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The effect of lateral opening wedge distal femoral osteotomy on leg length

A. Madelaine · T. Lording · V. Villa · S. Lustig · E. Servien · P. Neyret

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Abstract
Purpose Varisation distal femoral osteotomy is a well-described treatment for lateral compartment arthrosis in the young, active patient. This treatment may potentially alter the length of the lower limb. The objective of this study was to quantify the change in leg length following lateral opening wedge distal femoral osteotomy using a blade plate.
Methods Between 1998 and 2011, 29 lateral opening wedge distal femoral osteotomies were performed for symptomatic genu valgum with signs of lateral compartment arthrosis or patello-femoral symptoms. The mean age was 44.4 years (±11.3). Average follow-up was 80.2 months (±50.6).
Results The mean osteotomy opening was 8.3° (±2.3). The femoro-tibial mechanical axis (mFTA) was improved significantly, from 187.8° (±3.5) to 180.4° (±2.6) post-operatively ($p < 0.001$). The pre-operative leg length discrepancy was −0.7 cm, compared to −0.6 cm post-operatively, which was not significant (n.s.). There were five revisions to arthroplasty for disease progression at meantime of 166.6 months post-operatively. The probability of survival at 60 months was 91.4 % (95 % CI 74.9–100 %) with end-point of revision to total knee arthroplasty and 87.6 % (95 % CI 74.1–100 %) of revision for complications.
Conclusions Lateral opening wedge distal femoral osteotomy, performed for symptomatic genu valgum, has no effect on leg length. This technique allows good correction of the axis of the lower limb; however, the complication rate is not insignificant (14 %). Complications occurred mainly in post-traumatic cases and may be avoidable with attention to technique and optimum rehabilitation. The procedure should be reserved for young, active patients with significant symptoms.
Level of evidence IV.

Keywords Genu valgum · Femoral osteotomy · Leg length · Opening wedge

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Introduction

High tibial osteotomy is well described in the treatment of medial compartment gonarthrosis in the varus knee, especially in the young, active patient [9]. For lateral compartment disease, however, the results of tibial osteotomy are inferior, particularly in deformations in excess of 12° [4, 17].

Varisation distal femoral osteotomy allows realignment of the lower limb into varus, transferring force during weight bearing to the intact medial compartment in the same manner as a valgisation high tibial osteotomy [12]. Distal femoral varisation osteotomy may be performed using a lateral opening wedge or medial closing wedge technique. The most commonly described technique is the medial closing wedge [1, 2, 7, 8, 11, 13, 20]. In our centre, the preferred method is the lateral opening wedge. Little literature exists regarding the results and complications of this technique [6, 10, 16, 21]. Furthermore, to date, no study has examined the potential change in lower limb length associated with distal femoral osteotomy.

The purpose of this study was to quantify the change in leg length following lateral opening wedge distal femoral osteotomy using a blade plate and to report the results and risks of this technique. It was hypothesized that opening wedge osteotomy would increase lower limb length.

Materials and methods

Between 1998 and 2011, we treated twenty-seven patients (29 knees) with symptomatic genu valgum with signs of lateral compartment osteoarthritis, with or without associated lateral patello-femoral degenerative changes as seen on standard radiographs. All patients underwent lateral opening wedge distal femoral osteotomy. Two patients underwent bilateral procedures. We excluded patients who underwent combined high tibial osteotomy or femoral rotational correction. At the time of operation, the mean age was 44.4 years (±11.3). There were twelve males and seventeen females. The mean Body Mass Index was 25.5 (±3.5). All patients were operated in a single centre following the same operative principles. Prospectively collected data was retrospectively reviewed, including pre-, peri- and post-operative data and radiographs. We used the newly validated Knee Society Score (KSS), French version for pre- and post-operative evaluation. This measure gives an objective score based on symptoms, range of movement and axis and a subjective score based on knee function and patient satisfaction [5]. Patients were reviewed 2, 6 and 12 months post-operatively. The mean follow-up was 80.2 months (±50.6). The mean deformity in the twenty-nine knees, as measured by the femoro-tibial mechanical axis (mFTA), was 187.8° (±3.5). Twenty patients had an idiopathic genu valgum (69 %), six had post-traumatic deformity (21 %), one had recurrent genu valgum after varising femoral osteotomy (3.3 %), one after varising high tibial osteotomy (3.3 %) and one had sequelae of poliomyelitis (3.3 %).

Pre-operatively, radiological assessment included anteroposterior (AP) and lateral view of the knee in monopedal stance, a skyline view of the patellae at 30° of flexion and Rosenberg views of both knees (bipedal stance at 45° of flexion). Pre-operative planning was performed using weight-bearing long leg films (Fig. 1) to allow measurement of the femoral mechanical axis (mFA), the tibial mechanical axis (mTA) and the femoro-tibial mechanical axis (mFTA) [15]. This allowed determination of the location and magnitude of the deformity and planning of the site and degree of desired correction for the osteotomy. Radiographic measurements were made manually by two orthopaedic surgeons. Manual measurements of lower limb frontal plane alignment can be calculated with minimal measurement error [18]. Varus and valgus stress views were performed to appreciate any laxity and reducibility. Post-operatively, AP and lateral views of the operated knee were performed. Post-operative long leg views were performed in the immediate post-operative period (Fig. 1) and at 1-year post-operatively to evaluate any loss of correction. Leg length discrepancy (LLD) was measured on the pre- and post-operative long leg films.

Fig. 1 Pre- (**a**) and post-operative (**b**) long leg views of a 40-year old patient with idiopathic genu valgum. mFTA improved from 197° to 178° on the immediate post-operative long leg view

Pre-operative planning

The aim of the osteotomy was to correct the axis of the lower limb to a neutral alignment of between 0° and 3° of varus, with a preference for slight over-correction rather than under-correction. Careful pre-operative planning was used to determine the degree of correction and magnitude of opening of the osteotomy.

The correction must take into account both the bony deformity and any secondary deformity caused by wear in the arthritic compartment. When the deformation is centered in the diaphyseal region, the blade of the plate must be oriented at an angle to the joint line (Fig. 2a). The angle of correction should be equal to the degree of deformity, which in turn determines the angle of introduction of the blade plate. On the other hand, when the deformation is

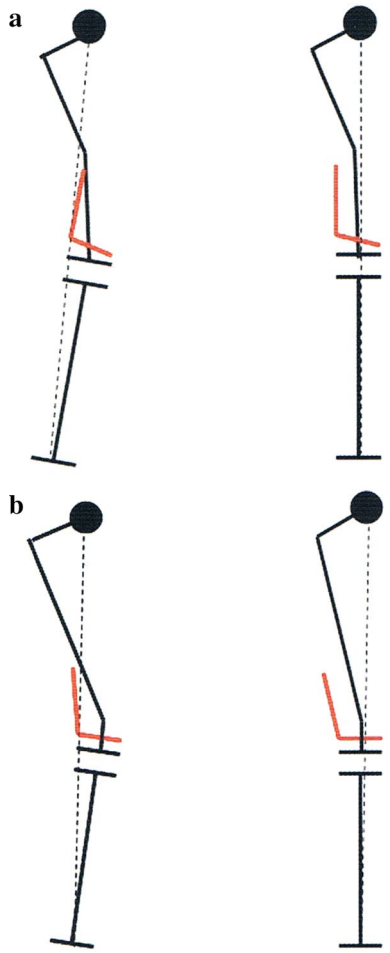

Fig. 2 Pre-operative planning: positioning of the plate in a case of diaphyseal deformity (**a**) and metaphyseal deformity (**b**) (Extract from: P. Neyret, G. Demey, E. Servien and S. Lustig. *Traité de chirurgie du genou*. *p148*. Copyright © 2012 Elsevier Masson SAS. Tous droits réservés)

centered in the metaphysis, the blade plate must be parallel to the joint line (Fig. 2b). This is the most frequent situation. An automatic correction is obtained, with an anatomic femoral valgus of 5°.

Surgical technique

A lateral incision, 15–18 cm in length, was used, and the bone approached in front of the iliotibial band but behind the vastus lateralis. Two guide wires were introduced using artery forceps: one across the femoro-tibial joint and one across the patello-femoral joint. These were used to guide the orientation of the blade plate and reduce the need for fluoroscopic control. The osteotomy site was then prepared. A horizontal osteotomy was used at the superior border of the lateral trochlea. The blade osteotome was introduced into the epiphysis for optimal fixation, with an entry point proximal and anterior to the origin of the lateral collateral ligament. The optimal obliquity of the blade in relation to the joint line depends on the location of the deformity and the magnitude of the desired correction. Determining the correct blade position for the desired correction is the most difficult aspect. A pre-operative AP radiograph was used to verify the correct position. The osteotomy was performed using a saw, at least 25 mm from the entry point for the blade plate to ensure an adequate cortical bridge. The blade plate was then introduced. The medial cortex was weakened by perforation with a guide wire, taking care to maintain cortical continuity. The orientation of the blade was assessed during the surgery with fluoroscopy and the angle between the blade and joint line measured on a printed radiograph. The osteotomy was opened using two or more Lambotte osteotomes, whilst the blade plate was impacted. The opening should be performed in a controlled and progressive fashion. The opening and impaction were continued until the plate was in contact with the lateral cortex of the femur. Fixation was then completed in the diaphysis using bicortical 4.5 mm screws above the level of the osteotomy. Bone grafting was performed using tricortical cortico-cancellous autograft from the ipsilateral iliac crest. Eight patients underwent concurrent procedures; seven patients had a lateral facetectomy, and one patient had an arthroscopy for medial meniscal tear.

Post-operative care

Rehabilitation, without limitation of flexion, was commenced from day two post-operatively. A knee brace in extension was used for mobilization, and patients were kept non-weight bearing on the operated limb for 2 months. Weight bearing was then commenced after review of radiographs. Prophylactic anticoagulation was commenced the day of surgery and continued for 30 days.

Ethical approval

For this type of study, formal consent is not required.

Statistical analysis

Statistical analysis was performed by the Laboratoire Biostatistique Santé (UMR 5558, Lyon, France). Results were compared using the Wilcoxon test. A p value <0.05 was considered significant. Survival analyses were performed using the Kaplan–Meier method. End-points analyzed were revision to total knee arthroplasty and reoperation for complication of internal fixation.

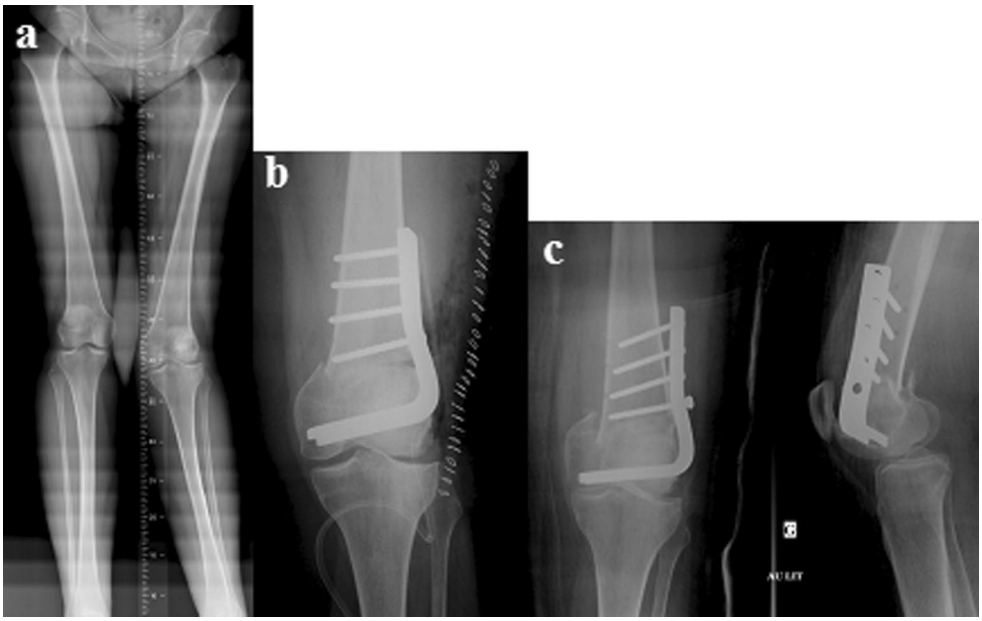

Fig. 3 40-year old patient with multiple sclerosis with loss of fixation of the osteotomy at day 20 post-operatively: **a** pre-operative long leg views with mFTA of 197°, **b** immediate post-operative radiograph, **c** fracture at day 20. The medial hinge fractured secondary to poor bone quality

Results

Clinical and radiological results

The mean angular correction obtained was 8.3° (±2.3). Pre-operatively, there was an average fixed flexion of 0.6° (±2.4) and passive flexion range of 128.9° (±22.5). At the most recent follow-up, mean fixed flexion was 1.3° (±3.5) and passive flexion was 127.7° (±12.4). These differences were not statistically significant (n.s.). The KSS fell significantly from 80.5 (±19.0) to 65.8 (±21.3) ($p = 0.006$). This was due to treatment of limb alignment in the new version of the score, which subtracts 10 points rather than adding 25 where the axis is less than 182°, the very aim of this intervention. For this reason, the new version of the KSS score is not appropriate for evaluating these outcomes. A total of 25 patients (86 %) were satisfied or very satisfied with their outcomes and four were unsatisfied. The functional score was improved from 50.4 (±14.6) to 68.5 (±27.6) although this was not statistically significant (n.s.).

Pre-operatively, the mean mFTA was 187.8° (±3.5), with a mean mFA of 97.4° (±3.7) and a mean mTA of 90.4° (±2.0). Immediately post-operatively, the mean mFTA had significantly improved to 180.4° (±2.6) ($p < 0.001$). The mean mFA was 90.0° (±2.2) and the mean mTA was 90.3° (±1.7). At the most recent follow-up, there was no significant loss of correction, with mean mFTA of 180.1° (±3.6) (n.s.).

There was no significant change in leg length. The mean pre-operative LLD was −0.7 cm (±1.1) whilst the mean post-operative LLD was −0.6 cm (±1.1) (n.s.).

Complications and survival

Post-operative complications were encountered in four patients (14 %).

One patient had a non-union requiring revision at 4.2 months post-operatively. This patient had post-traumatic genu valgum. There were no difficulties encountered during the surgery, with an opening of 7°. He was kept non-weight bearing for 2 months. One patient had delayed union of the osteotomy, which did not require surgical intervention and went on to union at 5.5 months. He had a recurrent genu valgum after previous varising distal femoral osteotomy. There were no difficulties encountered during the surgery, with an opening of 10°. He was also kept non-weight bearing for 2 months. One patient had a loss of fixation of the osteotomy at 0.7 months, requiring revision internal fixation. This patient, a 40-year old female, suffered from Multiple Sclerosis. She had long-term difficulty in ambulating and as a result had poor bone quality (Fig. 3). One patient had stiffness that required a Judet's arthromyolysis at 5 months. The aetiology of genu valgum in this case was post-traumatic (complex distal femoral fractures treated by several operations). The patient had pre-operative stiffness with 0° of fixed flexion and 30° of active flexion. After the femoral osteotomy, active flexion

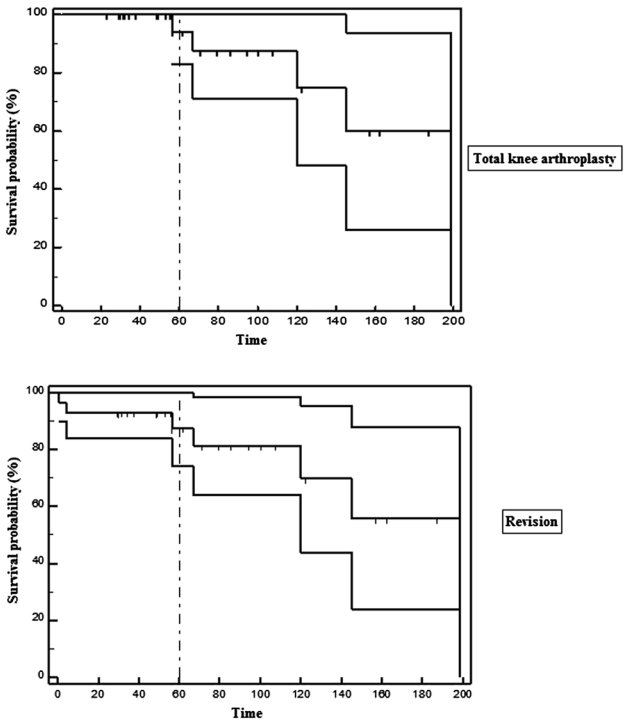

Fig. 4 Kaplan–Meier survival analysis curves with 95 % confidence interval

decreased to 10°. After the Judet's arthromyolysis, active flexion improved to 110°.

Removal of hardware was performed in 23 patients (79 %) for discomfort. The meantime to plate removal was 25.9 months (±40.2).

Five patients were revised to total knee arthroplasty (TKA) at meantime of 166.6 months post-operatively (95 % CI 132.0–195.2). With TKA as the end-point, the cumulative survival rate at 60 months was 91.4 % (95 % CI 74.9–100 %).

With all causes of revision as the end-point, the cumulative survival rate at 60 months was 87.6 % (95 % CI 74.1–100 %) (Fig. 4).

Discussion

The most important finding was varising distal femoral osteotomy, by an opening lateral wedge technique, has no impact on the length of the lower limb for corrections between 5 and 13°. The technique allows satisfactory angular correction, which is stable over the medium term. Subjective results are good with a high rate of patient satisfaction. The rate of significant post-operative complications was low, with only two early revisions. We do not consider removal of internal fixation to be a complication. There were only two cases of delayed or non-union of the osteotomy. The case of hinge fracture with loss of fixation occurred in a special case with poor bone quality. The osteotomy was complete rather than incomplete at the medial hinge, which compromised the stability of the fixation. We can conclude that rigorous technique is important to ensure optimal outcomes. This is the largest series of patients undergoing this intervention to date. This work provides information regarding outcomes with respect to Knee Society Scores, survivorship and change in leg length that may be useful in the selection of the surgical technique to be used in the case of painful genu valgum with medial compartment gonarthrosis. A review of the literature is summarized in Table 1.

No previous study has analyzed change in leg length after distal femoral osteotomy, by either lateral opening or medial closing wedge techniques. Using the lateral opening wedge technique, we have been able to restore a normal mechanical axis. Dewilde et al. [6] studied nineteen distal femoral osteotomies using a lateral opening wedge technique and fixed using a Puddu plate, with a follow-up of 68 months. The alignment was altered from 5.3° of valgus to 1.3° of varus, with 82 % survival at 7 years. There was one fracture at 2 months following a fall. These results are comparable to those of our study. In comparison, Backstein et al. [2] studied 40 distal femoral osteotomies performed using a medial closing wedge technique and fixed with a blade plate. At a mean follow-up of 123 months, the mechanical axis was improved from 191.6° to 178.8°; however, complications were not reported. Marin Morales et al. [13] studied nineteen medial closing wedge osteotomies with average follow-up of 78 months. Axial correction was from 196° to 181°. They reported one case of infection (5 %). Wang et al. [20] studied 30 medial closing wedge osteotomies with a mean follow-up of 99 months. The satisfaction rate was 83 % with axis improved from 18.2° of valgus to 1.2° of valgus. The rate of complications was 13 % with one non-union. Edgerton et al. [7] studied 24 medial closing wedge osteotomies with a mean follow-up of 60 months. The satisfaction rate was 71 % with axis improved from 198° to 181°. The rate of complications was 70 % with seven delayed or non-unions. Results for axial correction and satisfaction rate are comparable for the two techniques. The reported complication rates of the medial and lateral approach are comparable except for in the oldest study [7], which had a high complication rate. Of note, the series of medial closing wedge osteotomies did not report any neuro-vascular complications even if it is a well-known complication of this surgical approach [19]. However, we recommend that using an opening wedge osteotomy by lateral approach as there is no risk of neuro-vascular complications and with careful pre-operative planning, it is an easier technique for inexperienced

Table 1 Literature review comparing follow-up, pre- and post-operative axis and LLD and complications

References	Year	Cases	Mean follow-up (months)	Mean pre-operative axis (°)	Mean post-operative axis (°)	LLD pre/post	Complications
Lateral opening wedge distal femoral osteotomy							
Zarrouk et al. [21]	2009	22	90	194.5	–	–	–
Jacobi et al. [10]	2011	14	45	–	–	–	9 inc. 2 non-unions
Dewilde et al. [6]	2013	19	68	195.3	178.7	–	1 fracture
Saithna et al. [16]	2013	21	54	–	–	–	6 inc. 1 non-union, 2 losses of correction
Our Study	**2014**	**29**	**80**	**187.8**	**180.4**	**−0.7/−0.6**	**4 inc. 1 non-union, 1 fracture**
Medial closing wedge distal femoral osteotomy							
Edgerton et al. [7]	1989	24	60	198	181	–	17 inc. 7 delayed/non-unions
Finkelstein et al. [8]	1996	24	133	–	–	–	4 inc. 1 loss of fixation
Aglietti and Menchetti [1]	2000	18	108	197.5	186	–	0
Marin Morales et al. [13]	2000	19	78	196	181	–	1 infection
Wang et al. [20]	2005	30	99	198.2	181.2	–	1 non-union, 1 fracture, 2 losses of fixation
Backstein et al. [2]	2007	40	123	191.6	178.8	–	–
Kosashvili et al. [11]	2010	33	181	–	–	–	–
Opening or closing wedge distal femoral osteotomy							
Zilber et al. [22]	2004	11	126	193	182	–	3 inc. 1 fracture, 1 arterial injury
Varising tibial osteotomy							
Marti et al. [14]	2001	36	132	191.6	185.8	–	4 inc. 3 nervous injuries
Collins et al. [3]	2013	24	54	182.4	177.4	–	1 stiffness

Bold values indicate our result

inc. including

surgeons. Using the lateral approach, the plate is placed under the iliotibial tract. A high rate of patients in our study (79 %) complained of discomfort due to the plate. This symptom is frequently reported in the literature (21–86 %) [6, 10], but has little impact on patient satisfaction. Hardware removal is sufficient to solve the problem.

The method of fixation of the osteotomy appears to have a significant impact on the outcome. Different plate systems are reported in the literature. Dewilde et al. [6] studied 19 lateral opening wedge femoral osteotomies fixed with a Puddu plate with a mean follow-up of 68 months. Survival at 7 years was 82 %. They reported a single case of fracture at 2 months following a fall. A 95° blade plate may also be used, as in our study. Zarrouk et al. [21] studied 22 lateral opening wedge femoral osteotomies internally fixed with a 95° blade plate, with a mean follow-up of 90 months. Alignment improved from a mean of 14.9° of valgus (4°–17°) to between 6° of valgus and 3° of varus. Complications were not reported. For medial closing wedge osteotomy, Wang et al. [20] studied 30 patients using blade plate fixation with follow-up of 99 months. The average correction was 17°. The KSS improved significantly from 46 to 88. They reported one case of non-union, one post-operative fracture and two cases of implant fracture (13 %). Newer locking plate systems may also be employed for fixation. Jacobi et al. [10] studied fourteen lateral opening wedge osteotomies fixed with a locking plate, with follow-up of 45 months. Average correction was 5.8°. There were seven delayed unions and two non-unions requiring revision surgery (64 %). Similarly, Saithna et al. [16] used a locking plate in the treatment of 22 patients, with average follow-up of 54 months. The degree of angular correction was not reported. Survival at 5 years was 79 %. There was one non-union, one infection, two cases of loss of correction and two patients with persistent pain (18 %). These

studies report a higher rate of complications than in our study. As such, we recommend using a blade plate over a locking plate. It seems to be a good method of internal fixation, but with a not insignificant rate of non-union. In our study, delayed union or non-union occurred in post-traumatic cases with poor bone quality. To avoid such complications, technical improvement of the method of fixation is needed. The non-weight-bearing period may be an important factor in delayed union; however, there is no consensus in the literature regarding the optimum post-operative rehabilitation [16]. Edgerton et al. [7], using staple fixation, reported seventeen complications in 24 patients (70 %), including seven cases of delayed or non-union. From these results, we can conclude that staple fixation is not sufficient.

This study involved a homogenous group of patients, operated using the same technique and rehabilitation protocol. Some limitations of this study, however, should be noted. The duration of follow-up in our study is limited compared with similar studies due to our limited indications. However, this is the largest series of patients undergoing this intervention to date. Because of the heterogeneous rate of complications in the literature and the not insignificant rate in our study, this conservative procedure for lateral compartment osteoarthritis should be reserved actually for young, active patients with significant symptoms.

The new KSS was used in this study. It is important to note that this version includes more items than previously, which may result in an inferior score. Deformity correction in varising distal femoral osteotomy predominantly affects the knee in extension. The effect is clear in long leg views, but unknown in Rosenberg or flexion views. This is not reported in the literature nor examined in this study. Further study is recommended to examine the effect on the joint line in flexion.

Conclusion

Lateral opening wedge varising distal femoral osteotomy, using a blade plate and performed for symptomatic genu valgum, has no effect on leg length. This technique allows good correction of the axis of the lower limb; however, the complication rate is not insignificant.

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Conflict of interest The authors declare that they have no conflict of interest.

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