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Femoral press-fit fixation versus interference screw fixation in anterior cruciate ligament reconstruction with bone-patellar tendon-bone autograft: 20-year follow-up

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ABSTRACT

Introduction: The aim of this paper is to present our experience with femoral press-fit fixation in anterior cruciate ligament reconstruction using bone-patellar tendon-bone autograft.
Methods: The patient population was randomly placed in two groups: group A (58 patients), who underwent femoral screw fixation; group B (62 patients), who underwent femoral press-fit fixation.
Results: At last follow-up 9.2% of patients were lost; 28% of patients in group A and 64% of patients in group B had excellent International Knee Documentation Committee score (grade A); 66% of patients in group A and 32% of patients in group B had good International Knee Documentation Committee scores (grade B). The difference was statistically significant ($p < 0.05$).
Conclusions: Femoral press-fit fixation of bone- patellar tendon- bone autograft provides stable fixation at low cost, it ensures unlimited bone-to-bone healing and high primary stability, avoiding the disadvantages of hardware and the need for removal in case of revision.

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1. Introduction

The anterior cruciate ligament (ACL) is one of the most frequently injured ligaments in the human body. So, ACL reconstruction has become a common surgical procedure in orthopaedic surgery. Many different grafts have been used but the bone –patellar tendon-bone (B-PT-B) autograft is considered the gold standard.[1,2,9,19,22,29] The main advantage of B-PT-B autograft include high load to failure, adequate stiffness and rapid bone healing.[8] Various techniques have been used for femoral fixation of the graft, among which interference screws have been the most widely used, although various complications have been reported, including divergent screw placement, possible impingement and abrasion.[8] Metal interference screws are difficult to remove in case of revision surgery and they may also produce disturbance in postoperative magnetic resonance imaging. To avoid difficulties related to fixation devices, in 1987 Hertel developed a femoral press-fit fixation and in 1989 a tibial press-fit fixation.[10] Then several authors like Boszotta,[4] Paessler[20] and others[3,24] developed similar techniques. Several biomechanical studies have been performed in order to compare the press-fit fixation with commonly used implant fixations. The press-fit fixation has been shown to have similar pull-out strength and stiffness compared to fixation with interference screws in animal models[13,18,23,25,26,28].

The aim of this paper is to present our 20-year follow-up with femoral press-fit fixation in ACL reconstruction using B-PT-B autograft, comparing the results with a homogeneous group of patients who underwent the same procedure with femoral interference screw fixation.

2. Materials and methods

Between September 1994 and September 1997, the authors performed 120 ACL reconstructions using BPTB autograft.

Inclusion criterion was: documented ACL lesion associated with subjective knee instability. Exclusion criteria were: concurrent fracture of the knee, posterior cruciate ligament injury, poor bone quality and patellar problems. The study design was approved by the local ethics committee and all patients gave informed consent prior to inclusion in this trial.

This patient population was randomly placed in two groups, regarding the treatment. In the first group (Group A; n = 58), femoral interference screw fixation technique was used; while in

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the second group (Group B; n = 62), femoral press-fit fixation was used. In both groups was used the tibial interference fixation.

Group A: 58 patients randomly assigned to femoral and tibial interference screw fixation with screw (Kurosaka screw, Depuy, Warsaw, IN).[14] We had 37 males and 21 females. Mean age was 28 years (range 15–41); the left knee was affected in 32 patients, the right knee in 26. Eleven were professional athletes. The time between injury and surgery ranged from 1 month to 25 months (median 6 months). Twelve patients had undergone previous knee arthroscopies for meniscus tears. During ACL reconstruction, we performed 18 meniscectomies, 13 medial and 5 lateral.

Group B: 62 patients randomly assigned to femoral press-fit fixation. We had 44 males and 18 females. Mean age was 23 years (range 18–39); the left knee was affected in 26 patients, the right knee in 36. Fifteen were professional athletes. The time between injury and surgery ranged from 20 days to 18 months (median 5 months). Seven patients had undergone previous knee arthroscopies. During ACL reconstruction, we performed 13 meniscectomies, 5 medial and 8 lateral.

Clinical evaluation was assessed with International Knee Documentation Committee score (IKDC)[12] and with arthrometer KT-1000. The IKDC was formed in 1987 to develop a standardized international documentation system for knee conditions. Then several minor revisions were performed until its publication in 1998. The test can be used to evaluate different knee injuries, such as ACL lesions, posterior cruciate ligament lesions, meniscal tears, knee cartilage lesions and traumatic knee dislocation. Patients are divided in 4 grades, according clinical and radiological findings: grade A (normal), grade B (nearly normal), grade C (abnormal) and grade D (severely abnormal). All patients underwent pre-operative radiological examination in order to evaluate poor bone quality, such as osteoporosis or patello-femoral problems and computer-tomography at 2 and 6 months to evaluate graft integration. Patients were followed-up at different time intervals: 1, 6 and 12 months. Then were recalled at last follow-up for clinical evaluation. The data was stored on a Microsoft Excel database. Statistical analysis was performed using t-student test. Significance was set <0.05.

3. Surgical technique and rehabilitation

All operations were carried out under general or spinal anesthesia and tourniquet. A diagnostic arthroscopy was performed to verify the rupture of the ACL and to address associated injuries as mentioned above. After removing the ACL remnants, the femoral notch was prepared. The medial wall of the lateral femoral condyle was debrided until the posterior arch of the notch was clearly visible. Then a midline incision over the medial edge of the ipsilateral patellar tendon was made. The B-PT-B autograft was 10 mm wide and harvested with 20–25 mm of bone from the patellar and tibial tubercle. The bone blocks were formed to a trapezoid shape by using an oscillating saw. The tibial and femoral tunnels were reamed to an appropriate size depending on the width of the autograft bone blocks (in group B, 1 mm undersized to the bone graft). Then the graft was pulled through the tunnels with out-in technique for the tibial autograft and in-out technique for the femoral autograft, using a pull-through suture, so that the patella bone block was within the femoral tunnel and the tibial bone block was within the tibial tunnel. The graft was positioned so that no bone protruded into the joint. In group A an interference screw of Kurosaka (average dimension 7×25 mm) was used both in the femoral and in the tibial tunnel to fix the bone block. In group B, an interference screw of Kurosaka (average dimension 7×25 mm) was used to fix the tibial bone block, while the fixation of the femoral autograft was a press-fit fixation.

Rehabilitation differs in group A and B.

Group A. Standard protocol with brace adjusted to allow 0–90° of flexion during the first 2 weeks, then full range of motion was allowed. Full weight-bearing was permitted.

Group B. A fixed splint in full extension was worn during the first 2 weeks. The patient walked with toe touch weight-bearing using crutches. The immediate active quadriceps isometric exercises were started. On the fifteenth postoperative day, the brace was adjusted to allow motion between 0 and 60° of flexion. The patient continued walking with toe touch weight-bearing using crutches. Four weeks after surgery, the brace was adjusted to allow between 0 and 90° of flexion and the patient was permitted to bear 50% of his weight. At five weeks, the brace was adjusted to allow 0–120° of flexion and full weight-bearing was permitted. Six weeks after surgery full flexion was allowed. Swimming and bicycle without resistance were allowed.

4. Results

Eleven patients (9.2%) could not be contacted because they had changed address or were unable to participate because of geographic constraints, allowing a clinical assessment of 109 (90.8%) patients. The average follow-up was 19.5 years (range 18–21 years). Except for these patients, results were similar at different time intervals of follow-up. Therefore, the group A consisted of 53 patients, 34 men and 19 women. The group B consisted of 56 patients, 41 men and 15 women. All patients returned to normal activities such as moderate physical work, running or jogging.

At 6 and 12-month follow-up results were identical; in particular, 30% of patients in group A and 66% of patients in group B had excellent IKDC score (grade A); 68% of patients in group A and 30% of patients in group B had good IKDC score (grade B); 2% of patients in group A and 4% in group B had fair IKDC score (grade C). At the last follow-up, 28% of patients in group A and 64% of patients in group B had excellent IKDC score (grade A); 66% of patients in group A and 32% of patients in group B had good IKDC score (grade B); 6% of patients in group A and 4% in group B had fair IKDC score (grade C) (Table 1). The difference between the two groups was statistically significant ($p < 0.05$).

Using the KT-1000 arthrometer, at the 6 and 12-month follow-up the side-to-side difference was 1–2 mm in 38% and 69% of patients respectively in group A and B. The side-to-side difference was 3–5 mm in 62% and 31% of patients respectively in group A and B. At the last follow-up, the side-to-side difference was 1–2 mm in 35% and 68% of patients respectively in group A and B. The side-to-side difference was 3–5 mm in 65% and 32% of patients respectively in group A and B (Table 2). The difference was statistically significant ($p < 0.05$).

The most frequent complication was muscle atrophy (21% in group A and 25% in group B), followed by anterior algodystrophy (17% in group A and 13% in group B). Arthrofibrosis occurred in 6% of patients in group A and 11% in group B, all recorded at 12-month follow-up and treated with arthroscopical arthrolysis. Two patients in group A had to be revised because of Cyclops syndromes

Table 1
IKDC results between the two groups ($p < 0.05$) at last follow-up.

IKDC	Kurosaka screw	Press-fit
Grade A (Normal)	28%	64%
Grade B (Nearly normal)	66%	32%
Grade C (Abnormal)	6%	4%
Grade D (Severly abnormal)	0%	0%

Table 2
Side-to-side difference with arthrometer ($p < 0.05$) at last follow-up.

Side-to-side difference with KT-1000	Kurosaka	Press-fit
1–2 mm	35%	68%
3–5 mm	65%	32%
6–10 mm	0%	0%
> 10 mm	0%	0%

Table 3
Overall complications ($p = 0,4$).

Post-operative complications	Kurosaka	Press-fit
Wound infection	0%	0%
Extension gap >10°	0%	0%
Flexion gap <10°	2%	4%
Arthrofibrosis	6%	11%
Anterior algodystrophy	17%	13%
Patello-femoral crepitation	2%	0%
Cyclope syndrome	4%	0%
Patellar fracture	0%	0%
Interference screw problems	4%	0%
Muscle atrophy	21%	25%

recorded at 6-month follow-up and treated immediately. All complications are listed in Table 3.

5. Discussion

The most important finding of our study was the statistically significance difference between the two groups. Femoral press-fit fixation showed better clinical outcomes and knee stability, as reported in the IKDC evaluation and KT-1000 arthrometer examination. Group A had an increased laxity (statistically significant) respect to Group B: we argued that this is the consequence of possible femoral screw loosening. But an important point has to be raised up about this surgical technique: patient with poor bone quality and patello-femoral problems should be excluded.

The concept of press-fit fixation was introduced by Hertel in 1987.[10] It is a simple technique that offers several advantages, including biological graft healing, the absence of any intra-articular hardware making easier revision surgery, and avoidance of the cost of femoral implants.[8] Different authors[5,6] reported no statistical difference in failure or stiffness comparing a press-fit bone plug with a patellar tendon bone plug with interference screw fixation. Several biomechanical studies have been conducted in order to compare the press-fit fixation with commonly used hardware fixations. The press-fit fixation has been shown to have similar pull-out strength[25] and stiffness[18] when compared to fixation with interference screw in animal models. In 1995 Malek et al.[16] performed a cadaveric study between femoral press-fit fixation and interference fixation with Kurosaka's screw. They could find two reasons for the success of press-fit fixation: the power of press- fit in an undersized bone tunnel and the angle between tendon and bone plug inside the femoral tunnel. This angle decreases from extension to flexion of the knee and pull-out of the bone is possible only beyond 60° of flexion. This is the rationale we allow knee flexion beyond 60° only during the fifth-sixth week, when the autograft is incorporated into the femoral tunnel. Papageorgiou et al.[21] demonstrated that the bone plugs are fully incorporated after a healing period of 6 weeks in an animal model. For this reason, we performed post-operative computed-tomography (CT) in our patients and we showed bone healing and osteo-integration at 2 and 6 months (Figs. 1–2).

Advantages of press-fit fixation include unlimited bone-to-bone healing and avoidance of all disadvantages associated with hardware fixation, such as graft laceration, bio-incompatibility, biodegradability or allergic reactions.[15,17]

Few reports have analyzed the long-term results of press-fit fixation[3,7,8,11,30] and only one author have performed a matched-pair study between femoral interference screw and press-fit fixation.[27]

The original technique of ACL reconstruction using B-PT-B press-fit fixation was presented by Hertel in 1990 during the ESSKA congress in Stockholm,[10] but the 10-year results were published in 2005.[11] They used press-fit fixation both for femoral and tibial bone plugs. Assessment using IKDC score revealed 84% of patients had normal or nearly normal knee joints at follow-up, 15% had abnormal knee joints and 1% had severely abnormal knee joint. The average injured-uninjured KT-1000 difference was 1.8 mm. Fifty-nine% had a difference of 1–2 mm, 41% a difference of 3–5 mm to the opposite knee. The most frequent reported complication was ectopic bone formation, observed in 31% of patients and most often located at the apex of the patella.

Gobbi et al.[8] reported the 5-year results of femoral press-fit fixation of B-PT-B in ACL reconstruction in 40 athletes. The IKDC knee score revealed 85% of patients with a normal or nearly normal knee joint. They had one pull-out of the tibial bone block that needed revision surgery and four patients with patellar pain who needed second-look arthroscopy. Al-Husseiny et al.[3] presented a retrospective study of 42 ACL reconstructions using B-PT-B and femoral press-fit fixation. At a medium follow-up of 29 months, IKDC knee score revealed 88% of the patients with normal or nearly normal knee joint, 10% as abnormal and 2% as severly abnormal.

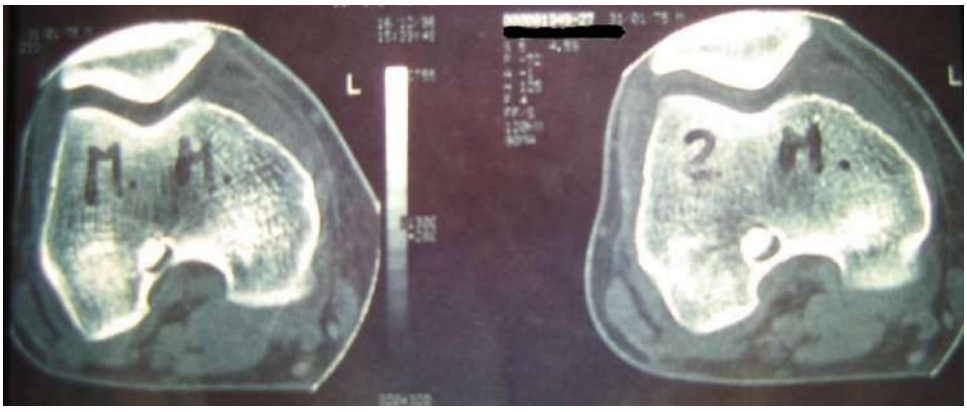

Fig. 1. CT scan at 2 months follow-up.

Fig. 2. CT scan at 6 months follow-up: the autograft is completely integrated with the femur.

Using KT-1000 arthrometer the side-to-side difference was 2 mm or less in 40 patients and 3–5 mm in 2. Thirty-five% of patients had irritation on the donor site and 3 underwent late arthroscopies due to arthrofibrosis. In one case, they had fracture of the patellar bone plug during impaction in the femoral tunnel.

Widuchowski et al.[30] reported the longest follow-up (15 years) of femoral press-fit fixation in ACL reconstruction using B-PT-B autograft. In a group of 52 patients, IKDC knee score revealed 75% of patients had normal or nearly normal knee joint. Post-operative complications were observed in 5 patients, of which one developed a superficial wound infection and 4 developed arthrofibrosis which required second-look arthroscopy in 2 of them. Felmet[7] reported the 10-year results of implant-free press-fit fixation for B-PT-B ACL reconstruction: IKDC score of the 148 patients enrolled in the study revealed 87% of normal or nearly normal knee joints. As major complications, he described 8 Cyclops syndromes that need second-look arthroscopy and as local complications he reported numbness of the skin in 40% of the patients. The only matched-pair study between 2 techniques of fixation we could find was that of Sarzaeem et al.[27], who reported the short terms results of 158 patients, randomly assigned to femoral press-fit fixation and interference screw fixation. Assessment with IKDC score revealed 83% and 85% of normal or nearly normal knee joints in press-fit and screw group respectively ($p > 0.05$). The mean laxity assessed using a KT-1000 arthrometer improved to 2.7 and 2.5 mm in press-fit and screw group, respectively. As major complications, they reported only 7 cases of infections (3 deep infections). Patello-femoral pain was observed in 12.7% of patients in press-fit group and 15.3% of patients in screw group, showing no significant differences ($p > 0.05$).

The donor site morbidity seems to be a major concern of all B-PT-B graft techniques. It includes complications such as damaging the knee extensor apparatus, the potential for subsequent patello-femoral joint pain or crepitation, patella fracture, patella tendon rupture, infra-patella contraction, numbness caused by damage of the infra-patellar branch of the saphenous nerve and possible loss of quadriceps strength. We reported anterior algodystrophy (also known as complex regional pain syndrome) as the second major complication, observed in 17% of patients in group A and 13% of patients in group B.

Our results are similar to those reported in the literature and prove that femoral press-fit fixation has the same efficacy of screw fixation, ensuring better clinical results and knee stability, avoiding all disadvantages of hardware. The femoral integration is the result of a normal process of graft osteointegration, achieved by adequate press-fit (undersizing the femoral tunnel) and by adequate rehabilitation protocol and the use of fixed splint in full extension during the first 2 weeks. But other factors need to be find to demonstrate for such difference in stability between the two different femoral fixation methods.

Bone quality and patello-femoral joint should be evaluated in each patient. The main limitation of our study is the absence of radiological evaluation at the last follow-up. Besides, the presence of two different rehabilitative protocols could be a bias and could negatively affect our statistical results.

6. Conclusions

We concluded that femoral press-fit fixation of B-PT-B autograft during ACL reconstruction is an efficient procedure. It provides stable fixation at low cost, it ensures unlimited bone-to-bone healing and high primary stability, avoiding the disadvantages of hardware fixation and the need for removal in case of revision. It is a simple technique but should be avoided in patient with poor bone quality and with pre-existing patello-femoral problems.

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