Knee pain caused by a fiducial marker in the medial femoral condyle

A clinical and anatomic study of 20 cases

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ABSTRACT – After 2-pin-based ROBODOC hip arthroplasty procedures, 10 of 18 patients reported persistent severe pain at the site of pin implantation in the medial femoral condyle. In a cadaver study, we found that the infrapatellar branch of the saphenous nerve, the saphenous nerve and the anterior cutaneous branches of the femoral nerve had been injured by the pins. At least one of these nerves was injured in 11 of the 20 specimens examined. Our findings indicate that the knee-pain may be partly caused by injuries to these nerves.

In computer-assisted orthopedic surgery (CAOS), fiducial markers are used to record the location of the bone to the computer device, on the basis of preoperative planning. The two-pin-based registration method of ROBODOC (Integrated Surgical Systems Inc. (ISS), Davis, CA) requires implantation of a distal pin in the medial femoral condyle and a proximal pin in the major trochanter. Both pins are implanted during spinal anesthesia before the planned procedure. A CT-scan of the femur is done immediately after pin implantation. The CT-data is transferred to the computer station where the cutting procedure is planned. The resulting program is then transferred to the robot at the beginning of the total hip replacement, which is usually performed one day after pin implantation. During the ROBODOC procedure, the pin is exposed and the robot detects the surface of the screw's head with its tactile sensor arm. After surgery, both pins are removed.

We assessed the intensity and duration of pain at the site of the distal pin implantation in the medial femoral condyle in patients who underwent a ROBODOC hip arthroplasty in our center. We also studied in human cadavers to what extent neural structures at the medial femoral condyle were damaged by implantation of the distal pin.

Patients and methods

18 consecutive patients underwent a pin-based ROBODOC hip arthroplasty. The length of the skin incision for the knee pin was recorded at the time of surgery. Patients were asked to quantify pain on a visual analog scale (VAS)—i.e., no pain at all (0) to extreme pain (10)—on the day after pin implantation and 6 months after arthroplasty and to note the pain, its duration and compare the pain at the hip wound with that at the knee.

Pins were implanted in 20 randomly-selected carbol-formol fixated cadaver specimens: 10 right and 10 left cadaver knees of 11 female and 9 male donors (Table 1). The average age was 75 (64–86) years. Moderate adiposity was found in 3 and severe adiposity in 2 cases. A pin—a titanium screw (ISS), 30 mm long, with a diameter of 5-mm was implanted in the medial femoral condyle. This was done according to standard implantation instructions about the ROBODOC procedure (2-pin method), in the same way as in routine operations, via a skin incision of 25–65 mm. The length of the incision was based on the subcutaneous fat

Table 1. Nerve injuries from pin implantation

No.	Sex	Side	Adiposity	Nerve	Damage
1	m	l		IPBSN	Cut
2	m	l		IPBSN	Cut
3	f	r			
4	f	r			
5	m	l		IPBSN	Cut
6	m	l		SN	Cut
7	f	r		SN	Cut
8	f	r			
9	m	l	moderate		
10	f	l		ACBFN	Screw in n.
11	f	r	moderate	ACBFN	Cut
12	m	l	moderate		
13	m	r			
14	f	r	severe	ACBFN	Cut
15	m	l	severe	IPBSN	Cut
16	f	r			
17	f	l		IPBSN	Screw in n.
18	m	r			
19	f	r			
20	f	l		IPBSN	Cut

layer so as to ensure a workspace large enough for intraoperative pin-detection. The adductor tubercle was used as an easily palpable anatomical landmark and the incision was made 1 cm distal to the tubercle. Subcutaneous tissue was then split, and a longitudinal incision made in the tendon of the vastus medialis. A hole was drilled with a 3.5 mm-diameter drill using a tissue protector. A guide wire was placed in the hole and the screw implanted over the wire until the screw's head touched the surface of the bone. All implantations were done by either one of two experienced surgeons who regularly perform this operation in vivo.

After implantation, all specimens were dissected. The placement of the pin was noted on a schematic drawing of the medial femoral condyle. The positions were marked according to their position relative to the adductor tubercle. All neural structures were prepared, starting proximal to the joint at the level of the femoral and saphenous nerves. These nerves were followed and the infrapatellar branch of the saphenous nerve (IPBSN), the saphenous nerve itself (SN) and anterior cutaneous branches of the femoral nerve (ACBFN) were exposed and damage to them was recorded (Figure 1).

Results

10 of the 18 patients reported severe pain (¶ 5 on VAS) at the site of pin implantation after surgery and its subsequent removal (Table 2). Only 1 patient had no pain at all. On average, knee pain lasted for 75 (0–180) days after hip arthroplasty. 12 patients reported pain for more than 1 month and 13 that it was worse than that in the hip.

In all 20 cadaver specimens, the pins were securely placed in the medial femoral condyle (Figure 2). We found injuries to 3 nerves, the IPBSN, SN and ACBFN. At least 1 of these nerves was injured in 11 cases. In 6 cases the IPBSN was damaged, in 2, the SN itself and in 3, the ACBFN.

Damage to nerves was caused by partial or total cutting of the nerve, or by the screw itself. In 2 cases (ACBFN, IPBSN), the nerve had been screwed into the bone (Figure 1).

We found no correlation between the length of the skin incision and nerve injuries.

Discussion

Our patients had persistent knee pain. This was discussed in a ROBODOC user meeting (ISS,

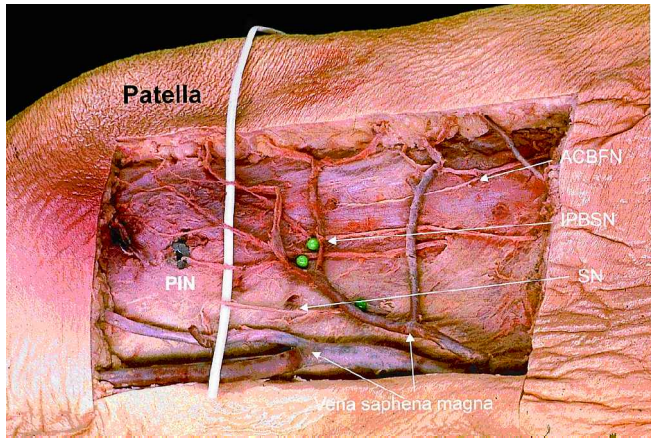

Figure 1. Dissection of the area of the medial femoral condyle with a pin in the IPBSN.

Table 2. Intensity and duration of knee pain

Patient	A	B	C	D	E
1	4	2	0	2	N
2	3	10	6	40	Y
3	4	0	3	90	N
4	4.5	0	4	15	Y
5	3.5	0	0	0	N
6	4	3	7	150	Y
7	4.5	10	5	30	Y
8	3	10	2	180	Y
9	3	10	0	1	Y
10	4	8	2	60	Y
11	8	0	5	35	Y
12	6.5	10	10	150	Y
13	4	6	7	170	Y
14	4.5	0	0	18	N
15	3.5	6	6	90	N
16	5	5	5	8	Y
17	2.5	7	5	150	Y
18	2.5	4	8	150	Y
mean	4.1	5.1	4.2	74	
SD	1.3	3.9	2.9	65	
range	2.5–8	0–10	0–10	0–180	

A Length of incision
B Pain after 1st operation
C Pain after 2nd operation
D Duration of pain (days)
E Worse than hip (Yes/No)

ROBODOC-User meeting, Wiesbaden, 10/1998) as a complication of the use of a fiducial marker at the medial femoral condyle. Knee pain after pin implantation in the ROBODOC procedure has also been reported by other centers but, to our knowledge, not yet systematically studied. Börner et al. (1997) reported knee pain caused by the distal pin of the ROBODOC pin-based registration method in their study of 465 patients. Pain was reported to last for not more than 6 weeks. Lahmer et al. (1999) reported that knee pain was a problem in one third of all ROBODOC patients who underwent the pin-based registration method.

Nerve injuries are one possible source of pain. A limitation of the cadaver study design was that only morphological changes could be detected without correlation to possible clinical findings. Trauma to bone, periost and tendons could also add to the patients' pain. However, we found nerve injuries in half of the cadaver specimens.

The innervation of the medial aspect of the knee is well described (Lanz and Wachsmuth 1972, Horner and Dellon 1994, Mochida and Kikuchi 1995, Ebraheim and Mekhail 1997). The region is supplied by the L3 and L4 segments via the saphenous nerve and the femoral nerve with its anterior cutaneous branches and the infrapatellar branch of either the saphenous nerve and/or the anterior cutaneous branches of the femoral nerve. Lanz and Wachsmuth (1972) have reported numerous variations of these nerves which we also found.

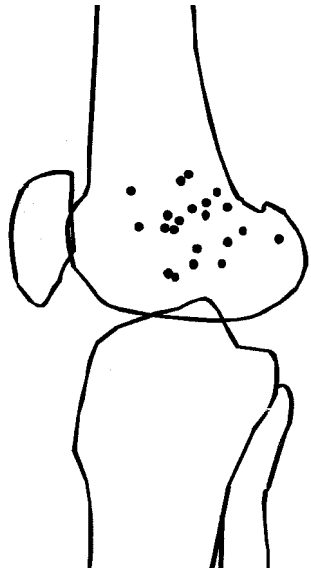

Figure 2. Locations of pins in the medial femoral condyle.

These variations in nerve supply of that region entail a high risk of nerve injury exist. Therefore, we do not believe that it is possible to define a safe zone in that area to reduce the risk of nerve damage. Whenever pin-based registration is necessary for a ROBODOC procedure, a different anatomic region, such as the lateral condyle, with fewer neural structures (Lanz and Wachsmuth 1972), should be chosen for placement of the distal reference point.

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