Total Knee Replacement In Non-Ambulant Patients: Osteoporosis, Severe Fixed Flexion Deformity and Weak Extensor Mechanism

“The Terrible Triad”

Radwan G. Metwaly, M.D.
Associate professor of orthopedics, Ain-Shams University, Cairo, Egypt
ORCID No. 0000-0001-5516-406x
radwanmetwaly@med.asu.edu.eg; dr_radwan05@yahoo.com

Zeiad M. Zakaria, M.D.
Associate Professor of orthopedics, Ain-Shams University, Cairo, Egypt
ORCID No. 0000-0002-3271-2550
zeiadzakaria@med.asu.edu.eg; zeadzakaria@gmail.com

Corresponding author:
Zeiad M. Zakaria, M.D.
Associate professor of orthopedics, Ain-Shams University, Cairo, Egypt
Tel: (+2) 01005468697
42, Al Banafsig 9, 1st settlement, 11865, New Cairo, Egypt
ORCID No. 0000-0002-3271-2550
zeiadzakaria@med.asu.edu.eg; zeadzakaria@gmail.com

Declarations:

- **Conflict of interest**: the authors declare that they have no conflict of interest.
- **Funding**: There is no funding sources.
- **Ethical approval**: all procedures performed in this study were in accordance with the ethical standards of the institutional and national research committee and with Helsinki declaration and its later amendments.
• **Consent to publish:** all authors are consented for publishing this study.

• **Author’s contribution:** all authors are contributed in the study.

• **Competing interests:** not applicable

• **Availability of data and materials:** available when needed.

**Abstract:**

**Background:** Knee osteoarthritis is among the most disabling disorders in elderly. With delay in proper management, muscular weakness, progressive flexion deformity and disuse osteoporosis “the terrible triad” are serious consequences, which could be major obstacles for the planned total knee replacements (TKRs). High risk for iatrogenic fractures, difficult gap balancing and failure to promote the patient activity are common expectations.

**Materials and Methods:** a retrospective analysis of all TKRs that were done in a university specialized unit between January 2015 till January 2021 searching for non-ambulant-patients was done. Twenty-two replacements for fifteen patients who were unable to walk at least three months before surgery were found. The median fixed flexion deformity (FFD) before anesthesia was 45°. Osteopenia was evident on X-rays and bone thickness intra-operatively. Quadriceps muscle strength was not more than grade four. The median preoperative functional KSS was 0°. The median preoperative WOMAC score was 90.63.

**Results:** twelve knees had remaining FFD one year after surgery with a median of 5°. Ten had iatrogenic fractures mostly affected the medial femoral condyle. One patient could not regain walking capability and eleven patients could not walk without assistance. The median postoperative functional KSS and WOMAC scores were 61 and 21.36 respectively.
**Conclusion:** TKRs in non-ambulant patients with evident terrible triad (muscle weakness, osteoporosis and FFD) is a risky procedure. Common complications include iatrogenic fractures and inability to regain normal physical capabilities. Despite the magnificent improvement in function, we do not recommend performing TKRs in such patients without strict patient counseling with possible drawbacks.

**Keywords:** Flexion deformity, Muscle weakness, Non ambulant, Osteoporosis, Total knee in elderly
Total Knee Replacement In Non-Ambulant Patients: Osteoporosis, Severe Fixed Flexion Deformity and Weak Extensor Mechanism

“The Terrible Triad”

Background:

Osteoarthritis is the most common articular cartilage disease. It is considered to be among the most disabling comorbidities in elderly specially when affecting lower limb weight bearing joints. As population is aging, the incidence of osteoarthritis has been doubled since the mid twentieth century.\textsuperscript{[1,2]} Knee osteoarthritis is responsible for more than 80\% of joint injury and disease burden.\textsuperscript{[3]} After failure of conservative measures, total knee replacement surgery (TKRs) is always considered as the treatment of choice.\textsuperscript{[4-7]}

With advancement of the disease, pain impedes normal physical activity and impedes performing the activities of daily living. Standing from sitting position, walking for even short distance and going up or downstairs become a major concern for patients and so they may prefer to reduce their ambulation to the minimal requirement and become more confined to chairs.\textsuperscript{[8,9]}

Non-favored consequences are evidenced with limitation in elderly physical activities. A strong association was found between cardiovascular comorbidities and osteoarthritis, with three times higher risk of having a heart failure or myocardial infarction.\textsuperscript{[10,11]} Psychological disturbances with increased risk of anxiety, depression and other mental disorders were found in one fifth of osteoarthritic patients.\textsuperscript{[12,13]}

Locally, as a result of limited ambulation, muscular integrity is reduced with weakness of pelvic stabilizers and quadriceps muscles leading to imbalanced gait and
increased difficulty in walking.\textsuperscript{[14,15]} With disease progression, disuse osteoporosis in bone is found which poses a superadded problem when surgical treatment is considered.\textsuperscript{[16,17]}

Prolonged periods of sitting, pain and muscle spasm lead to progressive fixed flexion deformity with loss of ability to fully extend the knee. This leads to more articular damage, increased pain and muscle spasm. Thus patients enter into a viscous circle of difficult ambulation due to pain and progressive flexion deformity. The delay in properly timed surgery either due to patient fears or due to late waiting list dating prolongs the non-ambulant situation upon which severe degrees of fixed flexion deformity expected.\textsuperscript{[18-20]}

Accompanied muscle weakness, bone osteoporosis and severe fixed flexion deformity presume huge challenges for TKRs and when present together, surgeons must be aware of the increased risk for the expected complications in the form of iatrogenic fractures, failure to fix the implant promptly with non-constrained prostheses and residual flexion deformity with imbalance of flexion and extension gaps. Postoperatively patients may not regain their capabilities of walking and performance of their activities of daily living that poses a high patient dissatisfaction.

The aim of this study was to estimate the pros and cons for performing total knee replacement in osteoarthritic patients who were non-ambulant for more than three months before surgery with consequent muscle weakness, osteoporosis and fixed flexion deformity to help surgeons in decision-making and patient counseling.

\textbf{Materials and Methods}
A retrospective analysis of all TKRs performed in a specialized adult knee reconstructive unit in a university hospital through a six-year period between January 2015 till January 2021 searching for knee osteoarthritic patients who were non-ambulant before surgery was done. Only TKRs for primary osteoarthritis were included. Patients with neuromuscular diseases limiting the physical capabilities, Charcot joints, revision TKRs and patients with advanced hip and spine diseases were excluded.

Among those who had TKRs, fifteen patients (four males and eleven females) were recorded as unable to walk for at least three months before surgery (average 4.8 months), and their average age at time of surgery was 67.7 years old. The main cause of delay was surgical dating problem (eleven surgeries) followed by patients fear from surgery (five surgeries) and the rest of delayed surgeries were due to control of comorbid conditions (two patients) or local condition (four patients).

The main pathology for surgery was primary osteoarthritis for all the fifteen patients although four patients were recorded as having post local injection with steroids or hyaluronic acid septic arthritis, and surgical debridement was done before surgery. But in these patients septic arthritis was not the primary cause of osteoarthritis.

Patients’ data was reviewed for the preoperative clinical examination including fixed flexion deformity, coronal plane deformity, range of motion, functional scores (KSS and WOMAC scores), involvement in any preoperative physiotherapy or rehabilitation programs, and preoperative X-rays searching for evident osteopenia. Postoperative data for the same parameters at 3 weeks and one year after surgery were retrieved but comparison was done between the preoperative and the one-year follow up measures.
Four patients had BMI > 40, and the most common comorbidity found was DM (eight patients). Other recorded comorbidities were hypertension, cardiac problems, hepatic problems and a single case of ITP, which had repeated attacks of bilateral knees intra-articular hemorrhage. Only two patients were free of comorbid medical conditions at time of surgery.

Fixed flexion deformity (which was recorded to the nearest five degrees) measurement differs before and after induction of anesthesia due to muscle spasm and so degrees of fixed flexion deformity measured at outpatient clinic (OPC) and post induction were searched. The median OPC measure was 45° and post induction FFD was 25° (ranging from 15° to 75°) with thirteen patients had improved FFD to less than 30° after induction. Comparison with postoperative measures was done with the post induction records.

Extensor mechanism muscle strength was recorded according to medical research council (MRC) grading system \[21\] (table 1) and a maximum record of grade four was found (14 knees with quadriceps muscle strength grade 4 and 8 with grade 3 with an average of 3.6 and a median of 4). Osteoporosis was evident in a qualitative manner in the form of wide medullary canal, narrow cortices, reduced radiological opacity and was confirmed from the intra-operative data where severe thinning of the cortices was documented.

Table (1): the MRC muscle strength grading scale

<table>
<thead>
<tr>
<th>Muscle strength grade</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No movement is observed</td>
</tr>
<tr>
<td></td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Only a trace or flicker of movement is seen or felt in the muscle or fasciculations are observed in the muscle.</td>
</tr>
<tr>
<td>2</td>
<td>Muscle can move the joint only if the resistance of gravity is removed.</td>
</tr>
<tr>
<td>3</td>
<td>Muscle can move the joint only against gravity with the examiner’s resistance completely removed.</td>
</tr>
<tr>
<td>4</td>
<td>Muscle strength is reduced but muscle contraction can still move joint against resistance.</td>
</tr>
<tr>
<td>5</td>
<td>Muscle contracts normally against full resistance.</td>
</tr>
</tbody>
</table>

Although performance-based physical function tests (as 30s chair stand test, stair climb test and 6-minute walk test) are done in the preoperative clinical package for patients undergoing to have TKRs, these functional tests were recorded as inapplicable and physical activity was retrieved from functional KSS, which was recorded in all the twenty-two knees as zero as the results were with minus values. The median objective KSS was also recorded as zero. The median preoperative satisfaction and expectation parts of the KSS were 8 and 6.5 respectively.

The WOMAC score is used as a patient reported outcome measure and reflects the patient satisfaction ranging from 0-100 with the highest value reflects patient dissatisfaction. The median preoperative WOMAC score was 90.63 (ranging from 70.04 to 100).
Range of motion (ROM) as well as the flexion deformity degree was recorded in degrees for the nearest five using digital goniometer in mobile phone application and the median preoperative ROM was 45° (ranging from 15° to 80°).

As regard the coronal mal-alignment, three patients had valgus knees with four TKRs done, and twelve had the more common varus deformity with eighteen TKRs done.

Results

The analysis was done using the Statistical Package for the Social Sciences (SPSS software version 19, SPSS Inc., Chicago, IL). Using the Non-Parametric test Kruskal-Wallis (χ²) test, the mean rank and medians of the different studied parameters were estimated. p<0.01 was considered statistically highly significant. Results are shown in table (2).

Table (2): comparison of the preoperative and one-year follow up results:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Pre-operative</th>
<th>Post-operative (at one-year follow up)</th>
<th>X²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FFD</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>25.00</td>
<td>5.00</td>
<td>31.318</td>
<td>0.000**</td>
</tr>
<tr>
<td>Mean Rank</td>
<td>33.23</td>
<td>11.77</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>15-75</td>
<td>0-15</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td><strong>KSS Objective</strong></td>
<td></td>
<td></td>
<td>33.702</td>
<td>0.000**</td>
</tr>
<tr>
<td>Median</td>
<td>0.00</td>
<td>62.00</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td>Mean Rank</td>
<td>11.59</td>
<td>33.41</td>
<td>0.000**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>Median</td>
<td>Mean Rank</td>
<td>Range</td>
</tr>
<tr>
<td>------------------</td>
<td>-------</td>
<td>--------</td>
<td>-----------</td>
<td>-------</td>
</tr>
<tr>
<td><strong>KSS Functional</strong></td>
<td>0-28</td>
<td>0.00</td>
<td>61.00</td>
<td>0-88</td>
</tr>
<tr>
<td><strong>KSS Satisfaction</strong></td>
<td>25-75</td>
<td>8.00</td>
<td>29.00</td>
<td>4-16</td>
</tr>
<tr>
<td><strong>KSS Expectation</strong></td>
<td></td>
<td>6.50</td>
<td>12.00</td>
<td>4-11</td>
</tr>
<tr>
<td><strong>WOMAC</strong></td>
<td></td>
<td>90.63</td>
<td>21.36</td>
<td>76.04-100</td>
</tr>
<tr>
<td><strong>ROM</strong></td>
<td></td>
<td>45.00</td>
<td>75.00</td>
<td>15-80</td>
</tr>
<tr>
<td><strong>Muscle</strong></td>
<td></td>
<td>4.00</td>
<td>5.00</td>
<td>3-4</td>
</tr>
</tbody>
</table>
Total knee replacements were done for the fifteen patients. Seventeen knees with CCK implants and four with PS implants with tibial stem insertion) with failed implant fixation in one patient who had intra-operative iatrogenic comminuted fracture of the whole medial femoral condyle due to severe osteoporosis that could not be fixed or reconstructed at time of surgery. Knee arthrodesis was planned later on for this patient.

Ten intra-operative iatrogenic fractures were recorded most commonly in the form of medial femoral condyle fracture (4 cases) followed by three cases with avulsion of the medial epicondyle and another three cases with anterior tibial plateau fracture. Most of the fractures recorded were during full trial or plastic insertion. (fig. 1)

![Fig (1): case presentation for a male patient 78 years old with (A): bilateral fixed flexion deformity of 45°. (B, C): range of motion of right knee (45°-55°-115°) with extension lag of 10° due to weak extensor mechanism. (D, E): pre-operative X-rays showing varus alignment. (F, G): post-operative X-rays of left side with fracture of the medial femoral epicondyle fixed]
with locked plate. (H): 3 weeks after bilateral TKRs showing patient started regaining walking capability supported with a frame.

Only three knees could have full extension with no flexion deformity immediately after surgery, the median immediate postoperative FFD was 10° (range from 0°-20°). These three TKRs had preoperative post-induction FFD of 15°.

Following rehabilitation, seven other TKRs could gain full extension which had immediate postoperative FFD of 5°. Twelve patients had remaining flexion deformity one year after surgery with a median of 5° (range from 0°-15°). Comparing the immediate postoperative FFD with the one-year follow up revealed that physiotherapy could improve only 5° of FFD in this patient group.

Comparing the preoperative post-induction FFD with the one year follow up results showed highly statistically significant improvement in the flexion deformity.

As regard muscle strength, preoperative median MRC was recorded as grade 4 (range from 3-4). Postoperative median MRC was grade 5 (range from 3-5). Physiotherapy could not improve the muscle strength in five knees of five patients (two of these patients had bilateral TKRs, the other two knees had improved MRC grade from 3 to 4). One of these patients had not gained the walking capability (failed TKR) and the other four patients could walk 6 months after surgery only with the assistance of a walking frame. Again the muscle strength grade comparison with the one year follow up showed highly statistically significant improvement.

For the range of motion (ROM), a median of 75° (range from 0-110°) was gained at the end of rehabilitation for one-year after surgery. When compared with the preoperative median ROM, a highly statistically significant improvement was found.
Comparing the preoperative KSS parts with the one year KSS showed a highly statistically significant improvements in all parts with the median postoperative objective, functional, satisfaction and expectation results were 62, 61, 29 and 12. The same highly significant improvement was found in the one-year postoperative median WOMAC score (21.36 ranging from 4.17 to 94.79)

Discussion

Ambulation in elderly is very crucial. With decreased activity levels, serious consequences are inevitable. \[^{22}\] Cardiovascular diseases are common comorbidity among osteoarthritis patients, whether as a result of decreased activity or a mere coincidence. Their effect on the general health status worsens the physical capabilities and vice versa. \[^{10,11}\] In this study five of the fifteen patients had associated cardiac comorbidities in the form of low ejection fraction (EF\text{\%}), coronary heart disease and previous myocardial infarction. high BMI also affects the general health condition as well as the physical capabilities. Morbid obesity with BMI > 40 were recorded in four patients out of the fifteen patients included. The cumulative burden of osteoarthritis and comorbidities increases patients’ suffering affecting the health related quality of life scores.

Delay of proper surgical timing was attributed to busy waiting list schedules due to increasing number of patients in need of joint replacements and patients constrain against surgery. Hudak et al. \[^{23}\] explained various assumptions for patients-side delay. Some patients consider osteoarthritis not as a disease but as a part of their normal aging, others presumed that their surgical candidacy requires more severe symptoms than they do have while others do not believe that surgery could improve their quality of life
In this retrospective study, three patients were the cause of delay while seven were delayed due to dating. The other five patients were delayed due to associated local (infection) or medical condition.

With advancement of knee osteoarthritis, pain, muscle spasm and decreased ambulation leads to progressive flexion deformity (FD), muscle weakness and osteoporosis “ the terrible triad”. This triad was recorded in osteoarthritic knees in patients with connective tissue diseases mainly rheumatoid arthritis. In this retrospective study, the authors reviewed primary osteoarthritis as the main articular cartilage disease with exclusion of other pathological conditions like rheumatoid arthritis, neuromuscular diseases, Charcot joints and revision cases.

To our knowledge, this is the first time to link primary osteoarthritis with inability to walk due to delayed surgery to grasp the attention to the possible occurrence of such triad in delayed proper timing of TKR in primary osteoarthritis patients. Although only fifteen patients were found in this retrospective five years study period, this rare situation should be highlighted to increase the awareness of the possible complications that might occur with unsatisfactory outcomes.

Assessment of the extensor mechanism integrity before TKRs is very important. At least quadriceps muscle strength of grade three of five on the MRC score was suggested for success of the procedure. A recent systematic review by Vasta et. Al, showed that preoperative rehabilitation programs in the form of isometric quadriceps strengthening, antagonists stretching and neuromuscular balancing exercises could improve QoL for osteoarthritis patients and decrease the postoperative hospital stay but there is no clear evidence on their effect on improved function in the postoperative period.
Preoperative rehabilitation was not routine in the study group and weak muscle strength (median of 4) was recorded. Improvement in muscle strength was found after TKRs (median of 5), which suggest that TKRs facilitates rehabilitation due to decreased pain and so improving the physical capabilities and the quality of life for elderly patients. Similar improvement could be found as regard the ROM that was improved from a median of 45° preoperatively to 75° after one year of follow up.

Osteoporosis is a silent disease. The relation between osteoporosis and osteoarthritis had been studied as two different age-related diseases with shared incidence and pathological mechanisms. Physical activity improves the function capabilities of arthritic joints as well as bone quality. In order to follow osteogenetic rehabilitation programs that involve low-impact activities like brisk walking or jogging, cooperative patients with painless joints are needed.\cite{16,17} TKRs in osteoporotic bone carry higher risk of iatrogenic intraoperative fractures. Surgeons fall in debate when trying to improve the physical capabilities for patients with arthroplasty surgeries due to the fear of complications.\cite{26-29}

Alden et al.\cite{29} found that iatrogenic fractures during TKRs were most commonly affecting the medial femoral condyle with bone thinning diseases (like osteoporosis and rheumatoid arthritis), component design, component position and excessive bone cuts are of among the predisposing risk factors. Ten intraoperative fractures out of twenty-two TKRs (45.4%) were recorded most commonly affecting the medial femoral condyle (four cases), the medial femoral epicondyle (three cases) and the anterior tibial plateau cortex (three cases). Lombardi et al. reported a 4.4% risk of intraoperative fractures in TKRs from a cohort of 898 surgeries.\cite{30} Patients with the presence of the terrible triad (bone thinning, FFD and muscle weakness) are at ten times higher risk to suffer from intraoperative fractures. A special relation between the
preoperative coronal mal-alignment and the location of the fracture could not be statistically proven due to limited case number.

Flexion contracture is a well-known cause of low functional scores due to higher muscle energy expenditure required causing increased tiredness from activities like standing from sitting position, walking and climbing stairs. [18] Campbell and Trudel, [31] found that severe single FFD affects the contralateral knee and spine worsening the functional ability of patients. FFD impede full foot ground bearing making normal standing and walking impossible.

The presence of FFD increases the risk of residual post-operative flexion. [32] Many authors had recommended incomplete intraoperative correction of severe degrees of FD as part of such contracture could be corrected with serial postoperative casting and physiotherapy. [33] Scott, [34] predisposed a “rule of one third” in management of FFD > 40° when correction should be limited to one third of that recorded after induction of anesthesia. A residual FD of more than 15° after TKRs was found incompatible with normal gait cycle and velocity due to increased quadriceps contraction force demands to 22% of those with fully extended knees. This contraction force demands increase to 50% with 30° of flexion contracture. [19] So primarily every surgeon do his best in order to gain full extension to improve the quadriceps biomechanics after surgery. With the presence of severe flexion contractures and to avoid massive bone resection from distal femoral cuts, a compromise could be accepted according to the rule of one third. In our opinion, this rule was unacceptable for all patients as in cases of more than 45° of flexion deformity after induction of anesthesia, an expected >15° of residual deformity would be in need for aggressive rehabilitation protocols that may lead to periprosthetic fractures with such osteopenic thin bone. If
such residual FD could not be corrected, failure to walk again would be the result with unsatisfactory PROMs.

In our unit, the philosophy was to fully correct any flexion deformity if possible with the maximum allowed distal femoral bone cuts and not to accept a residual FD of > 15° that could be improve with physiotherapy. Six knees were found to have FD of > 45° after induction of anesthesia, five of them had residual deformity of 15° immediately after surgery and one knee had a residual FD of 20°. The improvement after one year of follow up was of only 5° in four patients confirming our hypothesis.

The median preoperative FFD was 45° and that improved to 25° after induction of anesthesia, this was significantly improved to 5° one year after surgery. But actually four knees had a residual FD of 15° (18.1%), three with 10° (13.6%) and five with 5° (22.7%). Which means that although a significant improvement was achieved in the flexion deformity, only 45.4% could have full knee extension and this goes with that preoperative FFD is one of the most common causes of persistent flexion contracture.

Semi-constrained condylar prosthesis was used in most of the cases (17 patients 77.2%) due the need of stemmed femoral component to strengthen the bone or the independable state of ligaments stability. The cases where a non-constrained prosthesis were used, a tibial stem was inserted to support load sharing on diaphyseal bone.

The most important finding of this study was the marvelous improvement in the knee functional scores and WOMAC score indicating high patient satisfaction after surgery upon which the risk-benefit of such a procedure should be highlighted. One patient failed to regain walking ability (due to medial femoral condyle (MFC) fracture), eleven patients could walk with assistance and three could regain their walking capability one year after surgery without assistance. With such results, we do
recommend TKRs in non-ambulant primary osteoarthritic patients with the terrible triad of muscle weakness, bone thinning and FFD but only after strict patient counseling of possible complications.

We are aware of the study limitations due to small sample size but this is explained by the rarity of the condition as it is a debatable issue whether to proceed for surgery or not as it carries a high risk of complications. Another limitation is due to the heterogenous technique for managing flexion deformity we cannot sit up a protocol to guide which technique should be followed for such cases and management of flexion deformity in such patient group should be individualized following the acceptable techniques of bone cuts and soft tissue release.

**Conclusion:**

Delayed proper timing for TKRs in primary osteoarthritis may lead to serious consequences in the form of muscle weakness, bone thinning and flexion contracture “terrible triad”. With advancement of disease, the physical activities of the patients are markedly affected with possible progression to non-ambulant status and patients prefer to be confined to wheelchairs. Although we had found a magnificent improvement in the functional objective scores and patient reported outcomes, higher than usual risk of possible complications in the form of residual deformity, intraoperative fractures and failure of surgery were recorded. Surgeons must be aware of the possible complications and to weigh the cost-benefit on individual basis. Patient education as regard the pros and cons of surgery is mandatory.
References


doi: 10.1097/01.NAJ.0000520240.29643.e2.


doi: 10.1016/j.arth.2008.06.014.


