



Research Article

Closing Wedge Osteotomy of the Femur Fixed by 90° Plate Blade in Valgus Knee Osteoarthritis

Ostéotomie de Fermeture du Fémur Fixée par une Lame de 90° dans l'Arthrose du Genou en Valgus

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ABSTRACT

Introduction. The closing wedge osteotomy (CWO) of the femur is a surgical technique for the conservative treatment in valgus knee osteoarthritis. The objective was to access the clinical, radiological and functional results of the CWO of the femur fixed by a 90° blade-plate. **Methodology.** This was a retrospective analytical study from January 2011 to January 2020 in Dakar. It included all patients operated on for closing wedge osteotomy of the femur fixed with a 90° plate blade. The International Knee Society (IKS) score was used to assess functional outcome. Preoperative and last follow-up values of IKS scores and mechanical femorotibial angles were compared. **Results.** We studied 20 patients (21 knees), including 14 women and 6 men, were included. The satisfaction rate for the final functional result was 85%. It concerned the improvement of the pain and the axis of the limb. Mean IKS scores had significantly increased to 39.6; 17.2 and 56.8 points respectively for knee, function and global IKS ($p < 0.05$). At the last follow-up, the IKS function score was good in 86% of cases. The average consolidation time was 4.3 months. The average postoperative mechanical femorotibial angle was $0^\circ \pm 2.4$ with an average angular correction performed of 16.2° . The final correction was in varus from 0 to 4° in 12 cases and in valgus from 0 to 4° in 9 cases. The mean loss of correction was 2.5° . The main complications were delayed consolidation in 9 cases, rupture of the lateral hinge in 8 cases, loss of correction in 7 cases, appearance of medial compartment wear in 4 cases, 2 cases of infection and dismantling of the plate blade. Within the range of $\pm 4^\circ$, the varus or valgus correction did not influence the functional result. **Conclusion.** The closing wedge osteotomy of the femur fixed by a 90° plate blade improves knee function and delays prosthetic surgery. Delayed consolidation is the most frequent complication in the postoperative evolution.

RÉSUMÉ

Introduction. L'ostéotomie cunéiforme fermante (OCF) du fémur est une technique chirurgicale pour le traitement conservateur de l'arthrose du genou en valgus. L'objectif était d'évaluer les résultats cliniques, radiologiques et fonctionnels de l'OCF du fémur fixée par une lame-plaque à 90° . **Méthodologie.** Il s'agit d'une étude analytique rétrospective de janvier 2011 à janvier 2020 au Centre Hospitalier de l'Ordre de Malte à Dakar (Sénégal). Elle a inclus tous les patients opérés d'une OCF du fémur fixée par une lame-plaque à 90° . Le score de l'International Knee Society (IKS) a été utilisé pour évaluer le résultat fonctionnel. Les valeurs préopératoires et de dernier suivi des scores IKS et des angles mécaniques fémoro-tibiaux ont été comparées. **Résultats.** Nous avons étudié 20 patients (21 genoux), dont 14 femmes et 6 hommes, ont été inclus. Le taux de satisfaction du résultat fonctionnel final était de 85%. Il concernait l'amélioration de la douleur et de l'axe du membre. Les scores IKS moyens avaient significativement augmenté à 39,6 ; 17,2 et 56,8 points respectivement pour le genou, la fonction et l'IKS global ($p < 0,05$). Au dernier suivi, le score IKS fonctionnel était bon dans 86% des cas. La durée moyenne de consolidation était de 4,3 mois. L'angle fémoro-tibial mécanique postopératoire moyen était de $0^\circ \pm 2,4$ avec une correction angulaire moyenne de $16,2^\circ$. La correction finale était en varus de 0 à 4° dans 12 cas et en valgus de 0 à 4° dans 9 cas. La perte moyenne de correction était de $2,5^\circ$. Les principales complications ont été un retard de consolidation dans 9 cas, une rupture de la charnière latérale dans 8 cas, une perte de correction dans 7 cas, l'apparition d'une usure du compartiment médial dans 4 cas, 2 cas d'infection et le démontage de la lame de la plaque. Dans une fourchette de $\pm 4^\circ$, la correction en varus ou en valgus n'a pas influencé le résultat fonctionnel. **Conclusion.** L'ostéotomie cunéiforme de fermeture du fémur fixée par une lame plaque à 90° améliore la fonction du genou et retarde la chirurgie prothétique. Le retard de consolidation est la complication la plus fréquente dans l'évolution postopératoire.

KEY RESULTS**What is known of the subject**

The closing wedge osteotomy (CWO) of the femur is a surgical technique for the conservative treatment in valgus knee osteoarthritis.

Aim of the study

Clinical, radiological and functional results of the CWO of the femur fixed by a 90° blade-plate at Centre Hospitalier de l'Ordre de Malte of Dakar (Sénégal).

Key results

1. The satisfaction rate for the final functional result was 85%.
2. It concerned the improvement of the pain and the axis of the limb. Mean IKS scores had significantly increased to 39.6; 17.2 and 56.8 points respectively for knee, function and global IKS ($p < 0.05$).
3. At the last follow-up, the IKS function score was good in 86% of cases. The average consolidation time was 4.3 months.
4. The average postoperative mechanical femorotibial angle was $0^\circ \pm 2.4$ with an average angular correction performed of 16.2° . The final correction was in varus from 0 to 4° in 12 cases and in valgus from 0 to 4° in 9 cases.
5. The mean loss of correction was 2.5° . The main complications were delayed consolidation in 9 cases, rupture of the lateral hinge in 8 cases, loss of correction in 7 cases, appearance of medial compartment wear in 4 cases, 2 cases of infection and dismantling of the plate blade.

Implications for future practices or policies

The CWO should be performed more frequently in Cameroon due to the fact that its survival rate makes it possible to reduce the time required for a total knee arthroplasty; which is a particular advantage in countries with limited resources where the cost of prosthetic surgery

osteotomy fixed with a 90° plate blade in valgus knee osteoarthritis.

PATIENTS AND METHODS**Study design**

A retrospective study of 20 consecutive patients (21 knees) operated on for closing wedge femoral osteotomy fixed with a 90° plate blade was carried out from January 2011 to January 2020 at Centre Hospitalier de l'Ordre de Malte of Dakar (Sénégal). Ethics committee approval was obtained. The data used were those of postoperative registers, medical records and that of the prospective follow-up of the electronic database. Objective and subjective pre- and postoperative functional assessment was conducted using the IKS score (International Knee Score). The result was considered excellent above 85 points, good between 70 and 84, average between 60 and 69, and mediocre below 20 points. Postoperative follow-up radiological images were analyzed to extract data on consolidation time and angular correction. The osteotomy was considered consolidated on the radiograph when the bone callus was objectified on at least three cortices (internal, anterior and posterior). As the majority of patients in the series did not have pre- and post-operative pangonometry, we measured the anatomic femorotibial angle, which is the angle formed by the anatomical axis of the femur and the tibia passing through the center of the knee. Then we deduced, according to the Langlais and Thomazeau formula [7], the mechanical femorotibial angle, which is obtained by subtracting 6° in women and 3° in men from the value of the anatomic femorotibial angle. Considering the correction objective of 0 to 4° varus, the mechanical femorotibial angle was considered normocorrected if its value was between 0 to 4° varus, hypercorrected if its value was between 0 to 4° valgus and undercorrected if it was more than 4° varus. Failed CWO survival was defined by performing total knee arthroplasty or when indicated in follow-up. The comparison of their preoperative values with those of the last follow-up was carried out.

Patient characteristics

In total, out of 32 patients operated during the study period, 20 were retained (21 knees operated). The 12 patients not included had unusable files or were lost to view. Regarding the 20 included, there were 14 women and 6 men. The sex ratio was 3/7. The average age was 44.4 years with extremes of 27 and 69 years at the time of the intervention. The patients had an average BMI of 28.1 kg/m². All had consulted for knee pain on the genu valgum with symptomatic involvement in 14 cases on the right, 5 cases on the left and 1 bilateral. The patient with bilateral involvement was operated on in two stages. Before surgery, the degree of genu valgum was moderate in 17 cases and severe in 4 cases. 1 patient had been operated for an external meniscectomy. Gonarthrosis was primary in 18 cases and secondary in 3 cases. Preoperatively, the mean angle of mechanical deviation was 16.2° . According to the radiographic stage of the

INTRODUCTION

Knee osteoarthritis remains one of the most frequent causes of consultation due to the socio-professional handicap it causes, dominated by pain and functional impotence. Its natural history is marked by a chronic evolution associated with intermittent painful crises leading to deformities of the axes of the lower limbs if it is not treated. [1] The analysis of the morphotype in the frontal plane constitutes an element of reflection on the femoro-tibial cartilaginous modifications.[2] In valgus knee osteoarthritis, the deviation causes an imbalance with a mechanical axis that passes outside the center of the knee. This induces a mechanical overload on the external tibial plateau and an alteration of the cartilage of the lateral compartment follows.[3] The treatment of knee osteoarthritis by osteotomy still remains a widely used surgical therapeutic solution.[4] The closing wedge osteotomy is an indication for conservative surgery reserved for patients suffering from disabling external femoro-tibial knee osteoarthritis on a genu valgum greater than 10° , with a target correction of 0 to 4° varus.[5] This operation is a reliable option for patients with valgus misalignment because early survival is strong and patient-reported score results are significantly improved.[6] The objective of this work was to access the clinical and radiological results of the closing wedge femoral

Ahlbäck classification(9), 1 knee was at stage 1, 10 at stage 2, 9 at stage 3 and 1 at stage 4.

Statistics

Data were entered using Epi Info™ version 7.1.5.2 software and analysis was performed using R Studio Version 1.0.143 statistical software (R Development Core Team, Vienna, Austria). General patient characteristics were described using standard descriptive statistics. Mean values and standard deviations were calculated for quantitative variables and counts and percentages for qualitative variables. The Chi2 test was performed to test the homogeneity of the distribution of qualitative characteristics and to analyze the differences between the proportions of the events of interest. For the quantitative characteristics (age), the Student test was used. The Wilcoxon test was used to compare the mean of the pre and postoperative data. The final significance level of the statistical tests was set at 5% ($p < 0.05$) with a confidence interval (CI) at 95%.

Surgical technique

The patient was installed in the supine position on an ordinary radiolucent table, with a cushion under the buttocks, a pneumatic tourniquet at the root of the limb. A foot callus was used to flex the knee. The approach was medial longitudinal, starting at the level of the joint space and going up 10 cm proximally. After incision of the intermuscular membrane, the vastus medialis was pushed back up and out using Hohman retractors. The internal surfaces of the femoral condyle and the femoral diaphysis were thus exposed. The knee was positioned and held by the aid in slight flexion with external rotation of the foot. A guide pin was placed in the joint parallel to the joint line. A second was placed 2 cm above in the external condyle and parallel to the first. A third pin was placed at the level of the metaphyseal-epiphyseal junction and parallel to the first two. Three holes with the 4.5 drill bit were made at the level of the second pin, then a striking chisel was introduced into these holes in order to prepare the bed of the blade. This path was parallel to the first two pin-guides over a length of 50 to 70 mm. The internal subtraction osteotomy was then performed. The axis of the first cut was located in that of the third spindle and in a direction parallel to the first two spindles. The second cut is made 5 to 8 mm above the third pin, the direction of which is oblique downwards and outwards to join the first cut at the level of the external cortex while preserving the latter. The cuts are made with scissors under scopic control. After removal of the internally based bone wedge, a 90° 3-hole blade plate was applied to the femur. The valgus correction allowed the apposition of the two osteotomy edges. The conservation of the external hinge was sought as much as possible to limit the translation of the epiphysis in relation to the diaphysis. Once applied to the medial cortex of the femur after compression of the osteotomy site, three cortical screws were inserted to ensure diaphyseal fixation of the plate. At the end of this fixation, the surgical site was cleaned, followed by closure of the various planes under a suction Redon® drain, protected by a dry dressing. After the operation, an analgesic immobilization is performed using a knee brace.

Antibiotic therapy was continued after the intervention associated with anticoagulant treatment. The removal of the Redon drain was done on the second day. The patient was discharged from the hospital on the fifth day unless there were complications and the sutures were removed on the fifteenth day.

Physiotherapy is started on the second postoperative day. It was about a mobilization for the recovery of the articular amplitudes of the knee with ambulation without support. It was started in the service and then continued in the rehabilitation center. The resumption of weight bearing was done from the twelfth week after clinical and radiographic control.

RESULTS

The mean follow-up at evaluation was 48.7 months \pm 10.2, with a minimum of 12 months and a maximum of 60 months. Satisfaction was good in 85% of cases, linked to the improvement of the axis of the limb and the decrease in pain. Evaluation of the global postoperative IKS values of the knees at the last follow-up showed that the result was excellent in 71.4% (15/21) of cases, good in 14.3% (3/21), average in 4.8% (1/21), and bad in 9.5% (2/21). (Figure 1).

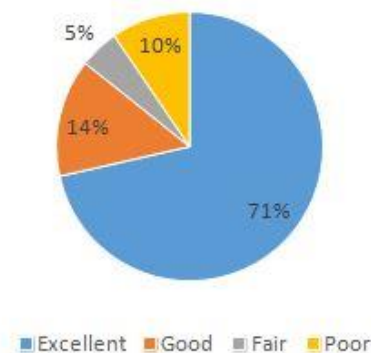


Figure 1. Overall postoperative IKS score at last follow-up

Mean IKS scores increased by 39.6; 17.2 and 59.2 points respectively for knee, function and global IKS. The pre- and post-operative comparison of IKS score values showed that varus femoral osteotomy provided a statistically significant improvement in knee function with a P-value < 0.05 (Figure 2). Radiographically, the mean time to union of the osteotomy was 4.3 months. The mean mechanical femoro-tibial angle was $0^{\circ} \pm 2.4$ and the mean angular correction performed was 16.2° . The mean difference in pre and postoperative mechanical deviation angles was statistically significant with a P-value < 0.05 (Table 1). It was noted that a mean loss of correction was 2.5° between the mechanical femoro-tibial angle at the immediate postoperative period and that at the last follow-up. The CWO was normocorrected in 12 cases, i.e. 57.14% and under-corrected in 9 cases, i.e. 42.85%. No case of overcorrection was noted. In addition to the 7 cases of loss of correction, 8 other complications were observed (Table 2). There were 9 cases of delayed consolidation, 8 cases of rupture of the lateral cortex of the distal femur, 4 cases of wear of the internal femoro-

tibial compartment and 3 cases of degradation of the external compartment; 2 cases of disassembly and parietal

infections, which required revisions and debridements respectively.

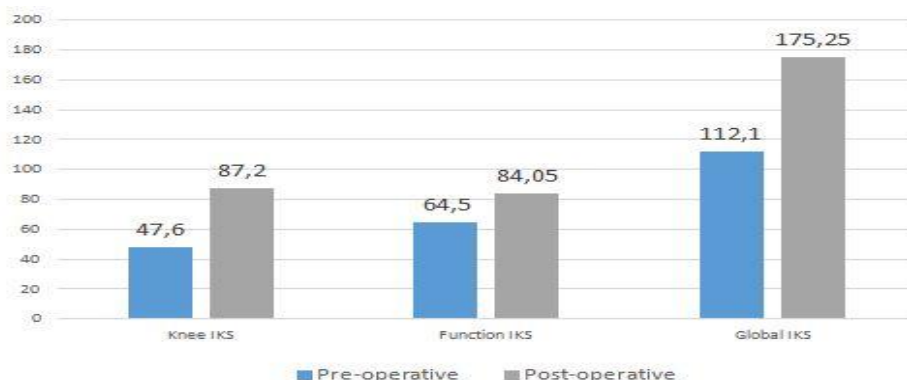


Figure 2. The pre- and post-operative comparison of IKS score values

Table 1. Post-operative radiologic data

Variables	Mean	Median	Sd	Min	Max
Consolidation delay (month)	4,3	4	1,3	3	6
Mechanical femorotibial angle	0,0°	0,0°	2,4°	-4°	4°
Angular correction made	16,2°	15°	5,3°	10°	36°
Loss correction	2,5°	2	0,8	2°	4°

Table 2. Distribution of postoperative complications

Complications	N=21	%
Consolidation delay	9	42,8
Rupture of the lateral cortical bone	8	38,1
Loss of angular correction	7	33,3
Medial compartment wear	4	19,04
Degradation of external compartment	3	14,28
Dissambly of blade plate 90°	2	9,5
Infection	2	9,5
Non-union	0	0
Screw breakage	1	4,76
Conversion to total knee prosthesis	0	0



Figure 3. This figure illustrates the radiographic result of a closing wedge osteotomy fixed with a 90° plate blade, without fracture of the lateral cortex (fig3B), whose evolution was favorable without loss of correction, with consolidation obtained at 3 months (fig3C).



Figure 4. This figure illustrates the radiographic evolution of an CWO interspersed with a few complications. Fig 5A: determination of the femorotibial angle and preoperative planning of the CWO. Fig 5B: AP view of the immediate postoperative CWO knee, showing a rupture of the lateral hinge. Fig 5D: AP view of the knee 1 month postoperative showing disassembly of the screwed plate part of the implant. Fig 5E: AP view of the knee in the immediate post-operative period of revision of the CWO. Fig 5F: consolidation at 4 months post revision with exuberant callus, and loss of varus correction

No case of pseudarthrosis was observed. During the study period, no conversion of CWO into total knee prosthesis was recorded. At the last follow-up, there was an improvement in the joint space. The following series of postoperative radiographic images (figures 3 and 4) illustrates the results of 2 cases of osteotomy.

DISCUSSION

The indication of osteotomy for the treatment of gonarthrosis is increasingly practiced due to the great improvement in its long-term results. In addition, it has the great advantage of not being a substitute procedure for knee arthroplasty, which is more relevant in young patients. Realignment osteotomies are reserved for young and active subjects with isolated unicompartmental osteoarthritis. The contraindications being an overlying pathology of the hip, an associated osteoarthritis of the internal compartment, an age greater than 65 years and a subluxation of the knee.[8] The technique used in this study has the advantage of not requiring a compass as in external opening varus femoral osteotomy. This is justified by the fact that when the blade is parallel to the tangent of the condyles and the plate is parallel to the internal cortex of the femur, the femoral axis is between 0 and 2° varus [9]. With an average follow-up of nearly 4 years in our series, there was an overall improvement in functional data. Mean IKS scores increased by 39.6; 17.2 and 56.8 points respectively for knee, function and global IKS. Authors have reported improvements in knee function scores following internal CWO, ranging on average from 20 to 40 points.[10] We obtained 86% of good and excellent results and 85% of our patients were satisfied with the final functional result, in particular the improvement of pain and the axis of the limb. Healy [11] found 93% good results with a follow-up of 5 years. In the literature, OFVs by internal subtraction classically give good results and this with a fairly high survival rate. This survival rate is assessed by several authors as the duration of non-use of total knee prosthesis. For Sternheim[12] it is 89.9% at 10 years, 78.9% at 15 years in a series of 45

patients. In a systematic review, Chahla[13] showed that at 4 years of follow-up, this rate varied from 83% to 92%. In our work, we noted a survival rate of 100%. In our series, the correction target was to obtain a varus of 0 to 4° because beyond that, the work of Mathews and Coventry[14] showed that there is an overcorrection responsible for a rapid degradation of the result. In our work, the mean angle correction was $16.2^\circ \pm 5.3^\circ$. Measurement of the average postoperative mechanical femoro-tibial angle reported a varus of $0^\circ \pm 2.4^\circ$. This result was similar to those of Backstein[15] and Learmonth[16] who found, in the 1990s, postoperative femoro-tibial angles of 1.2° and 0° varus respectively, with fixation made by 90° plate blades. More recently in 2020, Barnavon[17] found after an average correction of $11.1^\circ \pm 3.9^\circ$, an average mechanical femoro-tibial angle of 2.7° varus. In this study, radiographic consolidation was achieved on average at 4.3 months. This average was similar to those found by Omid-Kashani et al [18] of months and by Wang and Hsu [19] of 4.7 months. In these last studies, the same technique and the same implant as that of our work were used.

Complications of CWO were found in this study, with the first rank being delayed union in 9 cases out of 21 (42.8%), union between the 4th and 6th month. Delayed consolidation is a complication of femoral osteotomy which is much more frequent in external opening.[20] Nevertheless, it has been described in CWO with internal subtraction by certain authors such as Edgerton[21] who found a 25% rate of delayed union that progressed to pseudarthrosis. In Mathews' series[14] carried out on 21 patients, he found a rate of 19%. Compared to the results of the two previous authors, the significant rate of delayed consolidation in our series can be explained by the duration of the proscriptio of the support of the operated limb of 12 weeks. This duration was shortened to 8 weeks in the rehabilitation phase of the operated knee of their patients. Although CWO provides bone-to-bone apposition that promotes union, insufficient compression of the osteotomy site may predispose to delayed union. For this, Túrco[22] proposes the use of a locking plate for fixation of CWO to avoid this complication. Furthermore,

Stoffef[23] adds that unlike the tibia, the femur has a longer lever arm with more rotational forces acting on it distally, creating twisting micro-movements that slow bone healing when fixed with a plate blade. Also, to fight against this delay, they proposed a new design of locking screw plates which would provide fixation of the distal femoral osteotomy with compression and greater axial stability to neutralize torsional stresses.

Rupture of the lateral cortex was the second most important complication found in 8 cases out of 21. In no case was it articular. It has been described in the literature as having multifactorial causes. The anatomy and transition between the cortical and cancellous bone in the distal femur involve several biomechanical considerations that must be taken into account by the surgeon who is indicating a CWO of the distal femur in adults. There is a different capacity for plastic deformation on the one hand and on the other hand a difference in bone geometry between the supra-condylar area and the lateral condyle.[24] In addition, the biomechanical properties of the diaphysis and the metaphysis differ according to the cortical and trabecular configuration of the bone.[25] In 2001, Surer[26] described a peak point of the cutting angle in the CWO located 5 mm inside and above the metaphyseal-diaphyseal junction of the distal femur. According to his work, the apex of the cut should not be at or outside the medial edge of the distal femur. What would predispose to a rupture of the lateral cortex. In 2019, based on a comparative study on fresh cadavers, Nha[27] sought the ideal situation of the apex point of the CWO cutting angle, which would prevent a rupture of the lateral cortex. He observed that when the latter was above the epicondylar line, the occurrence of a lateral cortical fracture was statistically more significant. It recommended that the medial closure wedge osteotomy be performed more obliquely distal to the condyle rather than parallel to the supra-condylar area.

Loss of correction is more often encountered in OFV by external opening when a corticocancellous allograft is not used before fixation, as shown by the works of Madeleine[28] and those of Cameron[29]. In the latter, the losses of correction were respectively 10%, 7% and 4%. All the same, the loss of correction has also been noted by authors after performing a medial CWO. Forkel[30] meanwhile found a loss of correction in 1 out of 23 cases.

CONCLUSION

In valgus knee osteoarthritis, varus femoral osteotomy by medial closing wedge osteotomy fixed with a 90° blade-plate is a surgical method that provides a good degree of satisfaction and significant restoration of knee function. Properly performed, it re-aligns the limb, balances femoro-tibial mechanical stresses and slows the progression of cartilage degeneration. Its impact on the restoration of a painless and functional knee, evaluated by the improvement of the functional scores of the knee, has been sufficiently demonstrated. Its high survival rate makes it possible to reduce the time required for a total knee arthroplasty; which is a particular advantage in countries with limited resources where the cost of prosthetic surgery is still quite expensive.

Limits

This work has some limitations, namely the low number of files (less than 30) due to the significant number of incomplete and lost files. The patients were operated on by at least 3 senior surgeons in the department; which can lead to significant differences due to interindividual variability in the performance of the intervention.

Conflict of interests

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