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Total knee arthroplasty in severe valgus knee deformity: comparison of a standard medial parapatellar approach combined with tibial tubercle osteotomy

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Abstract
Purpose Primary TKA in valgus knees with a deformity of more than ten degrees may prove challenging, since bone and soft tissue abnormalities make accurate axis restoration, component orientation and joint stability attainment a difficult task. The purpose of this study was to determine which approach is optimal in these patients, by comparing the standard medial parapatellar approach to a lateral parapatellar combined with a tibial tubercle osteotomy (TTO).
Methods Forty-four valgus knees—with an axis deviation ranging from 15 to 36 degrees (mean 24°)—were dealt with primary TKA and followed up for a minimum period of 7 years. Lateral parapatellar arthrotomy combined with TTO was performed in 22 individuals (Group A) and a standard medial parapatellar capsulotomy in the remaining patients (Group B). The International Knee Society System Score (IKSS) was used for clinical evaluation. Radiological assessment was performed yearly postoperatively using long films for assessment of the anatomical axis.
Results The postoperative IKSS scores showed no significant statistical difference between groups A and B ($P < 0.05$). In the alignment parameter, however, residual valgus deviation occurred in 9% of patients from Group A and in 32% from Group B. No late-onset instability was displayed.
Conclusion Lateral parapatellar approach combined with TTO may prove highly beneficial in significant valgus deformities, as the anatomical axis is restored accurately and soft tissue release of the lateral contracted structures facilitated to an important extent.
Level of evidence I.

Keywords Valgus knee · Total knee arthroplasty · Lateral approach · Medial parapatellar capsulotomy · Tibial tubercle osteotomy

Introduction

A proportion of 10–15% of patients requiring a primary total knee arthroplasty (TKA) present with a valgus deformity (VD), the accurate correction of which poses a technical challenge [34]. Severe varus deformities are associated with a better outcome when compared with their valgus counterparts [19]. In the latter, most of the osseous defects are located on the lateral femoral condyle, whereas the tibial plateau is usually less affected [8, 10, 28, 30, 37].

Three grades of VD have been described [34]. In grade I, which accounts for 80% of all cases, the deviation is less than 10° and passively correctable, whereas the medial collateral ligament (MCL) is intact. Grade II occurs in 15% is characterized by an axis deviation ranging between 10° and 20°, whilst the MCL is elongated but functional. Grade III is seen in the remaining 5% and the axis deviation measures more than 20°. The medial stabilizing elements are not functional, and a constrained type of implant is often required [22, 34].

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Over the last 20 years, numerous approaches have been described [10, 20, 28, 29]. When using a conventional medial parapatellar capsulotomy in a valgus knee, the reported results have been inferior to those in significant varus knee deformities [2]. More precisely, the anatomical axis is accurately restored only in 22–30% of valgus knees dealt with a standard medial approach [19, 39]. Amongst the different factors that govern the long-term success of a TKA, restoration and maintenance of the anatomical axis is one of the most crucial [10, 28]. An inaccurate axis is related to impaired clinical outcome [35, 38]. However, when performing a lateral parapatellar capsulotomy, the results are more satisfactory in terms of both axis correction and clinical performance [4, 11, 21].

The purpose of this randomized controlled trial study was to evaluate the results of TKA in grades II and III valgus deformities, comparing a lateral parapatellar capsulotomy combined with a tibial tubercle osteotomy (TTO) versus a medial parapatellar capsulotomy, focusing especially on axis correction.

Materials and methods

Between 1995 and 2002, 379 primary TKAs were performed by the same surgeon. Fifty-six patients (15%) who had VD grades II and III (15°–36°) were included (see Table 1). Randomization computer assisted systems were utilized to select the patients that would undergo TKA with either a lateral parapatellar arthrotomy combined with a TTO (Group A) or with a medial parapatellar capsulotomy (Group B). Written informed consent for participation in the study was obtained. Based on the randomization procedure system, thirty patients underwent TKA via a lateral parapatellar capsulotomy and TTO and 26 underwent TKA with a medial parapatellar arthrotomy. In nine patients with a grade III deformity (6 of Group A and 3 of Group B), a constrained-hinged type of implant was used. These individuals were excluded from the study because the correction of the deformity relied more on implant properties rather than soft tissue balancing [13]. Other exclusion criteria included knees with active infection or neurovascular disorders, a VD of less than 10° and VD in revision TKA (see also Table 1).

Table 1 Total, excluded and remained number of patients having grade II and III valgus knees

Valgus knee grade II and III	Group A	Group B	Total
Initial no of patients	30	26	56
No of patients lost in follow-up (died)	2	1	3
No of constrained-hinged type TKA implanted (excluded)	6	3	9
No patients remained in the study	22	22	44

The remaining 47 individuals, 19 men and 28 women, with the median of their age being 75 years (range 57–81), were dealt with resurfacing TKA. Preoperative diagnosis was osteoarthritis in thirty-eight patients (81%) and rheumatoid disease in nine (19%). A posterior stabilizing prosthesis was used in 29 (62%) and a PCL retaining implant in 18 (38%) patients. The type of implants used up to 2000 was the Foundation (Encore Medical, Texas, USA) and after 2000 the Vanguard (Biomet Inc., Warsaw, USA). Three patients (2 of Group A and 1 of Group B) died of causes unrelated to the procedure during the first 2 years of follow-up. The remaining 44 patients were followed-up for a minimum of 7 years. The primary outcome measure was defined in 3 years and the secondary outcome measure in 7 years. Nevertheless, 76% of patients followed-up for more than 7 years and reached up to 15 years (Median = 12 years) (see also Table 2).

Preoperatively, every candidate was evaluated clinically for weight-bearing alignment, flexion contracture and ligamentous instability. This was further accompanied by preoperative radiological assessment, including standing anteroposterior, lateral and sunrise views of the affected knee, as well as measurement of the limb axis deviation with long-standing film views (15/22 of Group A, 16/22 of Group B) or CT-scan with anterior orientation of the patella. Postoperative radiological evaluation included views of the operated knee in accordance with anatomical axis deviation measurements based on the weight-bearing, long-standing film views or by CT-scan. By using an alidade, one of the authors—not involved in the index procedures—and one radiologist measured the valgus deformity pre- and postoperatively. Measurement accuracy was set to the closest integer. In Group A, the deformity ranged from 15° to 36° (Median = 23.5°); in Group B from 15° to 36° (Median = 25.5°). Fixed flexion deformity was present in seven knees out of Group A ranging from 5° to 22° (Median = 10°) and in 5 knees out of Group B ranging from 5° to 22° (Median = 8°) (see also Table 3).

All patients were assessed postoperatively at 1, 3, 5 and 7 years with the International Knee Society System Score (IKSS) [17]. Two of the authors not involved in the index procedures examined clinically postoperatively the patients and evaluated them based on IKSS score system. In cases of malalignment, extension lag or fixed flexion, certain points were deducted. Clinical and functional scores of ≥85 points were categorized as ‘excellent’, 70–84 points as ‘good’, 60–69 points as ‘fair’ and <60 points as ‘poor’. At the same time, radiological assessment was performed yearly postoperatively. At the time of the latest clinic follow-up, the tibial and femoral components were evaluated radiographically with use of the Knee Society

Table 2 Patients' demographic characteristics

Valgus knee grade II and III (no = 44)	Group A (no = 22)	Group B (no = 22)
Age (year)	59–81 (Median = 76.5)	57–80 (Median = 73)
Male:female	9:13	7:15
Right:left	13:9	10:12
Anatomical axis deviation (valgus)	15°–36° (Median = 23.5°)	15°–36° (Median = 25.5°)
Diagnosis		
Osteoarthritis	16 (73%)	19 (86%)
Rheumatoid arthritis	6 (27%)	3 (14%)
Type of resurfacing prothesis		
Posterior stabilized	15 (68%)	11 (50%)
PCL retaining	7 (32%)	11 (50%)
Follow-up (year)	At least 7 years	
	76% >7 years (Median = 12 years)	

roentgenographic evaluation system [9]. In addition to component positioning, each radiograph was evaluated—in a blind manner—by the same radiologist for the presence of osteolysis. This was defined as an expanding area of focal radiolucency measuring ≥1 cm in diameter. Any component with a circumferential radiolucency at the bone–cement or component–cement interface was considered to be loose [8]. Institutional Review Board ethics approval was gained prior to the control trial and review process [Asklepeion Voulas General Hospital (P.No. 41/12.01.1995)].

Surgical technique

Group A patients underwent a lateral parapatellar capsulotomy accompanied by a TTO measuring 5–6 cm. In order to medially displace the patella, the osteotomy was performed laterally. The tubercle was thus hinged medially offering wide exposure of the joint surface (Fig. 1).

Tibial resection was performed in a routine fashion, whereas the distal femoral cut was done in 3° of valgus in relation to the femoral axis. Both the AP axis of Whiteside and the epicondyle axis were used to assess and confirm the orientation of the femoral cut. In twelve knees, the posterior cruciate ligament (PCL) was sacrificed and a posterior stabilizing implant was used.

The tibial tuberosity was fixed back to its original position in twenty patients (91%). In two cases (9%), tibial tubercle transfer was deemed necessary, in order to obtain satisfactory patellar alignment and tracking. Fixation was done using at least two wire loops. In two individuals, tubercle fixation was achieved with two 4.5 mm cortical screws. None of the knees in Group A had their patellae resurfaced.

In Group B individuals, a standard medial parapatellar arthrotomy was done. In sixteen cases (73%), apart from the usual lateral soft tissue releases, the posterolateral corner was released from the distal part of the femur with the knee flexed using a curved osteotome or with the knee in full extension with the 'pie crust' technique. Accurate patella tracking was achieved in all cases. In fifteen patients, the PCL was resected and a posterior stabilizing prosthesis was implanted.

Group A patients were instructed to mobilize with the use walking aids for a minimum of 6 weeks as part of the postoperative physiotherapy protocol, or until there was evidence of radiological union of the osteotomized tuberosity. In Group B, the patients were allowed partial weight mobilization immediately, gradually achieving full weight bearing by 6 weeks.

Statistical analysis

Statistical analysis was performed using SPSS 17 (SPSS, Inc., Chicago, IL). Due to the sample size, non-parametric statistical tests were employed. The intra-group pre- and postoperative comparisons were conducted with the help of the Wilcoxon's signed rank test, whilst for the inter-group pre- and postoperative comparisons, the Mann–Whitney *U* test and Fisher's exact test were employed. Results were considered statistically significant at $P < 0.05$.

Results

Forty-four patients (22 for each group) were followed-up for a least time period of 7 years. For each group, preoperatively and postoperatively five measures were obtained: (a) the *IKSS score*, (b) the I*KSS functional score*, (c) the *maximum flexion* (range of movement; ROM), (d) the *mediolateral stability parameter* and (e) the *perceived pain* according to the *Visual Analogue Scale* (VAS). Moreover, based on the radiographic measurements, two additional postoperative measures were obtained: (f) the *anatomical*

Table 3 Preoperative and postoperative results in valgus knee grade II and III of Group A and Group B

Valgus knee grade II and III (no = 44)	Group A (no = 22)	Group B (no = 22)
IKSS		
Pre[a]	38.5 (31–52)[g]	38 (30–52)
Post[b]	89.5 (67–100)	89.5 (63–99)
Intra[c]	($z = -4.113$, $P < 0.001$, $r = -0.62$)[h,j]	($z = -4.113$, $P < 0.001$, $r = -0.63$)
Inter[d]		
Pre	ns ($U = 233.5$, $r = -0.03$)[i]	
Post	ns ($U = 216$, $r = -0.09$)	
IKSS functional		
Pre	37.5 (20–50)	37.5 (20–50)
Post	80 (55–90)	80 (50–90)
Intra	($z = -4.153$, $P < 0.001$, $r = -0.63$)	($z = -4.128$, $P < 0.001$, $r = -0.62$)
Inter		
Pre	ns ($U = 215.5$, $r = -0.01$)	
Post	ns ($U = 232.5$, $r = -0.03$)	
Maximum flexion (ROM)		
Pre	75° (60°–87°)	74° (65°–85°)
Post	110° (95°–125°)	112.5° (90°–125°)
Intra	($z = -4.126$, $P < 0.001$, $r = -0.62$)	($z = -4.133$, $P < 0.001$, $r = -0.62$)
Inter		
Pre	ns ($U = 183$, $r = -0.23$)	
Post	ns ($U = 232$, $r = -0.04$)	
Perceived pain (VAS)		
Pre	4 (3–5)	4 (3–5)
Post	9 (7–10)	9 (7–10)
Intra	($z = -4.145$, $P < 0.001$, $r = -0.63$)	($z = -4.164$, $P < 0.001$, $r = -0.63$)
Inter		
Pre	ns ($U = 236$, $r = -0.02$)	
Post	ns ($U = 226.5$, $r = -0.06$)	
Radiolucent lines		
Post	1 (0–3)	1 (0–3)
Inter	ns ($U = 210$, $r = -0.12$)	
Anatomical axis alignment		
Pre	23.5° (15°–36°)	25.5° (15°–36°)
Post	5° (3°–10°)	5.5° (3°–13°)
Intra	($z = -4.110$, $P < 0.001$, $r = -0.62$)	($z = -4.110$, $P < 0.001$, $r = -0.62$)
Inter		
Pre	ns ($U = 221$, $r = -0.07$)	
Post	ns ($U = 164.5$, $r = -0.28$)	
Valgus deformity		
Post	2 (9%)	7 (32%)
Inter		
Total no[e]	ns ($P = 0.132$; Fisher's exact test)	
Degree[f]	($U = 181$, $P < 0.05$, $r = -0.31$)	
Fixed flexion deformity		
Pre	10° (5°–22°)	8° (5°–22°)
Post (>5°)	None	None

Table 3 continued

Valgus knee grade II and III (no = 44)	Group A (no = 22)	Group B (no = 22)
Tibial tubercle transfer	No = 2 (9%)	None
Late-onset instability	None	None
Postoperative extension lag	None	None

[a] Preoperative results
[b] Postoperative results
[c] Intra-group comparisons
[d] Inter-group comparisons
[e] Total number of patients with deformity
[f] Degree of deformity (IKSS scoring system for alignment deformity)
[g] Median (range)
[h] (test employed, significance, effect)
[i] Not significant (test employed, effect)
[j] 'U' Mann–Whitney *U* test, '*z*' Wilcoxon's signed rank test

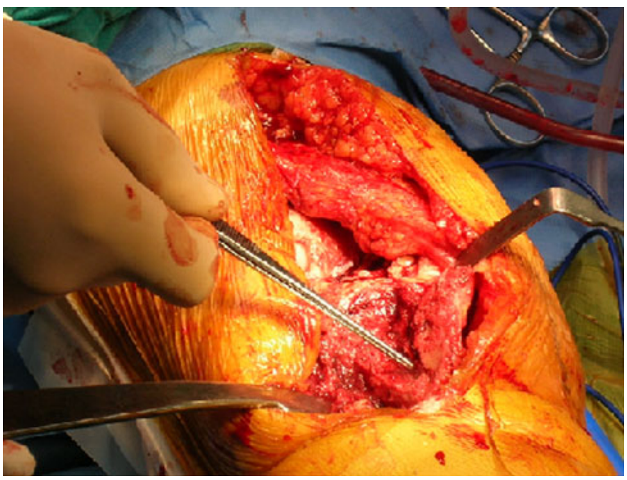

Fig. 1 Lateral side tibial tuberosity osteotomy

axis alignment and (g) the *periprothetic radiolucency*. The preoperative and postoperative clinical characteristics measured in this study of both Group A and Group B are summarized in Table 3.

Regarding the postoperative mediolateral stability parameter of Group A, 20 knees scored the highest rate (15 points; when <5°) and 2 knees scored 10 points (6°–9°) and there were no cases of late-onset instability (Fig. 2a, b, c). Moreover, two knees showed mild valgus deviation from the ideal range: the first deviated valgus 9° and the second 10° from the ideal range, thus scoring −6 and −9 points, respectively (−3 points for each degree exceeding the ideal range). Furthermore, radiolucent lines (≤1 mm) were detected predominantly in zones 1, 2 and 4 of the femoral component on the lateral views and in zones 1 and 4 of the tibial component on the AP views. At the primary outcome measure on the third follow-up year and at the secondary outcome measure follow-up time (7th year), in Group A, the patients' IKSS scores remained almost unchanged (<5%). Considering the patients' results, in Group A, 73% of the patients had 'excellent' results, 18% 'good' and 9% 'fair'. All tibial tubercle osteotomies united successfully. No femoral or tibial components radiolucencies were also noted in 82% of Group A at the latest outpatient follow-up. In the remaining 4 knees, non-progressive radiolucent lines of 1 mm or less were found in less than four zones on the anteroposterior and lateral views.

Regarding the postoperative mediolateral stability parameter of Group B, 16 knees scored 15 points (<5°) and 6 knees 10 points (6°–9°) and there were no cases of late-onset instability. Moreover, their VAS score ranged from 7 to 10 (Median = 9), while 7 knees deviated from 10° to 13° from the ideal range, thus scoring −9 to −15 points (these knees showed a fair clinical result). The detected radiolucent lines (≤1 mm) ranged from 0 to 3(Median = 1). Alike, radiolucent lines (≤1 mm) were detected predominantly in zones 1, 2 and 4 of the femoral component on the lateral views and in zones 1 and 4 of the tibial component on the AP views. Though at the primary outcome measure on the third follow-up year, the patients' IKSS scores remained almost unchanged (<5%), at the secondary outcome measure follow-up time (7th year) the scores of 3 patients in Group B showed deterioration (>5%). Considering the patients' results, in Group B, 64% of the patients had 'excellent' results, 23% 'good' and 13% 'fair'. In addition, no femoral or tibial components radiolucencies were noted in 77% of Group B, at the latest outpatient follow-up. In the remaining 5 knees of Group B, non-progressive radiolucent lines of 1 mm or less were found in less than four zones on the anteroposterior and lateral views.

Having identified the preoperative and postoperative characteristics of Group A and Group B, further analyses

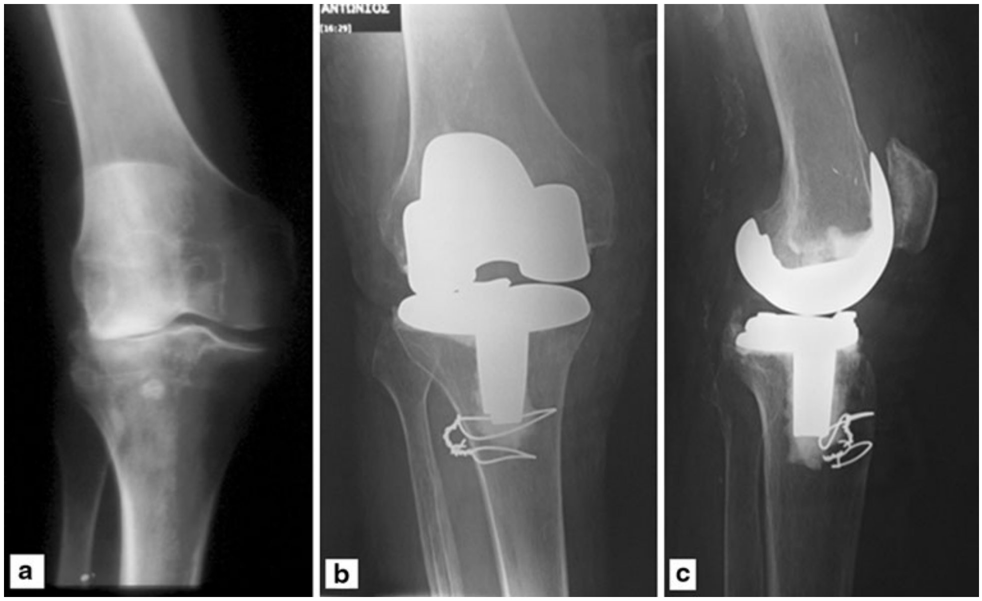

Fig. 2 Preoperative anteroposterior radiograph (**a**) and postoperative anteroposterior (**b**) and lateral (**c**) radiographs are shown

were conducted to compare and contrast the two Groups. First, *preoperatively*, the two groups did not statistically significantly differ in their IKSS score, IKSS functional score, maximum flexion and VAS score (see Table 3).

Subsequently, the *postoperative* characteristics at the secondary outcome of the two groups were compared (see Table 3). The results of the statistical analysis showed that the two groups did *not* statistically significantly differ in their IKSS score, IKSS functional score, maximum flexion and VAS score. Furthermore, *no* significant difference was found between the two Groups when radiolucent lines were compared. Additionally, there was *no* difference in the number of lucent lines in those patients with incomplete axis correction versus those with normal alignment. Though there was an observable difference between two methods regarding the absolute number of the knees with valgus deformity (9% vs. 32%, for respectively Group A and Group B), this difference was found *not* to be statistically significant. Nevertheless, the two techniques appear to statistically significantly differ *in the degree of the deformity* in the anatomical axis alignment (IKSS scoring system for alignment deformity; -3 points per degree), with the Group A patients suffering a significantly smaller degree of deformity (see Table 3).

Besides, focusing on the complications of the Group A patients, in one case, a 5 mm proximal migration of the osteotomized fragment occurred, due to breakage of one screw. However, this did not affect the final outcome. Another patient suffered from anterior tibial compartment syndrome and had to be taken to theatre. Another individual case suffered from patellofemoral maltracking.

Table 4 Postoperative complications in Groups A and B

Complications	Group A	Group B
Proximal migration of osteotomized tibial tubercle	1 (4%)	None
Deep venous thrombosis	1 (4%)	None
Superficial or deep infections	None	None
Haematomas, bruises, skin blisters	5 (23%)	3 (14%)
Irritation problems of the soft tissues	2 (9%)	None
Skin necrosis	None	None
Peroneal nerve palsy	None	None
Patellar dislocation	None	None
Tibial fracture	None	None

There were no superficial or deep infections in either Group. Moderate subcutaneous haematomas occurred in five individuals of Group A and in three of Group B. All healed uneventfully. There were only two cases that demonstrated irritation of the overlying soft tissues from the wire loops. In one of them, the wire loops had to be removed 14 months after the operation. Lastly, one individual of Group A suffered from a deep venous thrombosis, which was successfully treated without any deleterious effects to the final outcome. No patient required a revision TKA (see Table 4).

Discussion

The most important finding of the present study was that in the primary TKA of moderate to severe valgus deformity, the results of both surgical techniques were ‘excellent’ to ‘good’ in the same extent. More specifically, the ‘fair’ results were very low. In Group A was only 9% and in Group B 13%. Nevertheless, evaluating the residual valgus deviation, deformity was observed only in 9% of the patients treated with TTO, in contrast with the fact that deformity was found in almost one-third (32%) of the group treated with the medial approach. This difference was found *not* to be statistically significant, which might be due to the absence of a large series. However, the two techniques appear to statistically significantly differ *in the degree of the deformity* in the anatomical axis alignment (IKSS scoring system for alignment deformity; -3 points per degree), with the Group A patients suffering a significantly smaller degree of deformity (2 knees of Group A deviated valgus 9° and 10°, respectively from the ideal range; versus 7 knees of Group B deviated from 10° to 13° from the ideal range).

A lateral approach combined with TTO may prove highly beneficial in moderate to severe valgus knees. Anatomical axis is restored accurately. Furthermore, the lateral retinacular release is part of the procedure and the blood supply to the extensor mechanism is not significantly affected.

In the last 25 years, a number of different surgical techniques have been proposed [2, 8, 14–16, 21, 25, 29, 34, 39, 42]. In 1979, Insall described a soft tissue balancing technique [16] in which the ITB was divided transversely above the joint line, while the LCL and popliteus were detached from the lateral femoral condyle [8, 16]. Whiteside recommended sequential releases of the ITB, popliteus, LCL and the lateral head of gastrocnemius [42]. The same author also performed tibial tubercle transfer when the Q angle was greater than twenty degrees. Furthermore, Buechel [3], Fiddian [11] and Keblish [21] suggested a lateral capsular approach. Healy [14] and Krackow [22, 23] recommended medial soft tissue advancement combined with lateral release.

In order to achieve soft tissue stability when dealing with a valgus deformity, proper bony alignment and ligament balancing are critical [20, 27, 30]. A slightly more varus result has been suggested to counteract any tendency of the joint to shift back into its original position [27]. In a twenty-year follow-up study, Miyasaka demonstrated successful bony alignment in 75% of cases, achieving a postoperative range between 2° and 7° of valgus [27].

There is no consensus regarding the sequence in which the lateral elements should be released. The ‘inside-out’ or the ‘outside-inside’ technique [3, 4, 8, 10, 21, 28, 39] have been proposed as well as the ‘pie crust’ method through the taut PLC or ITB with the knee in full extension [1, 5]. If a lateral soft tissue release is not deemed adequate when accessing the flexion and extension gaps, the medial side should be addressed [28]. Several techniques have been described for dealing with an incompetent MCL [14, 22, 23].

In their study, Politi and Scott achieved soft tissue balancing and good-to-excellent results by using a lateral cruciform retinacular release, in which the LCL and popliteus are not released [33]. Stern et al. [39] accomplished ligamentous balancing with sequential releases from the lateral side of the femur without MCL reconstruction, achieving good-to-excellent results in 91% of cases. The postoperative axis alignment was 5° to 9° valgus. Laurencin et al. [24] treated knees with 25° VD, where lateral retinacular release was accompanied by sequential lateral release achieving postoperative anatomic alignment between 0° and 10° valgus in 96% of patients.

In a cadaveric study, Peters et al. [31] studied the flexion–extension gap symmetry during release of the lateral structures. Complete release of the ITB had a more profound effect on the extension gap. Conversely, complete release of the LCL and popliteus from the femur affected the flexion gap to a greater extent. However, selective release of the ITB, PLC and popliteus produced a smaller magnitude of correction, with a more symmetrical effect on the flexion–extension gap.

Karachalios et al. [19] concluded that a residual VD may not result in early component failure, but can be associated with a worse clinical outcome when related to patellofemoral malalignment. Krackow [22] reported good results in 90% of patients when correcting moderate VD using a PCL-sparing prosthesis. The PCL is not usually contracted in valgus knees. However, when a large axial deformity is confronted, release of the PCL is necessary. In those cases, a PCL-substituting prosthesis should be selected [3, 18].

When the knee joint is approached via a lateral parapatellar arthrotomy, release of the lateral retinaculae is integrated in the approach. As the medial side remains undisturbed, vascularity of the patella is preserved [22, 40]. Laurencin reported three cases of patellar avascular necrosis (AVN) using a medial parapatellar approach with an extensive lateral retinacular release [24]. Miyasaka reported a single case of patellar fracture 3 years postoperatively secondary to AVN [27]. In this study series, there was no incidence of patellar AVN.

In a lateral capsulotomy, the extensor mechanism is displaced medially offering an excellent view of the lateral structures, thus facilitating their adjustment. This encourages more conservative releases and prevents unnecessary steps that may potentially create instability [21].

During eversion, the patellar ligament may be particularly prone to avulsion in the presence of scar tissue and through forceful retraction. In order to protect the extensor mechanism, additional techniques are required either proximally (V–Y quadricepsplasty or ‘quadriceps snip’) [6, 12] or distally [4, 7, 32, 41, 43].

TTO has been valuated as highly beneficial and a safe step in achieving gentle eversion of the patella [4, 7, 32, 41, 43]. In addition, it prevents internal rotation of the tibia, which enables proper positioning of the tibial component [22, 32].

In a medial capsulotomy, patella tracking is less than optimal and related complications are more commonly encountered postoperatively [21, 22, 42]. Conversely, via a lateral approach patellar tracking is assured [18, 21]. Additionally, when combined with TTO, alignment of the extensor mechanism may be adjusted and improved when required [21]. No patellar instability was observed in this study. In two cases, it was elected to transfer the tuberosity medially achieving an optimal balancing of the extensor mechanism.

Burki et al. [4] applied TTO as a part of their routine in revision TKAs and in a number of valgus knees and obtained excellent results in 88% of cases. No complications from the osteotomy side were reported in this study, apart from one case diagnosed with compartment syndrome. Burki observed that when the tibial tubercle is osteotomized spaciously, the anterior tibial compartment may be traumatized. Thus, he recommended fascial release of the affected compartment [4]. The length of the osteotomized tubercle in their study measured 7 cm, while it was shortened to 5 cm in this study. Piedade et al. [32] observed TTO fractures and tibial plateau fissures in 8.7% of patients. Consequently, one should consider the size of the bony fragment apart from the quality of the fixation in order to achieve sound consolidation of the osteotomy.

Common peroneal nerve palsy has been reported as a complication after TKA for VD, at a rate of 1–3% [5, 22, 24, 28, 34]. The latter usually may occur via traction or induced ischaemia [26]. Other mechanisms of injury may include compression or crushing from tight dressings [36]. When using the ‘pie crust’ technique, there is a greater deal of concern [4, 5]. Fortunately, none of the patients in this study presented with a peroneal palsy, despite the advanced stage of the deformity.

There are some limitations regarding the findings of the current study. Firstly, it is important to mention the absence of a large series. Nevertheless, it is argued that this was due to the decision to focus on patients with grades II and III valgus deformities which comprise 2–3% of osteoarthritic knees and somewhat justifies the relatively small sample. Another potential limitation may be the lack of comparison with a third cohort group, which would include patients who underwent lateral parapatellar approach without TTO.

The findings in the current study may be clinically relevant for the orthopaedic surgeon dealing with such complex deformities by helping him to adopt a detailed preoperative plan on a routine day to day basis and envisage any precarious challenges intraoperatively as well as to provide useful solutions. The surgeon himself should be familiar with either approach. The lateral procedure with TTO is more technically demanding and requires a more rigorous postoperative regime. Complications from the osteotomy can easily be avoided if care is taken at crucial stages of the procedure. In the author’s opinion, the lateral parapatellar arthrotomy combined with TTO facilitates the accurate restoration of the anatomical axis, as the contracted structures are easily accessed. It is believed that the *extent of the deformity* that could be corrected in the anatomical axis alignment would be succeeded more precisely with the lateral approach and TTO in primary TKA. Furthermore, risk of avulsion of the tibial tuberosity or patellar ligament is minimized because the osteotomy enables safe patellar eversion.

Conclusion

The use of a lateral parapatellar approach combined with TTO may be highly beneficial in moderate to severe valgus deformities, as the anatomical axis is restored accurately and soft tissue release of the lateral contracted structures is facilitated to an important extent. The clinical outcomes (IKSS, IKSS functional, maximum flexion and VAS score) did not significantly differ between the two cohort groups. Nevertheless, residual deviation from the ideal range was more frequently encountered in the medial approach.

Conflict of interest None.

IRB approval Institutional Review Board approval was given prior to the review process.

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