (TO and

58 MY) examined the worst part of the scar cosmesis. The three criteria measured with
59 MSS were color, contour and distortion, each on a scale of one to four points. The
60 fourth criterion of MSS is appearance, rated at one for matte and two for shininess.
61 The Visual Analogue Scale (VAS) was also used for evaluation by both surgeons
62 (objective) and patients (subjective): zero denoted excellent, while ten denoted poor.
63 In addition, we further examined whether sensory disturbance existed or not. Using a
64 TKK2335 algometer (Takei Kiki Kogyo Co., Ltd., Tokyo, Japan), we conducted an
65 objective evaluation and mapped the sensory disturbance areas on tracing paper.
66 Area-measuring software was downloaded from the Internet (lenaraf220.xls) and used
67 for surface-area measurements. The kneeling motion was evaluated to determine
68 whether kneeling was possible. If the patient could kneel on the operated knee without
69 any support for more than ten seconds, we defined his or her kneeling motion as
70 possible.

71 A t-test and χ^2 -test were used for statistical analysis, and a risk rate of $p < 0.05$
72 was determined as significant, using the StatView 5.0 software for Macintosh (SAS
73 Institute Inc., Cary, NC, USA).

74

75 **Results**

76 The mean operation time required for a transverse incision was 125 minutes,
77 taking slightly longer than for longitudinal incisions (118 minutes), although it was not
78 a statistically significant difference. Blood loss during surgery was nearly equal.
79 Concerning complications, one patient suffered from a fungal infection one year
80 following the surgery, and a two-stage revision TKA was performed using the same
81 transverse incision. After an additional year, fungal infection was detected again, and
82 the re-revision TKA was again conducted using a midline longitudinal incision that was
83 perpendicular to the previous transverse incision. Neither a third fungal infection nor
84 skin problems have occurred so far, one and a half years following the re-revision
85 surgery. A proximal deep vein thrombus was found in one knee in each group, which
86 was improved by heparin administration. No pulmonary embolism occurred in either
87 group. We obtained satisfactory KSS scores in both groups, without a significant
88 difference, at one year after the operation (Table 2).

89 As for wound complications, in the transverse incision group, three knees had
90 subcutaneous hematomas, which were treated with puncture, and one knee had a
91 prolonged wound-healing time of more than two weeks. In the longitudinal group, two
92 knees had subcutaneous hematomas and one knee had a prolonged time for wound
93 healing. Neither superficial infection nor skin necrosis that required additional

94 treatment was found in any cases, but one knee had strong itching at the scar due to
95 hypertrophic scarring of the longitudinal incision (Table 3).

96 When follow-up evaluation took place one year after surgery, the wound
97 lengths at the knee extension were significantly longer in the transverse group than in
98 the longitudinal group. But the wound lengths at a ninety degree knee flexion were
99 approximately 15 cm, without a significant difference between groups. The average
100 wound width measured at its maximum was significantly smaller in the transverse
101 group than in the longitudinal group. The two MSS criteria, color and VAS, scored
102 lower in the transverse group and no significant difference was found among the three
103 criteria: appearance, contour and distortion (Table 4). The total score for the
104 transverse group was significantly lower than for the longitudinal group. The typical
105 appearance of the scar at one year after TKA using a transverse incision is shown in Fig
106 4A and 4B.

107 Subjective complaints of sensory disturbance, such as numbness or
108 hypoesthesia were found to be significantly less in the transverse group than in the
109 longitudinal group. Even patients without subjective sensory disturbance showed
110 some degree of sensory disturbance in the objective evaluation using an algometer. Its
111 frequency was significantly less in the transverse group than in the longitudinal group.

112 The sensory disturbance area measured by mapping was also significantly smaller in the
113 transverse group than in the longitudinal group (Table 5).

114 In total, 54 knees (70.4%) with transverse incisions, and 13 knees (40.6%) with
115 longitudinal incisions could kneel for daily-activity movements. Anterior knee pain
116 complaints in the transverse group (63.0%) were found to be fewer than those in the
117 longitudinal group (78.1%), but the difference was not significant (Table 6).

118

119 **Discussion**

120 The difference between our method and the conventional one is in the incision
121 only. Scar cosmesis, improvement in the disorder of the infrapatellar branch of the
122 saphenous nerve, and kneeling motion are the expected advantages of our method.
123 However, we have to take into consideration skin problems caused by decreased blood
124 supply by retracting the skin to maintain a clear operating field of view.

125 Langer's lines are well known as appropriate surgical incisions. They were
126 originally examined as slit-like wound arrangements after making circular holes with
127 pins on a corpse's skin. However, as for a juxta-articular area, such as the knee,
128 Langer himself noted that the line was complex, depending on the knee position when
129 the holes were made ⁹. Therefore, Borges ¹⁰ and Kraissl ¹¹ proposed relaxed skin

130 tension lines (RSTLs), which were simply obtained by pinching the skin. The RSTL
131 in the frontal knee runs transversely and corresponds to the crease. It is clinically well
132 known that the transverse incision provides a better cosmetic result for patients who
133 have undergone surgery for a patellar fracture, among other procedures ^{6,8}. In our
134 two-year follow-up study of TKA using transverse incisions, it was confirmed that scar
135 cosmesis was significantly better than in the longitudinal incision group.

136 It has been reported that the infrapatellar branch emerges from the main trunk
137 of the saphenous nerve at the level of the inferior pole of the patella. The infrapatellar
138 branch runs transversely, just inferior to the lower pole of the patella, and controls the
139 sense of the distal lateral side of the knee joint ¹². It has been described that the
140 direction of the incision at the graft-harvesting area, made obliquely rather than
141 vertically, can decrease the incidence of sensory disturbance ¹³. In TKA surgery, when
142 a longitudinal incision is used with a medial parapatellar approach, the nerve is cut off
143 before arthrotomy ¹⁴. When a transverse incision is used in TKA, the direction of the
144 incision corresponds approximately to the running direction of the nerve, so the nerve
145 can be confirmed and preserved in many cases.

146 Studies have described the possibility of a kneeling motion after TKA, varying
147 from 34 to 82 percent ^{5,15}. It may be associated with many factors: range of knee

148 flexion of at least 110 degrees ¹⁶, problems with the patello-femoral joint, muscle
149 strength, lumbar spine conditions, and adjacent joint conditions. In our department,
150 kneeling and rising from the kneeling position are allowed approximately three weeks
151 after TKA surgery, when the wound has healed perfectly and swelling has subsided.
152 At that time, many patients are nevertheless unable to kneel, complaining of their scars,
153 pain, and numbness around the wounds, as well as uncomfortable feelings.

154 While performing the kneeling motion, the kneeling triangle, the area bounded
155 by the femoral condyles on either side at the lower level of the patella proximally and
156 the tibial tubercle distally, faces the ground ¹⁷. Pain in this area becomes a major
157 obstacle to kneeling. We considered pain in this area to be caused mainly by injury to
158 the infrapatellar branch of the saphenous nerve. When a transverse incision is used for
159 TKA, the incised part does not face the floor, and less pain and numbness occurs
160 because the infrapatellar branch of the saphenous nerve is intact. In our investigation,
161 one year after surgery, we found that the performance of the kneeling motion was
162 greater in the transverse group than in the longitudinal group.

163 According to several studies in the literature, the skin over the anterior knee is
164 sufficiently fed with a blood supply by the perforating artery through the deep fascia ¹⁸.
165 By changing only the incision, from longitudinal to transverse, no blood-supply

166 reduction was caused in the skin. Further, it is generally believed that subcutaneous
167 tissue detachment should be avoided as much as possible ¹⁹. Although wider
168 subcutaneous dissection was needed in transverse incisions than in longitudinal
169 incisions, no major skin problems were seen in this series. It goes without saying that
170 careful and tender treatment of the skin is important, regardless of the incision. To
171 prevent skin problems, according to additional advantages, the tension of the wound can
172 be decreased only by the extension of the knee in the transverse incision.

173 From our results, we found that the same operative field of view can be
174 obtained using a transverse incision as with a longitudinal incision. There was,
175 however, a problem concerning which incision to make in the case of revision TKA. It
176 is not a problem to use a longitudinal incision perpendicular to the transverse incision,
177 which was made in the patellar fracture surgery ¹⁹. We did not encounter any wound
178 problems in the two-stage reimplantation performed at an interval of one year, although
179 we used a longitudinal incision that was perpendicular to the previous incision.

180 In our retrospective study, the case numbers were small and the follow-up
181 duration was short. Nevertheless, we demonstrated the safety of transverse incisions
182 and the possibility of scar-formation reduction. Additionally, dysfunction of the
183 infrapatellar branch of the saphenous nerve and kneeling motion were shown to be

184 improved.

185

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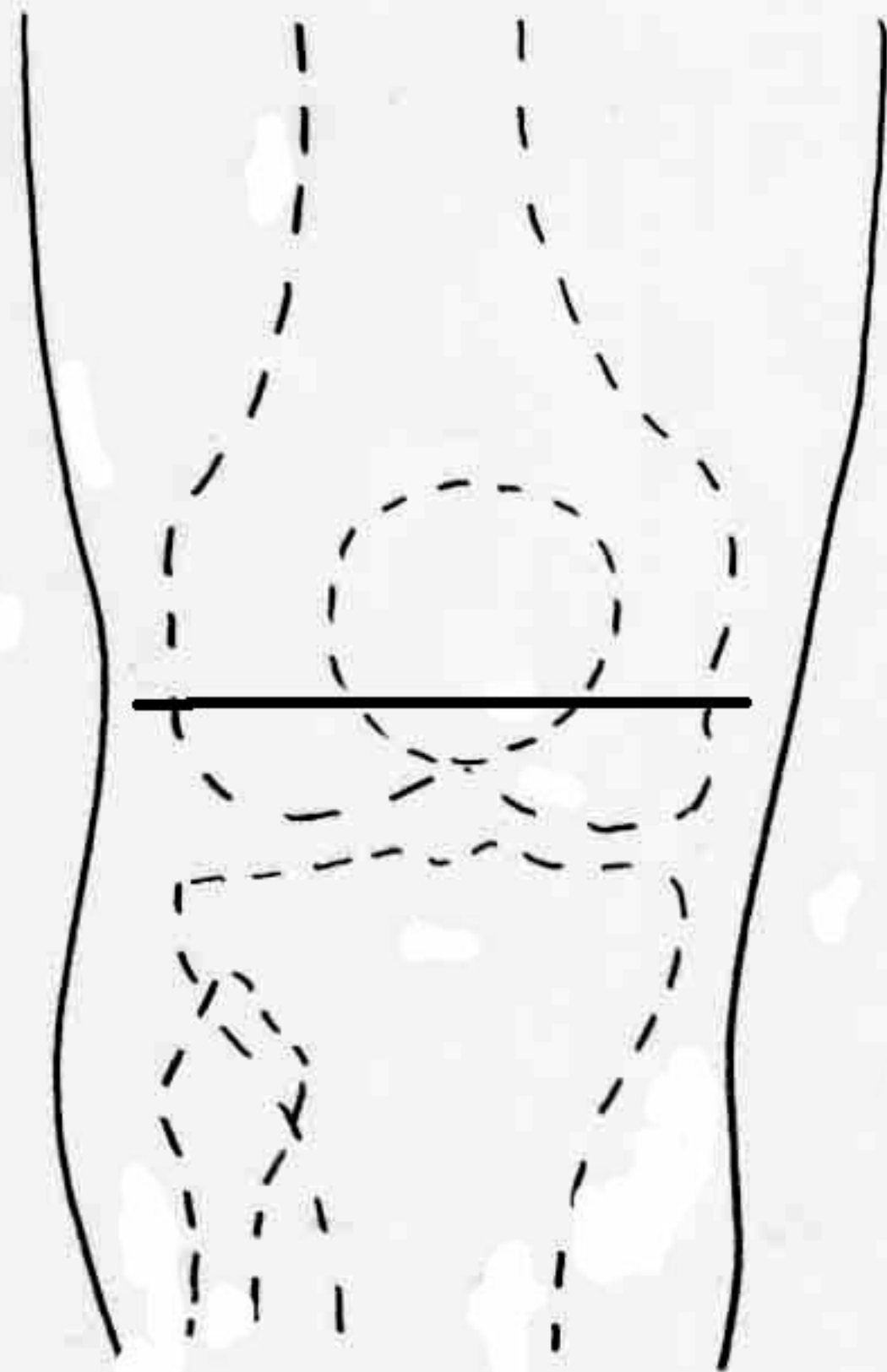
187 from anything related directly or indirectly to this article.

188

189

Table 1. Patient Demographics

	Transverse incision		Longitudinal incision		p-value
Number of patients	58		37		
Number of knees	61		40		
Mean age in years (range)	75.3	(57-82)	73.8	(51-84)	0.45
Male:female	11:50		6:34		
Preoperative diagnosis					
Osteoarthritis	57		37		
Rheumatoid arthritis	2		3		
Osteonecrosis	2		0		
Mean body mass index (range)	24.4	(20-33)	25.2	(19-33)	0.50
Mean femoro-tibial angle (range)	182.5	(160-194)	180.3	(162-188)	0.10
Mean follow up in month (range)	33.2	(24-41)	50.4	(42-60)	



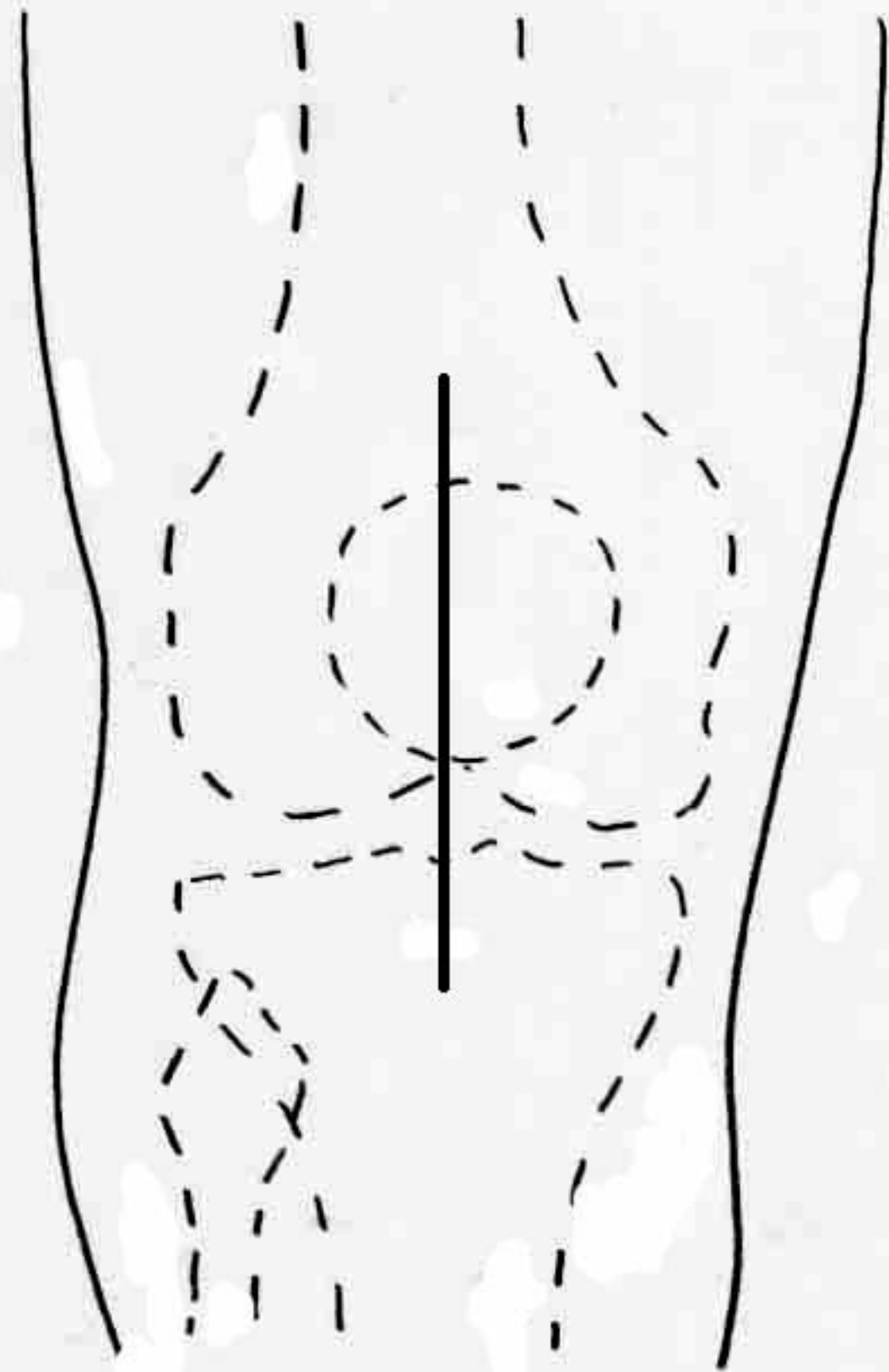








Fig 1 A,B. Skin incision.

A Longitudinal incision was made at the midline, from three centimeters proximal to the upper end of the patella to the tibial tuberosity.

B Transverse incision was made at a ninety-degree knee flexion at the level of the lower end of the patella, along the skin crease.

Fig 2. Infrapatellar branch of the saphenous nerve.

Attention was paid not to injure the infrapatellar branch of the saphenous nerve, when it could be recognized.

Fig 3 A,B. Surgical exposure.

The same operative field of view could be obtained using a transverse incision as with a longitudinal incision.

A Exposure of the tibial side

B Exposure of the femoral side

Fig 4. Scar cosmesis at one year after TKA using transverse incision.

Color, contour and distortion were scaled at one point respectively, and appearance was

evaluated as matte. Objective VAS was one and total MSS was calculated as five points.

A At knee extension

B At a ninety-degree knee flexion

Table 2. Surgical Data

	Transverse incision (n=61)		Longitudinal incision (n=40)		p-value
Mean operation time in min (range)	125	(98-180)	118	(85-187)	0.10
Mean intraoperative blood loss in ml (range)	239	(100-435)	264	(100-490)	0.37
Postoperative complications					
Periprosthetic infection	1		0		
Pulmonary embolus	0		0		
Proximal deep-vein thrombosis	1		1		
Knee Society Score					
Knee score (range)					
Pre-operative	48.6	(14-68)	46.7	(12-70)	0.56
At one year	81.3	(62-92)	79.8	(60-91)	0.65
Functional score (range)					
Pre-operative	44.5	(14-66)	46.0	(14-65)	0.76
At one year	75.2	(42-85)	76.5	(43-88)	0.80

Table 3. Wound Complications

	Transverse incision (n=61)	Longitudinal incision (n=40)
Subcutaneous hematoma requiring puncture	3	2
Delayed healing over 2 weeks	1	1
Superficial infection	0	0
Skin necrosis requiring treatment	0	0
Scar itching	0	1

Table 4. Postoperative Results of Scar

	Transverse incision (n=61)		Longitudinal incision (n=40)		P-value
Mean scar length in cm (range)					
Extension	13.7	(12.5-14.5)	11.6	(9-13)	<0.01
90 degree flexion	15.2	(14-17)	15.3	(13-17.5)	0.74
Maximum scar width in mm (range)	1.5	(1-3)	4.2	(2-9)	<0.01
Manchester Scar Scale (range)					
Color	1.5	(1-3)	1.7	(1-4)	0.13
Matte/shiny	1.2	(1-2)	1.3	(1-2)	0.22
Contour	1.1	(1-2)	1.8	(1-3)	<0.01
Distortion	1.5	(1-2)	1.4	(1-2)	0.33
VAS	1.1	(0-6)	3.0	(2-8)	<0.01
Total	6.5	(4-10)	9.1	(6-18)	<0.01
Subjective assessment (range)					
VAS	1.1	(0-4)	1.8	(0-6)	0.03

Table 5. Assessment of Hypoaesthesia

	Transverse incision (n=61)		Longitudinal incision (n=40)		P-value
Subjective assessment					
Number of knees with hypoaesthesia (%)	14	(21.3)	25	(62.5)	<0.01
Objective assessment					
Number of knees with hypoaesthesia (%)	21	(34.4)	33	(82.5)	<0.01
Mean area of hypoaesthesia in cm ² (range)	14.8	(0-35)	40.5	(0-90)	<0.01

Table 6. Assessment of Kneeling

	Transverse incision (n=54)	Longitudinal incision (n=32)	P-value
Kneeling is possible(%)	38 (70.4)	13 (40.6)	<0.01
Anterior knee pain (%)	34 (63.0)	25 (78.1)	0.14
Flexion angle (range)	121 (85-145)	123 (80-150)	0.33
Replacement of patellar (%)	28 (51.9)	18 (56.3)	0.69
Muscle strength of quadriceps femoris	4 (34), 5 (20)	4 (19), 5 (13)	

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