ORIGINAL PAPER

F. Geiger · U. Schneider · M. Lukoschek · V. Ewerbeck

External fixation in proximal tibial osteotomy: a comparison of three methods

Accepted: 22 March 1999

Abstract During a period of 6 years (1990–1996), 154 patients with unilateral gonarthrosis underwent proximal tibial osteotomy using 3 different methods of external fixation: (1) closing wedge osteotomy and bilateral fixation; (2) closing wedge osteotomy with unilateral fixation, and (3) opening wedge osteotomy with unilateral fixation. The most common complications were pin-tract infection (25%), temporary nerve palsy (10%), and loss of alignment (17%). At least one complication developed in 33% of patients in this study, indicating that the use and technique of external fixation in proximal tibial osteotomy can be problematic.

Résumé Nous avons effectué le suivi de 154 patients avec gonarthrose unilatérale ayant subi une ostéotomie tibiale haute. Entre 1990 et 1996, trois techniques différentes ont été utilisées: (1) une ostéotomie avec réduction osseuse et une stabilisation par le fixateur bilatéral; (2) une ostéotomie avec réduction osseuse et stabilisation unilatérale, et (3) une ostéotomie avec augmentation de l'angle et stabilisation unilatérale. Parmi les complications les plus fréquentes, on nota des infections des orifices d'insertion du fixateur (25%), des déficits neurologiques périphériques temporaires (10%), et une perte de l'alignement (17%). Dans 33% des cas de cette étude survint au moins une complication. De ce fait, la stabilisation par fixateur externe après ostéotomie tibiale doit être considérée comme problématique.

U. Schneider · M. Lukoschek · V. Ewerbeck
Orthopädische Universitätsklinik, Schlierbacher Landstraße, 200a,
D-69118 Heidelberg, Germany

F. Geiger (✉)
Maiglöckchenweg 13, D-55126 Mainz, Germany

F. Geiger (✉)
Department of Traumatology,
Johannes Gutenberg University, Langenbeckstrasse 1,
D-55131 Mainz, Germany

Introduction

Today the benefits of proximal tibial osteotomies for knees with angular deformities and unicompartamental osteoarthritis are generally accepted within certain specific limitations [5]. Various methods of fixation have been described, such as staples [1, 2, 11], the Charnley external fixation device [6, 20], AO plate [7], plate and screws [10], and a unilateral external fixation system [14, 16].

Since 1990 we have used 2 different systems for external fixation – either the standard AO-external fixator or the Heidelberg unilateral fixation system. We have assessed the value of these fixation devices, studying the duration of treatment, the incidence of complications and the stability of the alignment that they produce.

Patients and methods

Over a period of 6 years (1990–1996), 154 patients with unilateral gonarthrosis were treated by a proximal tibial osteotomy using external fixation. The clinical and radiological follow-up ranged from 6 months to 6 years with a mean duration of 1.5 years. Until removal of the fixation device, patients were seen at least every 2 weeks, and at least twice a year after removal. The medial compartment was affected in 132 patients, and the lateral compartment was affected in 22 patients.

Two groups of surgeons carried out 2 methods of fixation using: (a) the bilaterally fixed AO external fixator, and (b) the unilateral Heidelberg Fixator System (Zimmer). Distribution of the patients was at random, and was not influenced either by clinical factors or the surgeon. A closing wedge osteotomy was performed in the AO group. Where unilateral fixation was used, an opening-wedge osteotomy was performed when there was pre-operative ligamentous laxity, and this was carried out in 31 (HD-open group) of the 78 patients in that group; thus, there were 3 groups to study (Table 1).

There was no significant difference between the 3 groups regarding sex or the side of the operation (Table 1) ($P < 0.1$, chi-square-test), length of follow-up, mean age, and height and weight ($P < 0.1$, one-way analysis of variance [ANOVA]).

The day the patients were able to walk bearing full body weight without aids or bandages was considered the end of treatment. The period of hospitalization, and the length of time before the removal of the fixation method used, were also documented. Alignment was measured using 'one leg standing roentgenographs' where any deviation from the mechanical axis was noted. Statistical assessment

Table 1 Distribution of patients

	AO-close	HD-close	HD-open	Total
All patients	76	47	31	154
Medial compartment osteoarthritis	68	35	29	143
Lateral compartment osteoarthritis	8	12	2	22
Sex (male/female)	38/38	13/34	9/12	60/94
Side (right/left)	38/38	27/20	16/15	81/73
Mean age (years)	57	56	51	55
Mean height (cm)	166	165	167	166
Mean weight (kg)	79	76	74	77

of the stability of alignment was made: (1) the mean value of deviation was compared pre-operatively, post-operatively, at the time of removal of the fixation device, and again at the last follow-up; (2) the degree of post-operative change of the axis in either direction was measured – either overcorrection (+) or undercorrection (–) – providing a fairly reliable method of assessing the stability of the method used; (3) we calculated in how many cases a change of more than 3° could be detected. Changes of less than 3° were ignored as, according to Odenbring [12], such a deviation cannot be assessed by conventional X-ray views.

Statistical analysis was carried out using the SPSS program. Parameters such as varus/valgus, sex and site of operation were evaluated by cross-tabs using the chi-square-test. The same test was used for the assessment of complications. Differences in age, height, weight and duration of treatment as well as pre- and post-operative alignment were explored with the univariate ANOVA using the Turkey-B test. A significant difference was found with $P < 0.1$.

Results

Patients in all 3 groups stayed an average of 19 days in hospital ($P < 0.1$), but a significant difference was found in the time before removal of the external fixation method ($P < 0.1$). In the AO group it was removed after 54 days, in the HD-close group it was removed after 57 days, and in the HD-open group it was removed after 65 days ($P < 0.1$). Full weight-bearing walking without aids was achieved after an average of 84 days and there were no significant differences between the 3 groups ($P < 0.1$).

The most common complications were pin-tract infections (Table 2). Inflammation or “secretion” occurred in at least 25% of patients, and wound-healing problems appeared in 7%, but there were no examples of osteitis or osteomyelitis. Antibiotic treatment was required in 22%, and of these 16% were pin-tract infections. The appearance of an infection was not influenced by the type of osteotomy or of fixation ($P > 0.5$).

Chronic peroneal palsy only occurred in 3 cases, but a temporary palsy of the peroneal nerve, or weakness of the extensor hallucis longus, was found in 10% (Table 2). Open-wedge osteotomy did not produce peroneal palsy. No difference was noted in the incidence of nerve damage in those patients treated with the AO and the HD fixation device where the closing-wedge technique was used.

Thirty-four complications required further surgery (Table 2). Either a pin or the fixation device were removed due to infection in 9% of patients. Deep wound infection required surgical revision in 5 patients. Alignment needed correction in 9% of patients.

Pre-operative varus deviation ranged from 2° to 18° (average 9.2°) in knees with medial gonarthrosis. Patients

with lateral gonarthrosis had a mean valgus deviation of 7.8° (range: 4–14) (Table 3). Correction in varus gonarthrosis was 10.1° with no significant difference between the groups. Valgus deviations were corrected by a mean of 7.8° (Table 3). Those patients with varus gonarthrosis on whom a closing-wedge osteotomy had been performed were slightly overcorrected (mean=0.9°). A physiological mechanical axis of 0–2° was achieved in 75% of patients with pre-operative varus deformities, whereas a moderate over-correction (3–5°) was produced in 33%.

The post-operative angle changed before the removal of fixation in some patients. There was only a slight reduction of the mean angle in the AO-close and HD-close groups, but a higher rate of loss of correction was found in the HD-open group (Table 3). The greater amount of post-operative change before removal (irrespective of direction) was seen in the HD-open group (2.4°), whereas in the AO-close group this change was only 0.9° ($P < 0.1$) (Table 3). In all 3 groups a change of axis (0.5°) occurred in the period following the removal of the fixation and the completion of treatment. These changes can be attributed to the difficulty of accurate measurement ($P > 0.1$).

Stabilisation was considered to be accurate if the post-operative change did not exceed 3°. The post-operative angle was maintained until this fixation was removed in 89% of patients on whom external AO fixation was used. The post-operative angle was maintained in 75% of the HD-open group, and 77% in the HD-close group. Post-operative changes in alignment were seen in the 2 closing wedge groups in either direction, both over-correction and loss of correction in an almost equal proportion of cases. Loss of correction was seen in 25% of the HD-open group, and there was no post-operative over-correction (Fig. 1).

Discussion

After conventional closing wedge osteotomy, the bilateral fixation in the “AO-close” group was in place for a mean of 7.7 weeks. In “HD-close” with unilateral fixation, this period was not significantly different. But in “HD-open” with unilateral fixation was combined with an opening wedge osteotomy, the period was almost 10 weeks.

Another important parameter, which depends on the fixation device, is the attainment of the ideal post-operative angle. With the opening wedge technique, 1° per day of correction was continued until the correct axis was attained. This method guarantees optimal correction, but sev-

Table 2 Complications

	AO-close	HD-close	HD-open	Total	%
Pin-tract infection	17	12	9	38	25
Superficial wound infection	6	4	1	11	7
Deep wound infection ^a	2	3	1	5	4
Antibiotic treatment	16	9	9	34	22
Removal of fixator	7	2	6	15	10
Nerve palsy	14	5	0	19	12
N. peroneus transient	5	3	0	8	5
N. peroneus chronic	1	2	0	3	2
M. ext. hallucis isolated	7	1	0	8	5
Pseudarthroses ^a	5	2	2	9	6
Pin loosening	2	0	1	3	2
Fracture of bone ^a	0	1	0	1	0.6
Thromboses	2	0	1	2	1
Patella luxation	0	2	0	2	1
Compartment syndrome ^a	0	1	0	1	0.6
Haematoma ^a	3	0	3	6	4
New pin ^a	1	1	1	3	2
Realignment ^a	7	5	3	15	10

^aComplications leading to further surgery.

Table 3 The mechanical axis

	AO-close	HD-close	HD-open	Total
Medial compartment OA				
Pre-operative	-9.6°	-9.6°	-8.3°	-9.2°
Post-operative	0.9°	0.9	0.8°	0.9°
Mean	1.1°	1.2°	1.0°	1.0°
At last follow-up	1.1°	1.5°	-1.2°	0.7°
Amount of correction	10.7°	10.7°	9.1°	10.1°
Post-operative change	0.9°	1.5°	2.4°	1.3°
Lateral compartment OA				
Pre-operative	6.8°	8.2°	11.0°	7.8°
Post-operative	-0.8°	0.6°	0.0°	0.0°
Mean	0.0°	0.7°	0.0°	0.4°
At last follow-up	-0.3°	1.1°	-	0.5°
Amount of correction	7.6°	7.6°	11.0°	7.8°
Post-operative change	0.8°	2.5°	-	1.8°

Fig. 1 Percentage of post-operation changes greater than 3° before removal of fixator

eral radiographs are necessary. With the closing wedge technique, the definitive angle is achieved during surgery and only a single radiograph is needed. Most authors agree that in cases of medial gonarthrosis a slight over-correction of up to 2–5° towards valgus leads to better long-term re-

sults [2, 16–19]. In our study an overcorrection of up to 2° was found in 72% of patients with medial gonarthrosis while an overcorrection of 3–5° was found in 35%. It still remains difficult to achieve exactly the predicted alignment. Holden et al. [4] reported an average error of 1.6°, while Jackson and Waugh [6] found that in 35% of their operations the predicted axis was not achieved. In such cases external fixation, especially the unilateral version, offers the possibility to correct the angle post-operatively. This was done in 9.7% of our patients.

After surgery, firm stabilization during the healing period is important. Many fixation devices are not able to accomplish this fully, and in our study the post-operative alteration of the axis varied from 0° to 10°. Depending on the technique used, the post-operative mean deterioration varied from 0.9° to 2.4° (Table 3). In the opening wedge group, a change was always associated with loss of correction. In the two closing wedge groups, both loss of correction and over-correction were seen (Fig. 1). Changes of axis have also been reported [2] where loss of correction in 70% of the operated knees was found at 10-year follow-up. In another study [7] it was reported that revision surgery was performed in 1.9% of patients

due to loss of correction. There have been no reports of loss of correction within the fixation period.

A wide range of complications has been reported. Morrey [11] found complications in 5.9% of his patients; in another study [6] 158 complications were reported in 226 patients, and in the largest study [7] one or more complications were reported in 19.9% of cases ($n = 783$). In our study, complications were seen in 33% of all cases (Table 3), and 36 complications in 22 patients led to further treatment (Table 2).

The most common complication was infection, and 22% of our patients required antibiotics. This is a higher percentage than that reported by Jenny et al. [7] with 2% and Ortlepp and Slegling [13] with 8%. However, patients who had been put in a cast for 2 months did not have any infections [5]. In our study, infections of the wound were rarely seen in contrast to those of the pin-tract. Almost all the investigators who used external fixation reported a comparatively high rate of infection: Dinkelacker et al. [3] reported 4%, Menke [9] reported 10% and Wolfarth et al. [18] reported 16%.

Reports of the incidence of infections varies greatly in the literature, and comparison is made difficult since both internal and external methods of fixation have been used. It has to be stated, however, that 16% of our patients received antibiotic treatment because of pin-infections, which would not have occurred if external fixation had not been used.

No nerve palsies were seen in the opening wedge group, but these did occur in 10.6–18.4% of the two closing wedge groups. Most were only temporary and involved the peroneal nerve. Chronic palsy of the peroneal nerve was produced in only 1.9%, and there were no problems with the tibial nerve. Similar results have been reported: 2% of palsies occurred after immobilization in a cast [4]; 2.4% occurred following the use of staples [2]; 5.7% temporary palsies and 2.4% chronic palsies occurred after a plate had been used [7]; 15% palsies, of which 5% were persistent, occurred where external fixation had been used [18], and 15.7% of lesions, of which 7.9% lasted for more than 7 months, occurred where conventional osteotomy had been used [15]. There may be various reasons for the high percentage of this complication in our study. Kirgis and Albrecht [8] showed in an anatomic study that the distal Steinmann pin is often inserted in a high-risk area. Fibular osteotomy causes most of the nerve problems according to Sturz and Rosemeyer [17]. This would explain why palsies are seldom seen after open wedge osteotomies where the fibula does not have to be osteotomised. It is questionable whether the high number of temporary palsies in our study was caused by the fixation device. The HD-open group showed that it was more likely to be related to the fibula osteotomy.

Other complications were too rare to allow a distinction between the 3 groups, but there were 9 cases of delayed bone union. This problem has been seldom reported by other investigators. Jenny et al. [7] who used internal fixation with a plate reported 1 out of 783 operations with a pseudarthrosis, and Wildner et al. [19] who used a similar internal device reported 1.7% of delayed union.

This study has shown that proximal tibial osteotomy carries some risks when combined with external fixation, and the high proportion of pin infection requiring antibiotic treatment is especially alarming. Furthermore, these methods require many out-patient visits until bony union has been achieved in order to control alignment and infection. Where unilateral fixation was used, the treatment was prolonged and there was less stability. Should an external fixation method be chosen for this operation, it would be preferable to use a bilateral device because of the higher stability produced.

References

1. Coventry MB (1987) Proximal tibial varus osteotomy for osteoarthritis of the lateral compartment of the knee. *J Bone Joint Surg [Am]* 69: 32–38
2. Coventry MB, Ilstrup DM, Wallrichs SL (1993) Proximal tibial osteotomy. *J Bone Joint Surg [Am]* 75: 196–201
3. Dinkelacker F, Breyer B, Rahmzadeh R (1990) Die Korrekturosteotomie bei primärer und sekundärer Gonarthrose. *Aktuel Traumatol* 20: 124–128
4. Holden D, James SL, Larson RL, Slocum DB (1988) Proximal tibial osteotomy in patients who are fifty years old or less. *J Bone Joint Surg [Am]* 70: 977–982
5. Insall JN, Joseph DM, Msika C (1984) High tibial osteotomy for varus gonarthrosis. *J Bone Joint Surg [Am]* 66: 1040–1047
6. Jackson JP, Waugh W (1974) The technique and complications of upper tibial osteotomy. *J Bone Joint Surg [Br]* 56: 236–245
7. Jenny K, Jenny H, Morscher E (1985) Indikation, Operationstechnik und Resultate der transcondylaren Tibiaosteotomie bei Gonarthrose. *Orthopaede* 14: 161–171
8. Kirgis A, Albrecht S (1992) Palsy of the deep peroneal nerve after proximal tibial osteotomy. *J Bone Joint Surg [Am]* 74: 1180–1185
9. Menke W (1992) Die aufklappende Schienbeinkopfosteotomie mit homologer Spongiosa im Vergleich zur subtrahierenden Schienbeinkopfosteotomie mit Fixateur externe. *Zentralbl Chir* 117: 151–155
10. Miniaci A, Ballmer FT, Ballmer PM, Jakob RP (1989) Proximal tibial osteotomy. A new fixation device. *Clin Orthop* 246: 250–259
11. Morrey BF (1989) Upper tibial osteotomy for secondary osteoarthritis of the knee. *J Bone Joint Surg [Br]* 71: 554–559
12. Odenbring E, Egund N, Hagstedt B, Larsson J, Lindstrand A, Toksvig-Larsen S (1991) Ten-year results of tibial osteotomy for medial gonarthrosis. *Arch Orthop Trauma Surg* 110: 113–118
13. Ortlepp K, Siegling CW (1989) Nachuntersuchungsergebnisse nach proximaler Tibiakorrekturosteotomie. *Beitr Orthop Trauma* 36: 563–571
14. Pfeil J, Grill F, Graf R (1996) Extremitätenverlängerung, Deformitätenkorrektur, Pseudarthrosenbehandlung. Springer, Heidelberg New York, pp 61–93, 166–168
15. Sabo D, Flierl S, Thomson M, Cotta H (1995) Fractioned drilling – a technique for wedge osteotomy of the knee. *Int Orthop* 19: 352–354
16. Schwetlick G, Eisenschenk A, Mayer M, Dihlmann SW (1996) Bietet der unilaterale Fixateur externe bei der infrakondylären Umstellungsosteotomie Vorteile. In: Stuhler T (ed) *Gonarthrosen*. Thieme-Verlag, Stuttgart, pp 79–82
17. Sturz H, Rosemeyer B (1979) Die isolierte Großzehenheberschwäche nach Fibulaosteotomie. *Z Orthop* 117: 31–38
18. Wolfarth A, Heppt P, Goldmann A, Wirtz P (1991) Die valgusierende Tibiakopfumstellungsosteotomie. *Z Orthop* 129: 72–79
19. Wildner A, Peters A, Hellich J, Reichelt A (1992) Complications of high tibial osteotomy and internal fixation with staples. *Arch Orthop Trauma Surg* 111: 210–212
20. Ysauda K, Majima T, Tsuchida T, Kaneda K (1992) A ten-year follow-up observation of high tibial osteotomy in medial compartment osteoarthritis. *Clin Orthop* 282: 186–195