The Egyptian Journal of Hospital Medicine (October 2019) Vol. 77 (4), Page 5448-5454

Total Knee Replacement in Severe Varus Knees

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ABSTRACT

Background: Varus deformity is predominantly the commonest deformity in candidates for total knee arthroplasty. Obtaining a well-positioned and stable prosthetic construct with restoration of the normal mechanical axes of the limb and joint line have been shown to have an important bearing on the final outcome of knee replacement operations. **Objective:** The aim of this work is to study the results and outcome of total knee replacement in severe varus knees and how to manage the ligamentous laxity and bone defect to improve the alignment of the limb.

Patients and methods: This study was carried out in the period between January, 2016 and July, 2019. A prospective study was conducted involving 32 patients with 40 knees with a severe varus deformity, indicated for total knee arthroplasty. The implants used for these cases are total knee, however PCL sacrificing or CCK were used, according to the knee problem, the condition of the ligaments and the bone defect.

Results: The results of our study showed that the average knee society score (KSS) showed a highly significant increase postoperatively to be 93.0±4.5 in compared with average preoperative KSS of 30.2±15.0. The average knee function score at the last follow up was 75.3+10.0 (range from 65 to 80) compared with average preoperative knee 25.7+20.1 (range from 5 to 40).

Conclusion: Sequential medial soft tissue release must be performed to provide adequate stability without over releasing. PCL must be released in severe fixed varus deformity especially if accompanied by flexion deformity.

Keywords: Total knee replacement, Severe varus knees, Arthroplasty

INTRODUCTION

Arthroplasty is an operation to restore pain-free motion to a joint and function to the muscles, ligaments, and other soft tissue structures that control the joint[(1)].

Knee replacement surgery is one of the most successful surgeries in orthopedics. Hundreds of thousands of these operations are now carried out every year worldwide with excellent results. Knee replacement becomes necessary when the knee joint has been damaged from any cause and the resulting pain cannot satisfactorily be controlled by other means. The usual problem that can end up in the need for total knee replacement is chronic arthritis[(2)].

The goal of primary total knee arthroplasty is to reestablish the normal mechanical axis with a stable prosthesis that is well fixed. This is achieved by both the bone resection and the soft tissue balance. The femoral component should be aligned with 5 to 10 degrees valgus angulations in the coronal plane and 0 to 10 degrees of flexion in the sagittal plane. The tibia should be resected at 90±2 degrees to the long axis of the tibia in the coronal plane. In the sagittal plane, the posterior slope is dictated by the prosthetic design, but it appears preferable to recreate the posterior slope of the natural tibia[(3)].

Total knee arthroplasty has become a highly successful joint reconstruction procedure. Surgical outcomes, patient satisfaction, and implant survival have improved steadily since its inception and the operation has become widely accepted to afford relief of pain, restoration of range of motion and function[(4)].

Varus deformity of the knee is one of the most common deformities seen at the time of total knee arthroplasty. When a fixed deformity is present, the pathoanatomy usually involves erosion of medial tibial bone stock with medial tibial osteophyte formation, and contractures of the medial collateral ligament (MCL), posteromedial capsule, pes anserinus, and semimembranosus muscle. Elongation of the lateral collateral ligament is a late event.

A flexion contracture may coexist, which is manifested by contractures of both posterior capsule and posterior cruciate ligament. The ideal alignment is achieved through soft tissue releases aimed at balancing the collateral ligaments, and by placing the components in the correct orientation. If the proper alignment is not achieved, or if the ligaments are inadequately balanced, the components will be overloaded medially and subjected to excessive stresses, which may result in the eventual failure of the arthroplasty via either component loosening or accelerated wear. Intraoperatively, it is imperative to reassess each step of the soft tissue release so as not to overcorrect the deformity and create valgus instability[(5)].

AIM OF THE WORK

The aim of this work is to study the results and outcome of total knee replacement in severe varus knees and how to manage the ligamentous laxity and bone defect to improve the alignment of the limb.

PATIENTS AND METHOD

Patients: In the period between January, 2016 and July, 2019, a prospective study was conducted involving 32 patients with 40 knees who underwent primary total knee arthroplasty with severe varus osteoarthritis and deformities.

Received:4/08/2019
Accepted:4/09/2019

Exclusion criteria: -Revision cases. - Severe obesity. Severe osteoporosis. Vascular or neurological problems in the same limb.

The group of patients included 9 males and 23 females with a mean age at the time of surgery of 64.5 years old (range from 47 to 76 years).

Regarding body weight, normal weight was 9 (28.1%), over weight 16 (50.0%) and obese 7 (21.9%).

In all patients the indication for total knee replacement was intolerable pain interfering with the activities of daily living with severe varus knee

The primary diagnosis was primary osteoarthritis in 36 patients, and posttraumatic in 4 patients. The degree of varus deformity ranged from (15 º -20º) in 24 knees (60%) and more than 20º in 16º knees (40%)

28 knees had flexion deformity, 19 knee had mild (>15º), 8 knee had moderate (15º-20º) and one patient with had flexion deformity (>20º)

The prostheses used in this study were cemented; posterior stabilized in 32 knees and constrained condylar in 8 knees. Severe deformity, associated flexion deformity and the intraoperative asymmetrical gaps were indications for posterior stabilized prosthesis. Constrained condylar prostheses were indicated in severe deformity with ligamentous imbalance.

Clinical and radiological evaluation (Knee society scoring system) of patients was done preoperatively and postoperatively.

Ethical approval and written informed consent:
An approval of the study was obtained from Al-Azhar University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of the operation.

METHODS

I. Patient assessment:

[A] Clinical assessment:

It included a detailed history and a full physical examination.

1. History:

- Local:

The local assessment focused in particular on quantifying the pain and disability.

2. Physical examination:

a. General assessment:

b. Local examination:

1. Deformity

2. Instability

3. Range of motion:

4- Complete neurovascular examination of the affected limb.

[B] Radiological examination and planning:

Routine radiographic assessment included:

(1) Long film weight-bearing A-P

- Confirm the clinical diagnosis of advanced arthritis.
- Identifying as well as quantifying the degree and apex of the deformity.
- Preoperative planning: anatomical and mechanical axes of the femur and tibia, femoral and tibial cuts and components size.
- Bone defects: size, site, containment, shape and slope.
- The quality of the bone stock.
- Mediolateral osteophytes.
- Unusual anatomic variations that could cause intraoperative difficulty such as abnormal bowing, very small or very large intra-medullary canal were carefully observed.

(2) Special investigations:

According to patient's condition:

- Echocardiography for cardiac patients.
- Doppler U/S: for vascular disease.

II. Preoperative patient preparation:

- Two units of blood were prepared for each patient, but their use was according to the individual situation.
- Preoperative hydration: one litre Ringer's solution at the operation morning.
- All the patients received a prophylactic antibiotic (Ceftriaxone 1g /24 hours 24 hours preoperative and continued for 5 days postoperative)
- Low molecular weight heparin was routinely used for prophylaxis against deep venous thrombosis; it was usually started the evening (12 hours after the operation) and continued for 2 to 3 weeks postoperative (40 I.U. once daily) according to the activity of the patient.

Limb preparation: the protocol of limb preparation was as follows:

1. It is started in the night before surgery after the patient was advised to have a shower.
2. Followed by cleaning with soap and water followed by a topical antiseptic.
3. Then draping the whole limb with a sterile towel till the time of surgery on the following day.

Shaving:

- Better avoided, to avoid skin abrasions. Done only in hairy persons.
- Involve skin area along the planned incision with three cm clearance area on either side.
- This step is done just before entry to the operating room, while the patient is still in the induction room.

III. Operative technique:

- **Anesthetic technique**: combined spinal-epidural anesthesia was used in all patients due to its benefits:
- Peripheral vasodilatation: reduces the risk of D.V.T.
- Longer time without the risk of general anesthesia.
- Continued postoperative analgesia for two days.

- **Preparatory steps:**
- The number of persons in the operative theater was kept to minimum.

- Traffic in and out of the theater was minimized as possible.
- Urinary catheters was applied for collection of urine to measure the urinary output and for the patient comfort in the first 48 hours.
- All cases were done under tourniquet (450 mmHg)
- Sterile disposable draping was a routine use.
- The skin edges of the wound were sealed from the rest of the wound with plastic sheets

Statistical analysis

Recorded data were analyzed using the statistical package for social sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were expressed as mean ± standard deviation (SD). Qualitative data were expressed as frequency and percentage. The following tests were done:

- Independent-samples t-test of significance was used when comparing between two means.
- Paired sample t-test of significance was used when comparing between related samples.
- Chi-square (x^2) test of significance was used in order to compare proportions between qualitative parameters.
- The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following:
- Probability (P-value)
- P-value <0.05 was considered significant.
- P-value <0.001 was considered as highly significant.
- P-value >0.05 was considered insignificant.

RESULTS

A) Clinical results (Table 1)

1-Knee society score: There was highly significant improvement of the total knee society scoring postoperatively

2-Knee function score: There was highly significant improvement of the total knee function score postoperatively.

3-Postoperative mediolateral stability: There was significant improvement of the media lateral stability postoperatively ($P < 0.05$).

4-Postoperative range of motion: There was no statistical significant change of the range of motion between preoperative and postoperative.

5-Pain score: There was highly significant improvement of knee pain post operatively.

6-Walking score: There was highly significant improvement of walking function postoperatively.

7-Climbing stairs: There was highly significant improvement of climbing stairs function operatively.

8-Use of ambulatory aids: At the last follow up 9 patients used one cane. No patients used 2 canes (or crutches) or a walker. In comparison between preoperative and postoperative use of ambulatory aids according to the knee function score. Preoperative ranged from zero to -20 with mean value -10±6.9 and post-operative ranged from zero to -5 with mean value -0.81±1.7. There was highly significant improvement of the use of aides postoperatively.

Table (1): Comparison between preoperative and postoperative measurements.

	Preoperative	**Postoperative**	T-test P value
Knee Society Scoring System	30.2±15.0	93.0±4.5	22.6 0.0001*
Knee Function Scoring	25.7±20.1	75.3±10.0	18.8 0.002*
Mediolateral Stability	2.62±2.53	12.02±2.48	7.71 0.001*
Range of motion	89.1 15.3	98.5 15.6	1.25 0.165
Pain	15.1±4.22	45±6.25	17.6 0.0001*
Walking	18.5±6.5	40.0±5.5	16.9 0.001*
Climbing Stairs	16.1±8.2	40.0±9.5	22.5 0.001*
Tibiofemoral angle	23.2±6.7	6.9±1.32	8.01 0.0011*

9-Age: Although there was no statistically difference in the mean KSS and FKSS postoperatively between age groups, the younger age groups showed improvement in the mean score than the older patients (negative correlation by Pearson correlation coefficient test) (Table 2).

10-Degree of varus deformity: Although there was no statistically difference in the mean KSS and FKSS post operatively between degree of varus deformity, the patients with moderate varus deformity (15°-20°) showed improvement in the mean scores than the patients with severe deformity (>20°). (Negative correlation by Pearson correlation coefficient test) (Table 2).

11-Degree of flexion deformity: There is a statistical significance in the mean KSS in patients with mild degrees of flexion deformity compared to the more severe deformities (P value is less than 0.05). On the other hand, there is no statistical significance in the mean FKSS in patients with mild and severe degrees of flexion deformity although mean function scores is better in mild degrees than the higher flexion deformity degrees (Negative correlation by Pearson correlation coefficient test) (Table 2).

Table (2): Correlation between postoperative mean KSS and FKSS with age, degree of varus and degree of flexion deformity.

		Age	Degree of Varus	Degree of Flexion
KSS post	Pearson Correlation	-0.105	-0.235	-0.441
	P Value	0.411	0.091	0.021*
FKSS post	Pearson Correlation	-0.14	-0.225	-0.201
	P Value	0.312	0.025*	0.103

B) Radiological results: Limb alignment (Tibiofemoral angle):

The average postoperative tibiofemoral valgus angle was 6.9±1.32 degrees (range from 1 to 8 valgus), compared with average preoperative tibiofemoral varus angle of 23.2±6.7 (Table 1). There was significant improvement of limp alignment postoperatively

C) Management of tibial bone defect (Table 3)

Table (3): Different methods in management of medial tibial defects and number of cases.

Method Of Reconstruction	Number Of Cases
Salvageable Defects	14
Cheating Cut	13
Ignore undersized and lateralized	1
Bone grafts	
contained	2
uncontained	4
metal augments	
½ block	2
½ wedge	3
1/3 wedge	1

1-Management of the uncontained tibial bone defects:

There was no statistical significant relation between management of uncontained tibial defects approach (Table 4).

Table (4): Comparison between management of uncontained tibial defects approach.

Approach	Scores	
	Mean KSS	Mean FKSS
Bone graft	92.1±8.9	74.1±7.23
Metal Augment	90.3±8.78	71.6±5.22
U-test	1.10	1.01
P value	0.25	0.165

DISCUSSION

The results of this study depended on; a) Clinical evaluation of the patient pre- and postoperative and at follow up visits, according to the Knee Society Score, b) Radiological examination, pre- and postoperative and at follow up visits.

In our study the patient's age ranged from 47-76 with mean value 64.5. Regarding the gender of the patients, it was found that males were 9 (28.1%) and females were 23 (71.9%).

Regarding body weight, normal weight was 9 (28.1%), over weight 16 (50.0%) and obese 7 (21.9%). The primary diagnosis was post traumatic arthritis in 4 (10.0%) and primary O.A was 36 (90.0%). The degree of varus deformity range from (15 ^{o} -20^{o}) in 24 knees (60 %) and more than 20^{o} in 16^{o} knees (40%). 28 knees had flexion deformity and 19 knees had mild (>15^{o}). 8 knees had moderate (15 ^{o}-20^{o}) and one patient had severe flexion deformity (>20^{o}).

The results of our study showed that the average Knee Society Score (KSS) showed a highly significant increase postoperatively to be 93.0±4.5 in compared with average preoperative KSS of 30.2±15.0. The average knee function score at the last follow up was 75.3±10.0 (range from 65 to 80) compared with average preoperative knee 25.7±20.1 (range from 5 to 40).

Our results were in agreement with the study carried out by **Mullaji *et al.*** [6] on total knee arthroplasty for profound varus deformity. In this study the mean Knee Society Score before surgery was 22.8 ±13.7 (range, 0-64). After surgery, the mean Knee Society Score was 91.1±7.2 (range, 52-99), there was a highly significant improvement in KSS. The mean function score was 75.3 ±10.0 (range, 5-100). The preoperative score was 25.7 ±20.1 (range, 5°-40 °), it was found that there was a highly significant improvement in function score.

Lee *et al.* reported in their series improvement of the mean Knee Society Score from 21 preoperatively to 96 postoperatively and the function knee score from 39 to 77 in the mild varus group at 2 years follow up and improvement of the mean Knee Society Score from 14 preoperatively to 97 postoperatively and the function knee score from 33 to 79 in the severe varus group at 2 years follow up[7].

In the study of **Dixon *et al.*** the KSS increased from a mean of 24 (range, 0 to 43) to a mean of 94 (range, 78 to 100). The FKSS improved from a mean of 34 (range, 0 to 70) to a mean of 85 (range, 45 to 100)[8].

In this study the comparison between preoperative and postoperative mediolateral stability showed that the preoperative ranged from 2-8 with mean value 5.9±2.8 and postoperative ranged from 11-17 with mean value 15.1±1.3. There was significant improvement of the mediolateral stability postoperatively ($P < 0.05$).

In agreement with our study, **Seah *et al.*** [9]**,** studied the evaluation of mediolateral stability and functional outcome following total knee arthroplasty: results of a single hospital joint registry. They found that the mediolateral stability was significantly improved postoperatively, these results suggested that patients are likely to obtain a greater clinical benefit from surgery if they have <5° mediolateral laxity postoperatively at 2 years.

In contrary to our results **Yaratapalli *et al.*** [10]**,** studied the functional and radiological outcome of total knee replacement in varus deformity of the knee. They found that there was no significant improvement in lateral stability postoperative from preoperative, they attributed the results of unimproved lateral stability to the short period of follow up.

In our results the average postoperative range of motion was 98.5±15.6 (range from 90-120). In comparison to preoperative average range of motion was 89.1±15.3 (ranged from 77-95). There was no statistical significant change of the range of motion between preoperative and postoperative. This is because the preoperative range of motion is considered high and the duration of follow up was short.

In the study carried out by **Kubes *et al.*** [11]**,** they studied the range of motion after total knee arthroplasty in 72 total knee replacement. They found that there was a significant improvement in range of motion, the preoperative range of motion was 56±34 and postoperative was 73±24. They concluded that the improvement of range of motion was at least after 9 weeks.

These results indicated that knee ROM is difficult to predict from self-administered surveys of a patient's functional status. One possible explanation is that it is easier to compensate for poor knee ROM than for a similar problem with the hip. According to this theory, only patients with a particularly stiff knee will have function that is strongly affected by ROM. Indeed, one study found that patients with 70° of knee motion were severely impaired, and those with motion between 70° and 110° showed no relationship between flexion and function [12].

In our study, the knee pain according to the Knee Society Score, preoperative ranged from 10-20 with mean value 15.1±4.22 and postoperative ranged from 40-50 with mean value 45±6.25. There was highly significant improvement of knee pain postoperatively.

In agreement with our study, **Yaratapalli *et al.*** [10]**,** in their study, all patients had good pain relief compared to their preoperative status. The average preoperative pain score was 15, which was improved to 45 and no pain postoperatively.

In this study, the walking function, climbing stairs function and use of ambulatory aids score showed a significant improvement. In these cases, we always considered that postoperative patients programs and, especially, walking activity were very important to the status of the upper extremities for the possibility of walking with the help of crutches, especially in cases of bilateral procedures.

In this study, regarding bone preparation, accurate bone resection is one of the most important factors for achieving a successful and durable total knee arthroplasty. The technique of referencing distal femoral resection and proximal tibial cut (measured resection technique) from the intact lateral surfaces has the advantage of restoration of the normal joint line, preserving bone stock for future revisions and avoiding the increase in lateral laxity.

Numerous treatment options have been proposed for dealing with bone defects. The alternatives include additional bone resection, reconstitution of the defect with polymethyl-metha-acrylate with or without screw or mesh reinforcement, reconstitution of the defect with autogenous or allograft bone, metal augmentation, or custom implants[13-14]**.**

Autogenous bone graft (fixed by screws) was used in 4 cases in the present study with medial tibial defect 5-10 mm. Complete incorporation and healing of the graft was noticed after 11 to 16 months. The approach performed in the current study was to produce a step cut defect. After

removal of sclerotic and avascular bone from the floor and side wall of the defect, autologus resected bone usually from the intercondylar notch is fashioned to fit the defect then temporary k-wires used to held the graft till fixation by 2 cancellous screws.

The KSS for these patients was 92.1 and FKSS was 74.1. On the other hand 18 cases with steeply medial tibial defects more than 10 mm were reconstructed by metal augments. None of metal augmented cases showed evidence of loosening or subsidence till the last follow up. Although the scores of the patients used bone graft for reconstruction were better than the metal augments patients; yet this was statistically insignificant.

This slight difference in the score might be noticed because those patients reconstructed by the metal augments had much more severe deformity and defects compared by the bone grafted defects. Also it is well noticed that bone grafts and metal augments were used to reconstruct knees with steeply medial tibial defects and their tibiofemoral angle were >20° i.e. severe varus deformity except in 1 knee; the tibiofemoral angle was *17*° i.e. moderate deformity. This could be explained by that these knees had severe lateral instability (>15°) and severe flexion deformity. A constraint condylar knee prosthesis was implanted to achieve stability.

Parks and Engh [15] showed promising clinical results of bone grafts in TKR after evaluating the histopathology of nine bone grafts (autograft and allograft) used in primary TKR. All allografts were intact, but did not revascularize.

Liu *et al.* [16] operated upon 50 knees with medial tibial bone grafts fixed with screws and compared the results with those of a control group of normal TKRs and found no difference. One graft resorbed in their series and three patients had split fractures in the sclerotic medial tibial condyle.

Pei *et al.* [17] operated upon 19 knees with severe genu varum and bone defects treated with TKR and step cut bone graft for medial defects. No fixation was used for the graft. Long tibial stem extenders were used in three patients. The postoperative Knee Society Scores was improved significantly and there were no graft failures even at an average follow-up of 25 months.

The remaining knees showed the evidence of graft incorporation. The authors reported no difference in the long term follow-up results of both the groups. We also found no difference in the long term results after structural or impaction bone grafting, except for early incorporation of the morselized graft.

Watanabe *et al.* [18] performed autologous bone grafting in 30 TKRs without using screws and showed union in all cases.

It was recommend to use at least two screws for initial stability of the graft and to achieve compression at the graft host bone interface. **Rawlinson *et al.*** [19] in their cadaveric study, concluded that the use of stem extenders improves knee stability by reducing bone stresses and micromotion between the implant and the adjacent bone.

We also recommend and preferred to use stem extenders in all our cases. Similar results with the use of structural bone grafts in primary TKR have been shown by other authors such as **Altchek *et al.*** [14] (14 patients), **Scuderi *et al.*** [20] **Pierzchała *and* Kusz** [21] (14 cases with 4- year follow-up), and and **Keska *et al.*** [22] (8 knees).

In this study, the most challenging aspect of total knee arthroplasty in varus deformities is obtaining soft tissue stability and ligamentous balance. To achieve this proper ligament balancing and bony alignment are critical. Numerous methods of medial release and lateral ligament advancement have been described either soft tissue or bony procedures.

In this study, the philosophy in this study was sequential progressive medial soft tissue release with attention to 2 things. First we sacrificed the PCL in all the cases because the PCL was a major deforming force that tethers the soft tissue preventing balancing of the gaps especially if accompanied by flexion deformity. The second is that we didn't advance the lateral collateral ligament in any case and in severe cases in the study we assumed that we won't reach a well-balanced stable knees because of the severe lateral laxity, we used constraint condylar knees and we achieved a well-balanced stable knee.

In this study, proximal medial tibial resection can be an effective method for ligament balancing. However, an extensive bone resection may cause tibial component loosening, difficulty in revision surgery, and kinematic changes in the knee due to lateral translation of the tibial component. Although extensive medial soft tissue release has been associated with knee instability in some studies.

Choi *et al.* [23] suggested that proper postoperative fixation could improve stability in knees with varus deformity even after extensive release of medial soft tissues including the MCL.

In our study, the radiological assessment of limb alignment (Tibiofemoral angle) showed that the average postoperative tibiofemoral valgus angle was 6.9±1.32 degrees (range from 1 to 8 valgus), compared with average preoperative tibiofemoral varus angle of 23.2±6.7 (range from 15 to 36 varus). There was significant improvement of limp alignment postoperatively.

Dixon *et al.*[8]**,** had excellent clinical and radiological results in patients with severe varus using this technique.

Niky *et al.* [24]**,** in a study of 39 severe varus knees, could achieve gap balancing by reduction osteotomy and lateralisation of tibial component with the release of deep MCL alone in 20 knees. They noticed that flexion gap imbalance at 90° could be reduced by 1.7° and 2.8° for 4-mm osteotomy and 8-mm osteotomy, respectively. **Mullaji *et al.*** [6] in their attempt at quantification of the reduction osteotomy, found out that there was 1 degree correction of

varus in extension for 2 mm of resection. Both described this procedure to be effective with predictable results [6,24].

CONCLUSION

In conclusion; from the current study, there are many recommendations for management of varus osteoarthritis by total knee arthroplasty which are:

- Proper preoperative evaluation of the patients clinically and roentgenographicaly is mandatory.
- Referencing distal femoral resection and proximal tibial cut (measured reaction technique) from the intact lateral surfaces has the advantage of restoration of the normal joint line, preserving bone stock for future revisions and avoiding the increase in lateral laxity
- Sequential medial soft tissue release must be performed to provide adequate stability without over releasing.
- PCL must be released in severe fixed varus deformity especially if accompanied by flexion deformity.
- Patients with severe degrees of varus OA are more likely to have medial tibial bone defects and must be reconstructed by either bone grafts or metal augments and in the same time unloading the tibial surface by long stem to distribute part of the load stresses to the diaphysis
- Patients with severe bilateral varus knees must be done at the same sitting if possible or with short time interval; for avoiding over stress on the operated side.

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