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# Total knee arthroplasty in patients with extra-Articular deformity: A critical analysis

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**Abstract**
Total knee arthroplasty is the standard of care for the patients with severe degenerative joint disease. There are still controversies among surgeons about restoring alignment in knee with Extra Articular Deformity. Some author reports corrective osteotomy to align anatomical axis there by restoring mechanical axis indirectly, while others restores mechanical axis directly using special instruments. We conduct a qualitative analysis of outcome in restoring mechanical axis directly and indirectly by, Post op alignment, Perioperative morbidity, Advantages and disadvantages of devises used for osteotomy fixation, Merits and demerits of navigation and Period of rehabilitation. Twenty five articles have been identified with Extra Articular Deformity. Twelve are evaluating outcome of single stage corrective osteotomy coupled with Total Knee Arthroplasty, two studies about dual stage Corrective osteotomy with Total Knee Arthroplasty. Seven are restoring mechanical axis by intra articular correction using computer assisting navigation, and three achieving Mechanical axis by intra articular correction using Patient Specific Instrumentation, and remaining one is a comparative study between intra articular correction with Extra Articular Deformity. Our review shows that average preoperative deformity is slightly higher (>20* in coronal plane) in Extra articular correction group than Intra articular correction. But restoration of mechanical axis is superior with intra articular correction than with corrective osteotomy, more over complications like delay in rehabilitation, non-union, delayed union, and infections at osteotomy site are reported in extra articular correction which are not there with deformities corrected intra-articularly. Considering overall outcome, extra-articular deformity corrected by intra-articular resection carries good postoperative alignment with less complication rate. But not sufficient studies are available to support intra articular correction in knee with higher degree of extra articular deformity. As most of the studies with intra articular correction of extra articular deformity provides encouraging results not much studies supporting it with higher extra articular deformity.

**Keywords:** Knee arthroplasty, Deformity correction knee arthroplasty, intra articular correction, Extra articular correction

## Introduction
The incidence of knee osteoarthritis are increasing in trend, with view to upgrade quality of mobility and restore function patient with symptomatic OA often require total knee arthroplasty. In many case studies TKA shows excellent results with minimal complication rate. But in situations like pre-existing deformity of bone or soft tissue pathology can lead to raise the complication rate from 5% to 41% [1]. Aiming to improve the result of total knee arthroplasty in special situation clinical researches and technological researches are being made throughout the world. Success of total knee arthroplasty depends on number of factors starts with a) Patient selection, b) Appropriate prosthesis, c) Ligament balancing, d) Co morbid medical condition, e) Surgeon skill, f) Duration of surgery, g) Post-operative alignment of limb, h) Post-operative care [2].
Many studies express coronal plane alignment in anatomical axis, mechanical axis and vertical axis [3], whereas sagittal plane alignment is not much spoken. In a observational study of 76 TKA Jai-Gon Seo *et al* expressed sagittal mechanical axis is 2.4* flexed with palpable sagittal axis which is the line joining lateral epicondyle to anterior margin of greater trochanter [4]. To align the limb while performing TKA there are two schools of thoughts. One group of surgeons correcting mechanical axis directly and leaving the deformity undisturbed.

While others correcting anatomical alignment there by restoring mechanical axis indirectly. Correction of anatomical axis requires separate osteotomy and fixation with implants of various options. Restoring alignment is the prime concern while performing total knee arthroplasty in knee with EAD and is very essential to reduce abnormal loading over the prosthesis. However there are only limited studies critically analysing a) Perioperative morbidity, b) Post-operative alignment, c) Advantages and disadvantages of devises used for osteotomy fixation, d) merits and demerits of computer assisted navigation, e) Roll of Patient Specific Instrumentation, f)Period of rehabilitation while performing TKA in knee with EAD. The aim of this study is to review the available literature regarding different methods of arthroplasty procedures performed on degenerated knee with EAD, and their postoperative alignment, complication associated with corrective osteotomy and rehabilitation time. This review includes patients whose TKR has been done for osteoarthritis with extra articular deformity. Majority of cases included in the study used posterior stabilised prosthesis design by Medial Para Patellar approach in both groups. EAD situated in distal 1/3 of femur and proximal 1/3 of tibia in majority of cases performed arthroplasty with corrective osteotomy group. The outcome of procedure assessed by post-operative Hip Knee Ankle angle, Range Of Movement, Residual limb length discrepancy, start of full weight bearing from the day of surgery, and associated complications encountered. A detailed search has been done in Med-line (pub med), Google scholar and Knowledge Genie to get the details of most of the recent papers published.

**Should all the deformity be corrected?**

The question still prevails among orthopaedic surgeons. A group of well conducted studies have given mutually conflicting data. Twenty five articles have been identified with EAD. Twelve are evaluating outcome of single stage corrective osteotomy (CO) coupled with TKA, two studies about dual stage Corrective osteotomy with TKA. Seven are restoring mechanical axis (MA) by intra articular correction (IAC) using computer assisting navigation (CAN) without deformity correction, and three achieving Mechanical axis by IAC using Patient Specific Instrumentation (PSI) again without correcting deformity, and remaining one is a comparative study between IAC with EAC. Nine studies where prospective. Eleven studies where case reports. Three where level – IV, and case series studies

**Extra atricular deformity**

Extra articular deformity is defined as one with preoperative radiograph showing uniplanar or multiplanar deformity in shaft of femur or tibia resulting in gross alteration of limb neutral mechanical axis leads to secondary osteoarthritis of knee joint [5]. Most of the extra articular deformity in review results from previous fracture malunion. Some articles reported aetiology of EAD due to malunited osteotomy. Relative less number of cases reported with Paget disease [6] Hypophosphatemic rickets [7], Congenital dysplasia [8], Post-polio sequelae [9, 10].

While performing TKA in a knee with complex deformity the surgeon must understand the quantity and quality of the deformity, which exerts direct and indirect impact over the joint. Normally degenerative knee with complex deformity are classified by [20].

**Table 1**

| | |
|---|---|
| Bone involved | a)Femur b)Tibia |
| Type of deformity | a) Varus b) Valgus c) Recurvatum d) Antecurvatum |
| Cause of deformity | a) Fracture malunion, b) Result from osteotomy, c) Dysplasia |

**Mechanical Axis**

It's the weight bearing axis of the lower limb. Restoring it is important, without which prosthesis goes for early failure due to abnormal joint reaction force. In deformed knee arthroplasty has to be done where knee has to be brought towards mechanical axis in such a way that it bisects the joint equally. There are two schools of thoughts to achieve this.

a) One to initially restore the anatomical axis with corrective osteotomy and then to perform routine arthroplasty [1].

b) While the second group votes to leave the deformity as such and align the knee to the mechanical axis there by nullifying the abnormal force acting on the joint. This can be achieved either by computer aided navigation or patient specific instrumentation [1].

While restoring mechanical axis much importance given to coronal plane whereas mechanical axis in sagittal plan given least importance in literature. In one study Wang *et al* states 15* of recurvatum and 16* of antecurvatum of the femur is amenable to correct intra articularly [22].

This is because knee as a hinge joint moves only in sagittal plane and its deviation can be easily masked (Fig. 1). In a study of 76 TKA Seo J *et al*. [4] suggest, the sagittal mechanical axis is calculated with help of palpable sagittal axis, which is 2.4* anteriorly angulated with sagittal mechanical axis [4]. Restoration of sagittal mechanical axis is more important with flexion deformity than with recurvatum. This is because failure to restore Mechanical Axis in recurvatum can be compensated by knee flexion. Whereas in flexion deformity further extension is not possible for compensation, leading to abnormal forces transmitted to prosthesis leads to excessive wear and early failure.

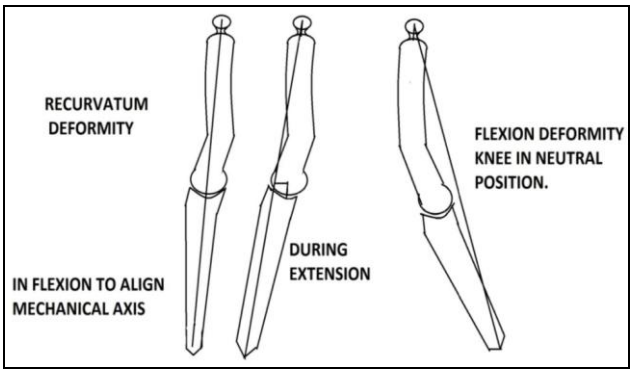


**Fig 1**

**Principles in restoring mechanical axis**

While addressing knee with complex deformity surgeon must look for quality of bone, existing deformity, deformity distance from joint line, footprints of previous surgery, and insitu implants [23]. The common principles instituted by many surgeons includes, a) Templating over preoperative roentgenogram, where a perpendicular line drawn far distally over the femur from the line joining centre of head with

centre of joint and if it negotiate collateral ligament extra articular correction is inevitable. The tibial deformity in which line drawn along the long axis of tibia passes out of joint line without crossing the articular surface, requires extra articular deformity correction [16].

b) Knee with deformity of more than 15* and 30* in femur and tibia respectively in coronal plane are not amenable to intra articular correction, which requires corrective osteotomy [20, 24, 9].

c) Another author gives much simpler guide that when preoperative deformity of femur or tibia or combined exceeds 20* in coronal or 25* in sagittal plane requires extra articular procedure [24]. Corrective osteotomy can be simultaneous coupled with TKA or Staged.

**Perioperative morbidity**

The overall success of TKA with EAD relays on two components, one is postoperative alignment and second is to minimise the expected complication. We scrutinize both case reports and prospective studies in respect of perioperative complications like peroperative fractures, reference pin site complication, non-union of osteotomy site, infections, occurrence of deep vein thrombosis, pulmonary embolism, wound dehiscence, post-operative stiffness. In a largest study of EAC by Madelaine A *et al.* [6], with two non-union of osteotomy site requires secondary procedure with bone grafting. On overall EAC group out of fifty-eight patients eight developed non-union of osteotomy site. On analysing the devise used for osteotomy fixation most of the non-union resulted with osteotomy stabilised with press fit long stem prosthesis. Out of osteotomy fixed with extra medullary device no complications regarding osteotomy reported. There are no correlations between period of weight bearing and non-union of osteotomy site in the review. Two cases in EAC and one in IAC group required postoperative manipulation for stiffness on referring the postoperative rehabilitation protocol all three patients started full weight bearing immediately. Other perioperative complications like deep vein thrombosis, pulmonary embolism, lesion of patellar tendon, infections are reported only less number of cases.

**Post-operative alignment**

Successful total knee arthroplasty based on successful restoration of neutral mechanical axis. Numerous principles and methodologies are established to attain proper alignment. Collectively these are broadly classified into Intra Articular Correction and Extra Articular Correction [11].

**Intra articular correction**

There are literatures on isolated non-comparative outcome studies on IAC from various parts of the world. Authors reported their immediate postoperative alignment by IAC with various system including computer assisted navigation (Klein *et al.* [12], Hamada *et al.* [13], Catani *et al.* [14], Tigani *et al.* [9], Rhee *et al.* [5], Bottros *et al.* [15]), Extra Medullary Jig guidance (Wang *et al.* [16]), Patient Specific Instrumentation (Thienpont *et al.* [17]). All the studies reported post-operative alignment between 0.2*-1.5*. Most notable study in this group is by Catani *et al.* [14] He achieved around 0.8* of postoperative mechanical axis deviation with preoperative mechanical axis of 10.4* with 20 knees.

**Extra articular correction**

Unlike intra articular corrections only limited data available regarding correction of extra articular deformity there are fifteen studies available in this review of which eleven are case reports. In 2014, Madelaine *et al.* [6] with 15 knees reports correction of mean MA from 19.2* preoperatively to 10* postoperatively. In this study overall survival at 22 month follow up was 86.7%. In other study Radke *et al.* [18] with 10 knees mean postoperative correction was 8* from preoperative deformity of 20.5*. Two other case reports from Lesiak C *et al.* [19] with 2 knee and Wilson J *et al.* [20] with one knee had executed dual stage correction of deformity and TKA with post-operative alignment of less than three degree of desired Mechanical Axis.

**Table 2:** Pre and post-operative alignment in extra articular correction group.

| | Preoperative | | | Postoperative | | |
|---|---|---|---|---|---|---|
| **Authors** | **ROM** | **MA** | **LLD** | **ROM** | **MA** | **LLD** |
| Lesiak A *et al* | NA | 21* | 5.3cms | 0-120* | NA | 1.5cm |
| Lonner J *et al* | NA | 29.4* | NA | NA | 1.4* | NA |
| Moyad T *et al* | NA | 30* | NA | NA | NA | NA |
| Rattanaprichavej P *et al* | 10-100* | 18.1 | 5cms | 10-115* | 4.6* | 2.5cm |
| Attar F *et al* | 5-100* | NA | NA | 0-120* | NA | NA |
| Hartford J *et al* | NA | NA | NA | NA | NA | NA |
| Eid M *et al* | NA | 14.3* | 1.8cms | NA | 2* | NA |
| Meehan J *et al* | 5-120* | 35* | NA | NA | 2* | NA |
| Xiao-Gang Z *et al* | 7-30* | 6.5* | NA | 3-105* | NA | NA |
| Hazratwala K *et al* | 3-82* | NA | NA | 0-115* | NA | NA |
| Fan J *et al* | 0-100* | 20* | NA | 0-110* | NA | NA |
| Wilson A *et al* | 5-90* | 11* | NA | 0-95* | NA | NA |
| Fletcher M *et al* | NA | NA | NA | 0-105* | NA | NA |
| Radke S *et al* | NA | 20.5* | NA | NA | 8* | NA |
| Madelaine A *et al* | NA | 19.2* | NA | NA | 10* | NA |
| Mean | 5-88.8* | 20.4* | 4.03cms | 1.8*-111* | 4.6* | 2cms |

ROM-Range of Motion, MA-Mechanical Axis, LLD- Limb Length Discrepancy.

**Osteotomy and fixation**

All extra articular correction are made usually with corrective osteotomy in most of the literature closing wedge osteotomy is performed whereas Wilson *et al.* [20] reported clamshell osteotomy in a case of femoral diaphyseal malunion followed by TKA in dual stage. Out of fifteen literatures nine used long steamed implant for osteotomy fixation and five of these nine literatures reported to have non-union at osteotomy site. Other fixation devices such as, T-shaped tibial plate, femoral blade-plate, Ilizarov Frame, locking compression plate. None of the osteotomy fixed using extramedullary device report non-union. On scrutinising the rehabilitation protocol invariably

all osteotomy with intramedullary stabilisation instituted with full weight bearing in first post-operative day.

**Table 3:** Osteotomy stabilisation devise in different study and complications.

| Authors | Cases | Stages | Device Used | Complications |
|---|---|---|---|---|
| Lesiak A *et al* | 2knee | 2 stage | Ilizarov Frame, plate osteosynthesis, antibiotic nail | 1 to 2cm shortening, one failed osteotomy requires multiple procedure |
| Lonner J *et al* | 11 knee | 1 stage | blade-plate in seven patients, a press-fit long-stemmed femoral component in two, and a retrograde femoral nail in two. | one nonunion with long stem, one pulmonary embolism, two post op mannupulation, |
| Moyad T *et al* | 1 knee | 1 stage | press fit long splinted stem for both tibia and femur | NCR |
| Rattanaprichavej P *et al* | 3 knee | 1 stage | retrograde femoral nail, long stem tibial prosthesis, lag screws | non union retro femoral nail, for which bone graft and plate fixation |
| Attar F *et al* | 1 knee | 1 stage | pressfit long stem | NA |
| Hartford J *et al* | 2 knee | 1 stage | long stem with locking t compression plate | NCR |
| Eid M *et al* | 9 knee | 1 stage | locking plate, staples, long stem with locking screw. | non prograssive radiolucent line in 2 knee |
| Meehan J *et al* | 1 knee | 1 stage | T shape tibial plate | NCR |
| Xiao-Gang Z *et al* | 2 knee | 1 stage | Long stemed prosthesis. | 1Delayed union. |
| Hazratwala K *et al* | 1 knee | 1 stage | retrograde femoral nail, | NCR |
| Fan J *et al* | 1knee | 1 stage | retrograde femoral nail, | nonunion |
| Wilson A *et al* | 1knee | 2 stage | retrograde femoral nail, | NCR |
| Fletcher M *et al* | 1knee | 1 stage | Long stemed prosthesis. | NA |
| Radke S *et al* | 10 knee | 1 stage | Long stemed prosthesis. With tension wiring | 1 thrombosis, one delayed union |
| Madelaine A *et al* | 15knee | 1 stage | Long stemed prosthesis. With blount staples or Plate. | 4 perioperative fracture, 2 nonunion, 1 infection, 1 postop stiffness |

**Computer assisted navigation**

Computer assisted navigation system was developed in view of improve the accuracy of bony cuts while performing TKA. And subsequently it became a boon for TKA with EAD and or retained implant [9]. Navigation assisted TKA was first documented in 1997 since then various types of navigation system introduced and practiced among arthroplasty surgeon [21]. Even the yield of navigation providing superior alignment to conventional method on routine knee arthroplasty is debatable; its effectiveness over conventional method in knee with EAD is equivocal. Wang J *et al*. [2002] [16], in his study of 14 knee with EAD quoted that only <20* of extra articular femoral deformity are amenable to correct intra articularly but Tigani D *et al*. [2011] [9] reporting two cases with 24* of coronal deformity in femur producing less than 3* of neutral mechanical axis using CANS which is the highest degree of coronal deformity corrected in our review. In a study Catani *et al*. [[14] 2011] reports improvement in TKA with EAD using CANS with 20 knees is the largest series in our review. In this study author suggests even with increment in Tourniquet time (TQ) of 98 min which is 30 min longer than conventional TKA no complications related to alignment errors, or preoperative complications reported. In our review out of total sixty three knee under gone computer assisted navigation only one knee report to have reference pin rupture [9], and one residual limb length discrepancy no other potential complications like infection, periprosthetic fracture, requirement of revision are not reported. Apart from drawbacks of navigation like increase TQ time, long learning curve there are no pit falls of navigation assisted arthroplasty in TKA with EAD.

**Table 4:** Pre and post operative alignment in computer assisted iac of ead.

| | Pre-Operative | | Post-Operative | |
|---|---|---|---|---|
| **Authors** | **Rom** | **MA** | **Rom** | **MA** |
| Bottros J *et al*. | 4-74* | NA | 0.6-90* | 1.3* |
| Hamada D *et al*. | 10-75* | 10* | 4-96* | 1* |
| Catani F *et al*. | 7-74* | 10.4* | 0-94* | 0.8* |
| Klein G *et al*. | NA | NA | NA | 0.6* |
| Tigani D *et al* | 0-68* | 10.7* | 0-81* | 1.5* |
| Rhee SJ *et al*. | NA | 7.2* | NA | 0.2* |
| Mean | 6-80* | 9.5* | 1-90* | 0.9* |

**Patient specific instrumentation**

As the incidence of degenerative arthritis with EAD presented for TKA is less and availability affordability and awareness of custom made patient specific instrumentation is not up to comparable level with other methods of intra articular correction there are not much literatures reporting PSI [11]. In our review one article, where Thienpont *et al*. [2013] [17] reporting usage of PSI for arthroplasty with EAD in ten knees. This study provide encouraging results with restoration of MA from 8.3* to 0.7* and improvement of mean range of movement from 87* to 112* and claims to have no post operative complication. Cost is another important factor Barrack RL *et al*. [11-49] in his study the mean raise in cost of PSI on compare to conventional TKA is $1178, Thienpont *et al*. [2015] [11-50] in another study with 80TKA stats average of 40% of total cost spent on manufacturing and imaging in PSI. Hence by available Literature even reduction in TQ time compared to navigation assisted TKA and free of drawbacks like easy learning curve PSI system carries disadvantages like cost, and availability. Yet many other studies have to come with PSI for assessment of PSI in arthroplasty of knee with EAD.

**Rehabilitation following tka with ead**

In our review all patients with who undergone IAC follow routine TKA post-operative protocol with immediate full weight bearing. In patients undergone EAC course of rehabilitation protocol altered according to type of osteotomy, and device used for osteotomy fixation with overall period taken for full weight bearing of 30 days. Out of fifteen studies four used isolated press fit long stem prosthesis without any additional augmentation, four used long steamed prosthesis with additional augmentation with staples, t-plate, wiring, locking screws, three studies used retrograde femoral nailing, two studies used mixed implants like long steamed prosthesis, compression plate, retrograde nail, blade plate, lag screws. Remaining two studies used extramedullary devises like locking plate, external fixation devises. Out of all EAD three authors follow delayed weight bearing with average of 13.2 weeks after the arthroplasty and all three single staged corrective osteotomy with arthroplasty. Madelaine *et al* in his study of fifteen knee with single stage EAC who follow delayed weight bearing report mean post-operative flexion of 115* which was reduced from 120*preoperatively with correction of preoperative fixed flexion deformity of 2.3*. Studies following early weight bearing and passive movements, achieved mean range of movement up to 110* from 83*preoperatively in EAC group and 89* from 74* in IAC group. This concludes that extra articular deformity undergone EAC with immediate rehabilitation protocol is superior to both IAC and EAC with delayed institution of rehabilitation.

**Conclusion**

As most of the studies with intra articular correction of extra articular deformity provides encouraging results but, not much studies supporting it with higher EAD (>20* in coronal plane). Even EAC doesn't seem superior to IAC in restoring mechanical axis, it can able to provide acceptable post-operative mechanical axis with good postoperative range of movement. Intra articular correction with Patient Specific Instrumentation or extramedullary jig guidance even producing good postoperative alignment, sizable volume of studies still lacking to access its benefit. With this data we conclude that in spite of intra articular correction of extra articular deformity looks safer extra articular correction is mandatory for knee with higher degree of extra articular deformity.

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