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Ten-year survival rate of 89% after distal femoral osteotomy surgery for lateral compartment osteoarthritis of the knee

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Abstract

Purpose The purpose of this study was to assess the accuracy, safety, and survival of distal femoral osteotomy (DFO) surgery for lateral compartment OA of the knee.

Methods A retrospective cohort study was conducted at a single UK centre, using prospectively collected data over an 8-year period (2009–2017). All patients had pre-operative radiographic analysis and digital planning of their deformity correction in addition to post-operative analysis of the achieved correction and yearly face-to-face follow-up. Complications (defined as an undesirable medical or surgical event as a direct result of the operation), reoperations, and failure (defined as conversion to arthroplasty or revision) were recorded.

Results From a total of 83 patients, 81 patients undergoing 86 primary DFOs were included in this study, with a mean follow-up of 99 months (SD 27 months). The mean pre-operative percentage Mikulicz point was 78.7% (SD 19.1%) and post-operative 35.9% (SD 14.8%). The mean accuracy of correction (intended correction − achieved correction) was an 8.2% overcorrection (SD 13.7%). The complication rate was 4.7%. Using Kaplan–Meier analysis, the mean survival was 113 months (95% CI 106–120) with the probability of surviving 10 years 89%.

Conclusion DFO for valgus alignment and lateral compartment arthritis is associated with low complications, long-term joint preservation, and the prevention of arthroplasty surgery. However, the accuracy of correction still requires improvement in intra-operative technique.

Level of evidence IV.

Keywords Osteotomy · Knee arthritis · Distal femoral osteotomy · Lateral compartment arthritis

Introduction

Distal femoral osteotomy (DFO) has long been accepted as a treatment modality for lateral compartment knee OA [5, 19, 21]. Osteotomy surgery has the advantage of preserving the joint, hence delaying or avoiding arthroplasty and subsequent revision arthroplasty, especially in younger patients [24]. Osteotomy surgery may also be preferred in those patients with active jobs or lifestyles due to improved range of movement when compared to arthroplasty patients [1, 2, 6, 10].

Even with these reported benefits, DFO is used much less than knee arthroplasty. Historical methods were technically difficult and fixation techniques unsatisfactory [17]. In addition, pre-operative planning in the absence of digital templating software was time consuming. Published evidence of osteotomy surgery involves small case series using heterogenous indications, analogue surgical planning, limited post-operative radiographic analysis, and implants which have now been superseded [3, 13, 20, 26].

This study presents a large series of distal femoral osteotomies for the treatment of lateral unicompartmental OA from a UK specialist centre. The aim was to provide data into the accuracy, safety, and long-term survival of DFO when using modern techniques such as digital planning, precision saws, and pre-contoured locking plate fixation. It was hypothesised that the combined use of such techniques would lead to a more accurate, safer and longer term treatment for lateral compartment OA in the presence

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of valgus coronal plane malalignment of the knee than has previously been reported.

Materials and methods

A retrospective cohort study was conducted at a single UK centre, using prospectively collected data. Eighty-three patients undergoing 88 DFOs (lateral opening or medial closing wedge) over an 8-year period (2009–2017) were eligible for inclusion. 2 patients were excluded due to post-operative imaging and follow-up taking place at a different institution. Therefore, a total of 81 patients undergoing 86 primary DFOs were included in this study, with a mean follow-up of 99 months (SD 27 months) (Table 1). Of the 86 DFOs, pre- and post-operative radiographic data were available for 84 (99%).

All patients had pre-operative radiographic analysis and digital planning of their deformity correction in addition to post-operative analysis of the achieved correction. Complications (defined as an undesirable medical or surgical event as a direct result of the operation [22]), reoperations, and failure (defined as conversion to arthroplasty or revision) were recorded.

Patients were considered for a lateral opening (LOW) or medial closing wedge (MCW) DFO if they had lateral knee pain with either Kellgren–Lawrence (KL) grade 2–4 OA in the lateral compartment or loss of the lateral meniscus or a lateral chondral defect in addition to a valgus mechanical axis. Patients were not considered for DFO if they had KL grade 3 or higher OA in any other compartment of the knee or had an inflammatory arthritis. A MCW osteotomy was preferred due to the superior primary stability with bone on bone contact. However, limb length considerations sometimes dictated that a LOW approach was more appropriate. In this case, it was grafted with allograft bone graft for improved primary stability and union [15].

Table 1 Patient demographics

Total number of DFOs	86
Males	45 (52%)
Females	41 (48%)
Mean age	48 (SD 12.9)
Mean BMI	28.8 (SD 5.4)
Mean pre-op KL grade	2 (SD 1)
Smokers	8 (9%)
Lateral opening wedge	3 (4%)
Medial closing wedge	83 (96%)

Pre-operative planning

All patients underwent a standard radiographic series: weight-bearing anteroposterior (AP), lateral knee, rosenberg and skyline views, along with weight-bearing long leg alignment X-rays with a sizing marker at the level of the knee.

Digital templating software (initially Philips NV, Netherlands, later TraumaCad, Brainlab AG, Germany) was used to calculate the size of the LOW or MCW required. The operative correction aimed to move the weight-bearing axis to a percentage Mikulicz point (%MP) of 45% of the width of the tibial plateau. However, the target was also adjusted to maintain the mLDFA within ± 3° of the normal range of 85°–90° [18].

Surgical technique

Medial closing wedge

A proximal biplanar osteotomy was performed under fluoroscopic control using a Precision Oscillating Tip saw (Stryker, USA) (Fig. 1). Fixation was achieved using an angle-stable internal fixation plate (Tomofix plate, DePuy Synthes, USA) (Fig. 2).

Lateral opening wedge

A proximal biplanar cut was made in a similar manner. Osteotomes were then inserted in sequential fashion to open up the osteotomy and laminar spreaders used to maintain the gap at the desired width (Fig. 3). The measured width of the gap was routinely made larger than the pre-operative plan by 1.3 mm to account for bone removed due to the thickness of the sawblade of the precision saw. A bespoke wedge-shaped bone allograft (femoral head) was used for supplementary construct strength. Fixation was then performed (Fig. 4).

Fig. 1 Intra-operative X-ray of medial closing wedge femoral osteotomy. Cutting cage of four breakable wires used to cut wedge

Fig. 2 Final X-ray of medial closing wedge osteotomy after closure and fixation

Fig. 3 Intra-operative X-ray showing opening of lateral opening wedge femoral osteotomy using laminar spreaders

Fig. 4 X-ray showing final fixation of lateral opening wedge femoral osteotomy

For either osteotomy, if the hinge fractured, fixation was augmented with a small fragment compression plate on the opposing cortex.

Post-operative regimen

Patients received venous thromboprophylaxis as per their risk assessment. All patients were allowed to partial weight bear for 4–6 weeks and then progress to full weight bearing depending on radiographic progression. A full range of movement of the knee was allowed immediately with no bracing. Post-operative knee X-rays were taken before discharge, at 4–6 weeks and 3, 6 and 12 months. Long-leg films were taken at 4–12 weeks once comfortably weight bearing. Follow-up was conducted by a research physio in a face-to-face clinic visit at yearly intervals after the first year. Further radiographs were only taken if there was a clinical need. Final follow-up was defined as the most recent face-to-face clinic visit.

Statistics

The sample size was determined by the time period consisting of complete data with adequate follow-up (2009–2017). Descriptive statistics were reported as the mean with standard deviations. Accuracy of correction was determined using a previously published method [8]. As these were varus corrections, accuracy = intended correction (%MP) − achieved correction (%MP) [8]. Survival analysis, with conversion to arthroplasty or revision as the endpoint, was performed using the Kaplan–Meier method. All statistical analyses were performed using SPSS Version 13.0 (IBM Corporation, USA).

Results

Pre- and post-operative radiographic parameters are presented in Table 2. 37 (44%) patients were accurate to within 5%MP, 51 (61%) within 10%MP, 70 (83%) within 20%MP, whilst 14 (17%) were found to be over 20%MP from their planned correction. There were four complications of which three were successfully treated surgically, whilst one patient died from a pulmonary embolism in the early post-operative period (Table 3). All three LOW patients had pre-operative Grade 4 arthritis and were revised to arthroplasty (Table 3). The mean time to arthroplasty surgery was 42 months (SD 15 months). Using Kaplan–Meier analysis, the mean survival was 113 months (95% CI 106–120) with the probability of surviving 10 years 89% (Fig. 5).

Discussion

The most important finding of this present study is that DFO has a high survival rate in the long term. This shows the aim of osteotomy surgery in significantly delaying the need for

Table 2 Radiographic parameters: pre-op and post-op mean tibiofemoral angle (TFA), mean mechanical Lateral Distal Femoral Angle (mLDFA), % Mikulicz point (%MP), and Accuracy

	Pre-op	Post-op	Accuracy
Mean TFA (degrees)	6.9 valgus (SD 3.9)	2.6 varus (SD 3.4)	
Mean mLDFA (degrees)	84.4 (SD 3.0)	91.9 (SD 3.9)	
Mean %MP	78.7 (SD 19.1)	35.9 (SD 14.8)	8.2 (SD 13.7)

Table 3 Complications

Total complications	4 (5%)
Fatal pulmonary embolism	1 (1%)
Non-union	1 (1%)
Osteotomy collapse	1 (1%)
Metalwork failure	1 (1%)
Total revisions	7 (8%)
Revision osteotomy	1 (1%)
Revision of hardware	1 (1%)
Revision to TKR	4 (5%)
Revision to UKR	1 (1%)
Plate removal	40 (47%)

arthroplasty is a sound one. The mean age of surgery was 48 years, and joint preservation is clearly preferable in such a young age group. With mean survival being almost a decade, one could also argue for the use of osteotomy surgery in elderly patients as an alternative to arthroplasty. Table 4 shows a comparison of this study with recent studies and indicates the results are similar to smaller cohorts.

Mean accuracy was 8.2%MP from the intended correction, hence a mean over correction. This accuracy is difficult to compare as there is little published evidence on this subject. A UK multi-centre report of osteotomy accuracy for varus or valgus corrections at the distal femur and proximal tibia showed a mean under correction of − 1.5% (SD 10.9%) [8]. Specific to DFO, Elattar et al. (2017) reported a surgical accuracy of 95% in 41 osteotomies [7]. However, the method used to calculate accuracy was different to this study. Their goals of correction were either a final MAD of between 5 mm lateral and 5 mm medial, or between 5 and 15 mm medial. This large range enabled a high accuracy, as opposed to the exact %MP goal in the present study. If solely using the same equation to measure accuracy (accuracy = 1

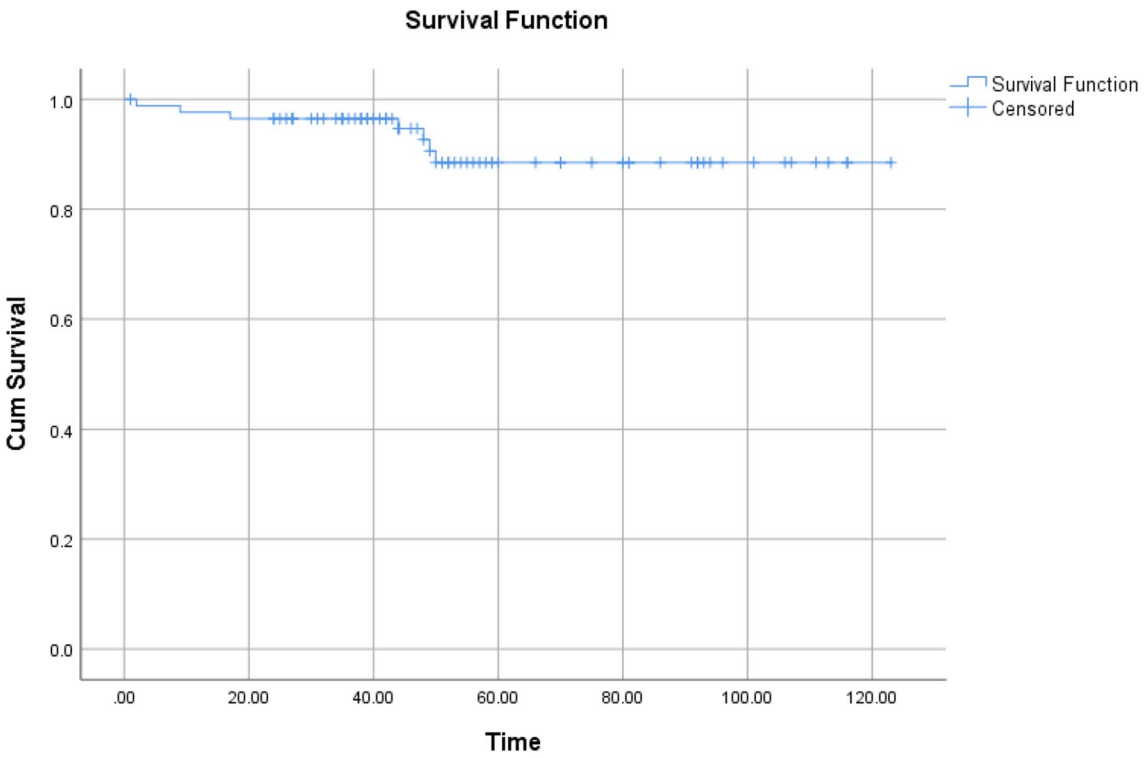

Fig. 5 Kaplan–Meier survival analysis

Table 4 Published survival of DFO

Study	Year	Cases	Follow-up (years)	Mean age (years)	Indication	Survival
Shivji et al	2019	86	8.3 (2–10.2)	48	OA and JP	89% at 10 years
Ekeland et al. [6]	2016	24	7.9 (4.0–10.2)	48	OA	74% at 10 years
Cameron et al. [1]	2015	19	4 (2–12)	OA: 41 JP: 26	OA & JP	74% at 5 years
Saithna et al. [19]	2014	21	4.5 (1.6–9.2)	41	OA	79% at 5 years
Madelaine et al. [16]	2014	29	6.7 (2.5 –10.9)	44	OA	91.4% at 5 years
Dewilde et al. [4]	2013	16	5.7 (2.6–10.6)	47	OA	82% at 7 years
Sternheim et al. [24]	2011	45	13.3	Unknown	OA	89.9% at 10 years

JP joint preservation

− error) as the aforementioned study, this current study had a mean accuracy of 81% (SD 32%). If the defined the 'goal' of this study was set at 45% ± 5%, the accuracy would be 87%. Cameron et al. aimed for a correction of ± 3° from neutral mechanical axes in 21 knees. 13 (62%) of those osteotomies achieved this target, which is superior to the present study's results, but in a much smaller cohort.

When reviewing previously published data, a report from Saithna et al. of 21 DFOs showed a mean correction to 37%MP [19]. Other studies showed a correction to a mean TFA of 1.6° (± 2.1) in 7 patients, and − 1.3 (± 4.0) in 19 patients [4, 25]. Forkel et al. reported the results of 23 MCW DFOs, and showed a mean correction to 42.6%MP (± 4.4) with no under corrections but one overcorrection to 25%MP [9]. A systematic review published in 2016 showed a mean TFA of 1.7° of valgus, corrected postoperatively to 1.2° of varus in 157 patients undergoing MCW DFO [26]. This systematic review included patients from the aforementioned studies and many historical studies. The results of the present study are comparable and show that DFO surgery is successful in correcting valgus deformity, but the degree to which the correction occurs is less certain. Interestingly, the current study only had two revision osteotomies which may indicate the degree of correction is less important to the success of the operation as long as a change in weight-bearing axis is achieved. Improvements in accuracy, and in particular, the reduction of outliers, have been shown in tibial osteotomy when using computer navigation [23]. However, one should be cautious in relying on navigation as non-weight-bearing intra-operative values are significantly different when compared with post-operative weight-bearing values [14].

In a 2016 meta-analysis, 2 of 236 (0.8%) patients undergoing MCW DFO suffered from a pulmonary embolus. Although one could argue patients may be at increased risk of venous thromboembolism (VTE) due to being partial weight bearing, the incidence of VTE in total knee arthroplasty is comparable [12]. 2 patients also suffered from failure of fixation, two from wound complications and two from non-union which is comparable to our present study [3]. Complications listed in the literature are low in incidence [13]. A total of 3 non-unions, 4 delayed unions, and 1 infection occurred in a total of 68 patients across 4 studies [1, 6, 11, 19]. Saithna et al. and Madelaine et al. both had 2 losses of correction from 21 and 29 cases, respectively [16, 19]. It should be noted that in those studies with delayed or non-unions used different fixation techniques than that of this study.

In this centre, removal of metalwork is an expected occurrence and patients are counselled pre-operatively of the likelihood of requiring this. It is the authors' view that metalwork removal should not be described as a complication, but a necessary final part of treatment. Removal is a day-case procedure and low risk. All the aforementioned studies had similar or higher reoperation rates for metalwork removal.

This study had its limitations. The data were retrospective in nature even though it was prospectively collected. The mean follow-up of 99 months was significant and long enough to record complications and correction levels. The data, including radiographical analysis, were also prospectively collected and so its quality was reliable. However, survivorship requires much longer follow-up to truly give an inclination on the use of DFO to delay or reduce the need for arthroplasty surgery. In addition, radiographic data regarding potential loss of correction over time were not available. Finally, this study did not report patient related outcome scores due to incomplete data. Many previous studies have already shown the success of DFO in reducing pain from lateral compartment OA and the aim of this paper was to report the accuracy, safety, and survival with modern planning and surgery, hence patient related outcomes, although important clinically, are not relevant to this study. Finally, this study only contained three LOW DFOs and even though all were converted to arthroplasty, drawing strong conclusions from this particular patient cohort was not possible.

Conclusion

DFO for valgus alignment and lateral compartment arthritis has a low complication rate and is associated with long-term joint preservation and the prevention of arthroplasty surgery.

However, the accuracy of correction still requires improvement. It is hoped the methods and data presented in this study will be used to refine surgical techniques and counsel patients, respectively, in the future.

Compliance with ethical standards

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

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Ethical statement Local institutional approval was given for the assessment and analysis of patient data to evaluate the service provided by Hampshire Hospitals Foundation NHS Trust (Reference: ORTHOEVA19). The study adheres to the 1964 Helsinki Declaration and its later amendments.

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