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Medial Epicondyle Osteotomy for Balancing Severe Varus Knee

Gabriel Stan

Abstract

Varus malalignment is the most common deformity leading to total knee arthroplasty (TKA) for knee arthritis. For correcting this deformity, a stepwise approach is used by surgeons during TKA. When a severe varus malalignment is present, there are some concerns regarding balancing procedure, meaning that aggressive release of medial structures could lead to instability and need for a more constrained implant. In this chapter, the results of an unconventional method for balancing severe varus malalignment are shown. This method is medial epicondyle osteotomy (MEO). For this reason, a total of 135 knees with severe varus deformity were studied. In 65 cases, the MEO technique was used for balancing during TKA. The other 70 cases were balanced using additional resection of medial tibial plateau. Clinical and radiological outcomes were measured before and after surgery for both groups. Also the results were compared to a control group consisting of 50 patients with TKA for varus deformity less than 15 degrees. The amount of resected tibial bone was noted for study groups. Range of motion, the Knee Society Score (KSS), frontal laxity, and correction of femoro-tibial angle were studied. Frontal laxity decreased from $12.81^\circ \pm 3.9^\circ$ to $0.37^\circ \pm 1.2^\circ$ ($P < 0.001$). The results showed no statistically significant differences between groups regarding the KSS, range of motion, femoro-tibial angle, and frontal laxity. The amount of resected tibial bone and the mean thickness of the polyethylene insert were statistically significantly smaller in the MEO group. MEO technique could be useful when treating severe varus arthritis knee during TKA by avoiding aggressive medial release and malalignment. Also the bone stock is preserved.

Keywords: medial epicondyle osteotomy , knee varus deformity, total knee arthroplasty, prosthetic outcomes, survivorship

1. Introduction

Total knee arthroplasty is a common surgical procedure for the end stage of knee arthritis, providing long-term pain relief and patient satisfaction. Although many studies have measured the success of knee arthroplasty in terms of survival, another important aspect of TKA is its functional outcome; that is, postoperatively, patients should be free of pain and able to perform daily activities such as standing, walking, and stair-climbing.

The varus knee is the most common deformity that requires total knee arthroplasty. Malalignment affects articular hyaline cartilage, menisci, subchondral bone, and ligaments, and contributes to progression of osteoarthritis (OA). When varus

alignment is present, the forces passing the knee are unequally distributed between condyles with an increased load passing through medial condyle due to an increase of the adduction moment during gait [1].

Anatomical changes are present in varus knee as a result of deforming forces. According to Puthumanapully, some reference axes and surface features are significantly different to normal knees [2]. For the femur, he found less femoral anteversion in varus knees. In the tibia, the tubercle (and tibial tubercle axis) was externally rotated and there was a medial tilt of the tibial plateau in the coronal plane. The coronal slope was found to be significantly more ($P = 0.001$) in varus knees (3.5°) when compared to normal knees (0°), indicating that the slope contributes to the varus deformity. Normal femoral version has been reported to be varied between 10° and 20° [3]. Retroversion or decreasing femoral anteversion is associated with external rotation of the knee and varus deformity contributing to the development of OA in adults [4]. Authors like Bretin and Papaioannou showed that loads shift from center to medial compartment when external femoral malrotation is present [5, 6].

OA also affects the anatomy of superficial medial collateral ligament (MCL), which is the main structure providing medial stability. These changes are secondary to fibrosis of the posteromedial complex, to impingement of marginal osteophytes, and to extrusion of the medial meniscus. According to Haidar, there is no shortening of the MCL in knee OA. There are deforming structures such as the oblique ligament with adhesion and thickening of posteromedial corner structures. Those changes are supposed to cause a posterior bowing to the superficial MCL without an actual shortening of the ligament. The scarring tissue in the posteromedial corner and the adhesion act as a soft phyte tensioning and deform the ligament and the posterior capsule [7].

Ignorance, fear of surgery, access to alternative and traditional medicine, and the high costs of treatment are among main reasons that contribute to late presentation for treatment. Factors like age of the patients, level of activity or disease progression have been discussed when deciding to choose methods of treatment in knee osteoarthritis (OA). Financial aid is a leading factor in decision-making of treating OA. Conservative treatment in knee osteoarthritis is also expensive because it fails to correct the malalignment and abnormal joint loading. The disease will progress and the TKA will be the optimal solution for treatment. Severe preoperative deformities have long been a challenge for surgeons performing total knee arthroplasty.

Limb alignment and proper soft tissue balance are the main factors that influence long-term results of TKA in terms of survivorship. What kind of alignment should be obtained, anatomical, mechanical, or kinematic, is still a matter of debate, but everyone agrees that a balanced prosthetic knee will provide better results. Most of the authors state that the mechanical alignment provides the best chances in terms of survivorship of TKA. Mechanical alignment means that femoral cut is perpendicular to the mechanical axis of the femur and tibial cut is perpendicular to the mechanical axis of the tibia [8].

Technical flows are challenging for surgeons no matter the surgical strategy. A part of this issue is represented by the instruments' errors. The accuracy of obtaining the desired angle of femoral distal cut is dependent on the ability to actually engage the intramedullary rod in the medullary canal respect the anatomic axis of the femur. This maneuver is influenced by the rod length and diameter and the intramedullary diameter of the femoral canal. The location of the entry hole also could have an impact upon alignment. Do to this, the surgeon must be aware that even if he/she is aiming for a mechanical alignment, for example, the instruments and placement of the entry holes could lead to errors. Alignment is critical to load transfer, both at the articular surface and at the implant-host interface, and hence essential for the success of total knee replacement (TKA). Most of the early failures

of TKAs are related to technical flaws. Valgus or varus malpositioning of the tibial component of a total knee implant may cause increased propensity for loosening or implant wear and they may eventually lead to revision surgery [9]. Experimental and clinical data indicate that, in order to achieve optimal mid-term and long-term results of a TKR, good alignment in the frontal plane of the lower limb is mandatory.

Releasing the superficial MCL can sometimes lead to a major instability of the knee and other surgical methods should be assessed for balancing the prosthetic knee in cases of severe varus deformity when aggressive MCL release is expected. A severe varus deformity (more than 15 degrees) is a challenge in terms of the type and extent of release required. More constrained types of implants may be needed if the MCL cannot be trusted.

A balanced knee must be the goal of every TKA because this will increase the chances for a better survivorship [10–13]. When malalignment is present, some parts of the soft tissue around the knee are contracted and must be released, thus leading to correction of the deformity [14, 15].

When severe varus deformity is present, medial structures become fibrous. Among the methods used to correct severe varus deformity, the most common are subperiosteal release of the superficial medial collateral ligament and joint line release of the medial collateral ligament. Some other methods like medial epicondyle osteotomy (MEO) and tibial reduction osteotomy are less used due to concerns regarding survivorship [16].

For this study, we used the medial epicondyle osteotomy technique because we believe that this method will allow early recovery, bone stock preservation, and a good overall alignment of the limb as we will show later in this chapter. Some authors also used the MEO technique in the past, but their method involves subsequently reattaching the medial epicondyle with screws, sutures, or anchors in an optimal position for balancing the prosthetic knee, which will not allow early rehabilitation after surgery. We did not reattach this fragment and early rehabilitation program was started. The goal of our study was to underline the results of TKA after using MEO as a balancing method for severe varus deformity. The results were compared with those of TKA after using additional resection of the tibial medial plateau to correct this deformity and to those of TKA for varus deformity less than 15 degrees when standard measures were used for balancing.

2. Materials and methods

Between April 2006 and April 2017, we performed 135 TKAs on patients with severe preoperative varus (of more than 15°). The control group included 50 patients with TKA for preoperative varus less than 15°. In 65 cases (40 female and 25 men), the MEO technique was used, and in 70 cases (45 female and 25 men), additional resection of the tibial medial plateau. The mean age at the time of the TKA in MEO group was 68.6; mean height, 1.72 m; and mean weight, 76 kg. In the resection group, the mean age was 65.4 years; mean height, 1.77 m; and mean weight, 76.9 kg. In the control group, there were 30 female and 20 male patients; mean age was 62.5; mean height was 1.71 m; and mean weight was 76 kg.

Patients with preoperative valgus and secondary OA to trauma or inflammatory diseases were not included in the study. All surgeries were performed by the same main surgeon, using the medial-parapatellar and subvastus approaches. The same type of cemented postero-stabilized knee prosthesis was implanted in all cases (Zimmer Nexgen).

No full weight bearing X Ray films were available for this study, so the distal femoral cut was performed at 5° of valgus relative to the anatomical axis of the

femur, using an intramedullary rod. The tibial cut was perpendicular to the tibial mechanical axis, also using an intramedullary guide. A 3° femoral external rotation was set in almost every case. Rotation of the femoral component was decided using Whiteside's line, transepicondylar axis, and posterior condylar reference. A combined anterior and posterior referencing was used for sizing of femur.

All patients underwent stepwise sequential medial soft tissue release consisting of deep MCL, posteromedial release, superficial MCL, and pes anserinus. All the osteophytes were removed. Bony defects were managed with the cement or structural bone grafts and screws. No stem extenders were used. For the control group, no further measures were necessary to balance the prosthetic knee.

For both study groups, these steps were insufficient for balancing the knee and therefore further action was necessary.

In the first group, the surgeon performed a medial epicondyle osteotomy, containing the insertion of the MCL, starting with a saw-blade and finishing with an osteotome (**Figure 1**). Then, a valgus stress was applied lowering the epicondyle to its new position. The inferior margin of the epicondyle was cut with a rongeur for not interfering with the articular part of the implant during movements. No fixation method was used for the epicondyle. The flexion and extension gaps were assessed for balance.

In the second group, as the medial compartment was still tight in extension and flexion, the surgeon performed a secondary asymmetrical tibial coronal recut using the specific instrument and removed an extra 2 mm of bone from the medial tibial plateau (**Figure 2**). Thus proceeding, the extension and flexion gaps were equal and the knee was balanced.

For all cases, the patella was resurfaced and no tourniquet was used. Rehabilitation started immediately after surgery, with alternative positioning of the knee in flexion-extension. On day 1 after surgery, all patients started active motion of the operated knee with flexion-extension exercises. Full weight bearing was allowed from day 1, using no brace for protection. No passive motion device was needed. Postoperative follow-up was scheduled 6 weeks, 3 months, 6 months, and 1 year after the surgery, and once per year afterward. The mean follow-up for the study was 7 years (± 3).



Figure 1.
Medial epicondyle osteotomy with TKA.

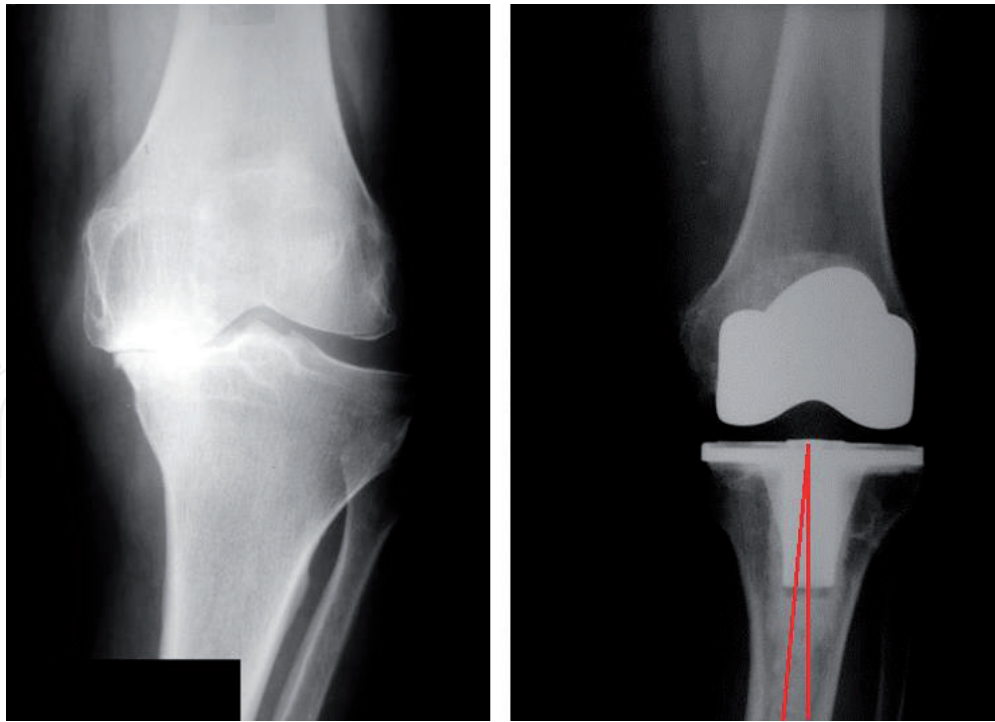


Figure 2.
 Additional medial tibial resection (note the varus malposition of tibial component).

The main inclusion criterion for the study group was preoperative varus deformity greater than 15° . The outcomes were measured: Knee Society score (KSS), the range of the motion (ROM), clinical frontal laxity of the knee, femoro-tibial angle, the mean thickness of the polyethylene insert, the amount of resected tibial medial plateau bone, and the union state of the osteotomy site. The amount of resected tibial medial plateau bone was defined as the difference between preoperative and postoperative distance from a perpendicular to the axis of tibia through the peroneal head and a perpendicular to the same axis through the lowermost point of the tibial medial plateau in anteroposterior Rx incidence. The choice of surgical technique was random and we did not use any criteria for performing one or other in this study, but we selected the patients who had a preoperative varus deformity greater than 15° .

Statistical tests were performed using SPSS software. Paired Samples Test was used to compare the results. The 0.05 level was used to denote statistical significance throughout testing.

3. Results

There were no statistically significant differences regarding personal characteristics (age, sex, height, and weight) between the two groups and the control group. No differences were noted regarding postoperative outcomes of KSS, range of motion, femoro-tibial angle, and frontal laxity.

The results are summarized in **Table 1**.

We observed a significant statistical difference regarding positioning of tibial component between groups. The mean angle between tibial component and tibial mechanical axis was $1^\circ \pm 3.5^\circ$ of varus for the MEO group, and $4^\circ \pm 2.5^\circ$ of varus for the resection group ($P < 0.001$). In the control group, the angle was $0.7^\circ \pm 2.3^\circ$.

The mean thickness of the polyethylene insert was 12.5 ± 1.24 mm in the MEO group and 13.61 ± 1.59 mm in the second group, with statistically significant $P = 0.005$.

Group		KSS	ROM	F-T angle	Frontal laxity
MEO	Preop.	18.15 ± 15.6	72.3° ± 23.5°	25.3° ± 5.51° varus	12.43° ± 3.5°
	Postop.	94.1 ± 5.6	112.3° ± 10.8°	4.0° ± 1.18° valgus	0.32° ± 1.3°
Resection	Preop.	21.44 ± 13.6	86.8° ± 15.5°	24.7° ± 5.1° varus	12.81° ± 3.9°
	Postop.	91.7 ± 7.6	115.4° ± 8.4°	4.1° ± 0.97° valgus	0.37° ± 1.2°
Control	Preop.	25.15 ± 12.1	76.4° ± 24.3°	15.6° ± 7.41° varus	8.81° ± 2.8°
	Postop.	96.3 ± 5.6	118.3° ± 9.7°	2.0° ± 1.2° valgus	1.34° ± 1.2°

Table 1.
Results after TKA for the study groups.

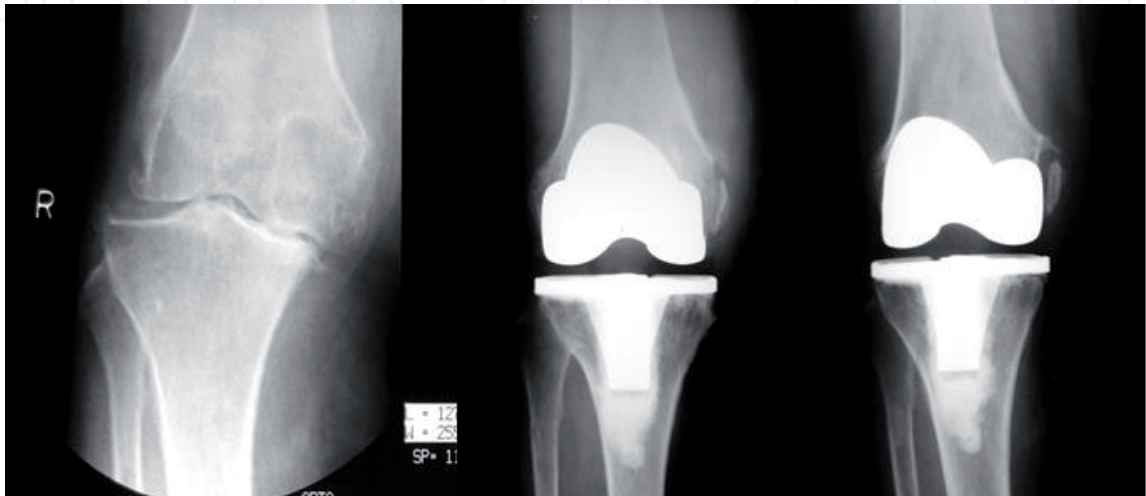


Figure 3.
Medial epicondyle osteotomy Rx (3 months and 5 years follow up).

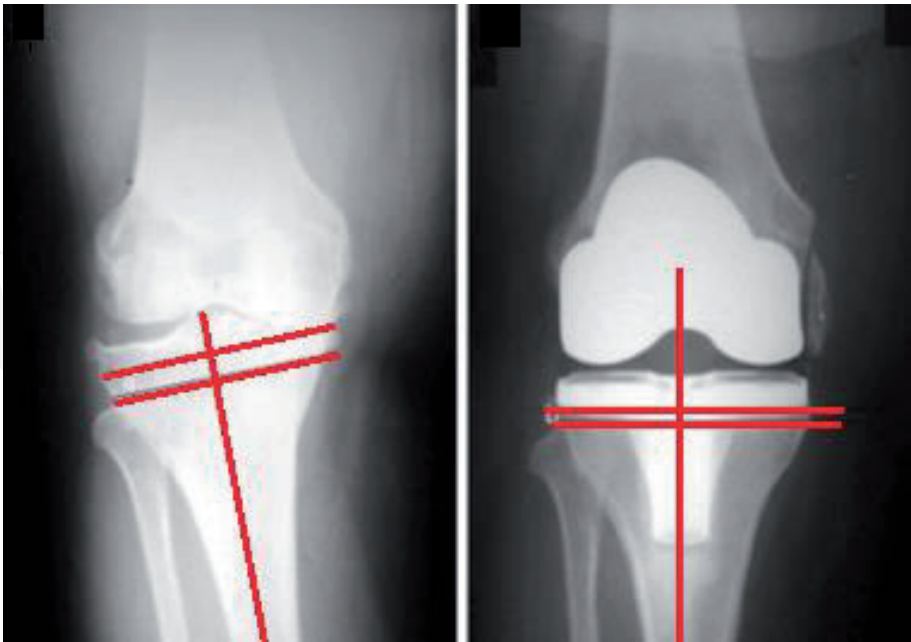


Figure 4.
The amount of tibial medial plateau resected bone- MEO.

For all knees with medial epicondyle osteotomy, a fibrous union occurred at the site of osteotomy (**Figure 3**). In this group, the amount of resected tibial medial plateau bone (**Figures 4 and 5**) was statistically significantly smaller than in the other group (1.33 ± 0.46 mm in the MEO group and 3.73 ± 2.5 mm in the other group; $P < 0,001$).

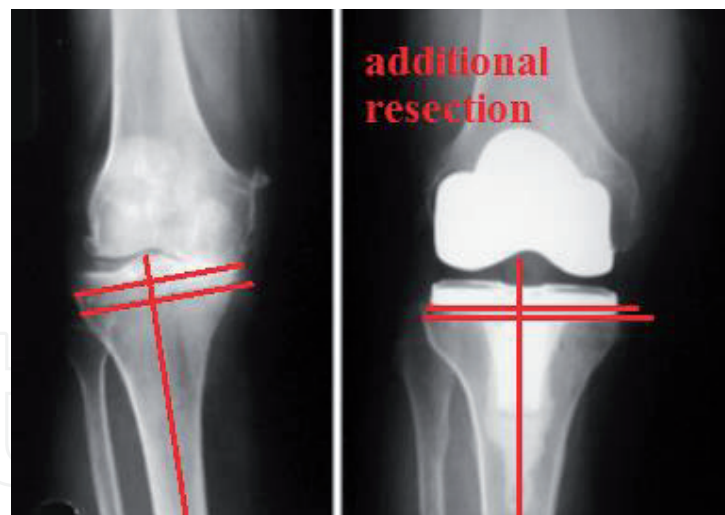


Figure 5.
 The amount of tibial medial plateau resected bone (an additional resection of tibial medial plateau case).

Residual frontal laxity was present in four cases, two in the MEO group and two in the second one. No revision surgery was necessary for any of the cases at the last follow-up.

4. Discussion

The varus knee is the most common deformity that requires total knee arthroplasty. Severe varus deformity grossly affects normal anatomy of the knee, meaning that bone and soft tissue are affected by the disease.

For better survivorship of a knee implant, it is mandatory to achieve a proper alignment and a perfect balance of total knee prosthesis. It is a great challenge for surgeons to balance a severe varus knee due to changes in the anatomy of medial compartment. Fibrosis of the posteromedial complex, marginal osteophytes, extrusion of the medial meniscus, adhesion and thickening of the oblique ligament with all the posterior medial complex, and posterior bowing to the superficial MCL are problems that must be corrected during surgery. MCL release is very important in balancing the fixed varus deformity. The surgeon must progressively release the medial soft tissue until it reaches the length of lateral structures. The endpoint of the release is when the knee is stable and the alignment is optimal. In severe varus deformity, the separation of the periosteal layer from the tibia is distal to the MCL attachment. For this reason, some authors raised concerns about the integrity of the MCL after aggressive release. Releasing the superficial MCL can sometimes lead to a major instability of the knee, requiring a more constrained implant [7]. Our method of medial epicondyle osteotomy for severe varus deformity could prevent this problem.

There are few literature reports that describe MEO as a method of balancing the prosthetic knee. Engh has described his results after medial epicondyle osteotomy during TKA. He performed this procedure on 80 patients [16]. The clinical results showed the KSS improvement from 42 to 93 points after surgery and the range of motion increase from 101 to 111 degrees. He has found no instability in his patients group during the follow-up period. Regarding frontal laxity, the mean varus-valgus stability measured 14.2 points (Knee Society scale, 0–15 points). Improvement of function and patient satisfaction was found in 95% of the cases. In every case of his study, the osteotomized epicondyle was fixed during surgery at the optimal position for balance. Despite this, bone union occurred only in 54% of the knees and

fibrous union occurred in 46%. No symptoms like tenderness, restricted motion, or other were associated with fibrous union. Other authors like Sim and Kwak reported their results after using medial epicondylar osteotomy for treating varus deformity in 32 cases [17]. Clinical and radiological outcomes, including the Knee Society score (KSS), the function score (FS), the range of the motion (ROM), the union state of the osteotomy site, were measured. They found an improvement of KSS after surgery from 46.5 ± 7.6 to 89.1 ± 5.9 points ($P < 0.001$). The FS increased from 39.5 ± 9.2 to 84.2 ± 8.5 points ($P < 0.001$). Also the range of motion was better after the surgery ($101.5^\circ \pm 28.2^\circ$ to $116.0^\circ \pm 10.8^\circ$; $P = 0.006$). A significant number of patients presented fibrous union on the osteotomy site despite the fixation of the condyle during procedure (10 patients). Bone union occurred only in 22 knees. There was no significant difference regarding clinical outcomes between the bone union group and the fibrous union group ($P = 0.175$). The femoro-tibial angle was corrected from an $8.2^\circ \pm 5.0^\circ$ -varus to a $5.6^\circ \pm 1.5^\circ$ -valgus ($P < 0.001$). Despite the fact that in both studies the epicondyle was fixed with sutures or screws, a major part of the patients presented fibrous union of the epicondyle. The authors concluded that there was no significant difference between the bone union group and the fibrous union group. We do not consider that any reattachment of the epicondyle is necessary, and in consequence, we did not perform fixation in any of the cases. Also no splinting after the surgery was used and the rehab program was started immediately, avoiding knee stiffness and accelerating recovery.

Nobody could tell for sure the ideal positioning of the knee prosthetic components. The disagreement among surgeons is amplified by the significant number of unsatisfied patients with TKA.

Most of the authors state that mechanical alignment provides the best chances in terms of survivorship of TKA. Mechanical alignment means that femoral cut is perpendicular to the mechanical axis of the femur and tibial cut is perpendicular to the mechanical axis of the tibia. If mechanical alignment is achieved, it means that mechanical axis of the leg passes through the center of the knee and the loads are equally distributed between medial and lateral compartments. The native knee interline is inclined about 3 degrees in varus, meaning that the mechanical alignment will change it to 0 degrees, changing the normal anatomy of the knee. The proximal tibial joint line is therefore converted from 87 degrees (3 degrees of varus) to 90 degrees and the distal femoral line from 87 degrees (3 degrees of valgus) to 90 degrees.

For these considerations, some authors proposed the so-called “anatomic alignment” when the tibial component was placed at 3 degrees of varus and the femoral component at 3 degrees of valgus, and overall alignment to be neutral [18]. There is an important variability in natural alignment among population. A significant part of neutral alignment is not normal, leading to distalization of the joint line on the lateral compartment, which can cause anterior knee pain. The concept of restoring constitutional alignment rather than mechanical has gained more interest recently. For the supplementary tibial resection group in our study, we have created the situation of placing the tibial component in varus. In case of a medio-lateral tibial plateau length of 8 cm, an additional resection of 2 mm from medial side lead to a maximum 3 degrees of varus positioning of tibial implant. Attention should be paid in cases where this additional cut adds to a previous unknown error of first cuts due to the instrument's or surgeon's mistake, and this could lead to a supplemental varus, and potential danger in terms of survivorship.

Other authors showed that a femoral component placed in 7° valgus, with tibial plateau placed at 90° to the long axis of the tibia, provides equal force distribution between the medial and lateral plateaus and consecutively best chances for

survivorship [19]. According to Howell, kinematically aligning the knee means coaligning the transverse axis of the femoral component with the primary transverse axis in the femur about which the tibia flexes and extends and placing the tibial component so that the longitudinal axis of the tibia is perpendicular to the transverse axis in the femur, about which the tibia flexes and extends [20]. This means that the femoral cut is plus 1°–2° in valgus and tibial cut, plus 1°–2° in varus compared with the mechanically aligned total knee arthroplasty [21]. The authors who propose this approach state that restoring mechanical alignment is unnatural in patients with constitutional varus and valgus alignment and could cause higher strain in collateral ligaments [22]. They say that by restoring the native alignment, patients will have better clinical and functional outcome scores as compared with patients in whom the limb alignment is corrected to neutral [23]. The present general consensus is that overall mechanical femoro-tibial alignment should be 0 ± 3 degrees, thus providing the best survivorship chances for the knee implant [24]. No matter of the technique used for TKA, the next important problem for surgeons are technical flows. The accuracy of obtaining the desired angle of femoral distal cut is dependent on the ability to actually engage the intramedullary rod in the medullary canal to be in line with anatomical axis of the femur. This maneuver is influenced by the rod length and diameter and the intramedullary diameter of the femoral canal. The location of the entry hole also could have an impact upon alignment. Do to this, the surgeon must be aware that even if he/she is aiming for a mechanical alignment, for example, the instruments and placement of the entry holes could lead to errors. Regarding tibial component alignment, we observed a significant difference between groups. For the MEO group, the alignment was neutral ($1^\circ \pm 3.5^\circ$) and in the resection group, the alignment was mainly in varus ($4^\circ \pm 2.5^\circ$). In 90% of MEO group cases, the tibial component is placed in line with mechanical axis. Only 5% of the knees from the second group present 90° tibial component placement. The vast majority of them are outliers due to additional asymmetric tibial varus cut. The MEO is a method that increases chances for a mechanical alignment of the prosthetic knee.

5. Conclusion

Based on our results, we suggest that the outcomes of TKA with MEO are similar to those with additional resection of the tibial medial plateau and to those from the control group. No revision surgery was needed at the last follow-up in any of the cases.

Some advantages of medial epicondyle osteotomy have resulted from this study. First of all, it avoids excessive weakening of the medial collateral ligament in cases of severe contracture of medial structures by lowering the epicondyle instead of aggressive releasing of the ligament. This will prevent also the need for a more constrained implant. The exposure during surgery is much easier and avoids complications like extensor mechanism disruption. It is a technique that provides optimal conditions for obtaining neutral overall alignment of the limb, minimizing the risk of malpositioning the tibial component, which is higher in cases of additional tibial resection. The tibial bone loss is less than that in additional resection group which is better for revision surgery.

This study highlights early and mid-term results of TKA with medial epicondyle osteotomy. Further analyses are necessary to assess the long-term results of this technique, especially in terms of survivorship. So far, there are no differences between groups regarding patient satisfaction, range of motion, or survivorship.

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