Articoli storici
A cura di Gianluca CANTON

Kettelkamp, DB , Leach, RE , Nasca, R. : Pitfalls of proximal tibial osteotomy. Clin Orthop 106:232–241, 1975

In questo lavoro del 1975 gli autori descrivono gli errori più comuni e le insidie correlate all'intervento di osteotomia tibiale prossimale, divisi in errori di valutazione (o selezione) del paziente ed errori tecnici. E' interessante notare come a distanza di più di 40 anni le raccomandazioni riportate siano ancora assolutamente valide e come le complicanze e le insidie da affrontare restino sostanzialmente le stesse.

Extended abstract

Proximal tibial osteotomy for degenerative genu varus and valgus has an excellent success rate with proper patient selection and technical proficiency. The aim of the study is to present some infrequently recognized pitfalls of proximal tibial osteotomy. The authors group pitfalls in evaluation and technical pitfalls.
Evaluation pitfalls include tibial plateau bone loss, patellofemoral arthritis, loss of joint space, articular surface obliquity and medial collateral ligament laxity. Technical pitfalls include loss of correction, peroneal nerve palsy and plateau fracture.
Excessive bone loss from one plateau prohibits weight bearing on both plateaus after osteotomy and results in an unstable knee. The authors call this situation the "teeter effect" as the tibiofemoral contact teeters from one side to another. Osteotomy as a single corrective procedure in this situation is contraindicated.
Patellofemoral arthritis and loss of joint space must be ruled out preoperatively to prevent poor post-op results.
Proximal tibial osteotomy usually results in some degrees of articular surface obliquity, defined as the deviation of articular surface from a line parallel to the floor. If varus and planning indicates postoperative articular surface obliquity in excess of 10 to 15 degrees, another type of reconstruction is indicated (femoral osteotomy or arthroplasty), since excessive obliquity can cause medial subluxation of tibia or femur and lead to unsatisfactory results.
In degenerative varus deformity, medial collateral laxity seems to be secondary to loss of articular cartilage and bone, but seldom represents a problem after osteotomy. Conversely, varus osteotomy for valgus deformity with medial collateral laxity conducts to bad results, because when walking the medial thrust of the femur produces medial joint opening and recurrent valgus deformity. The authors advise to tight the ligament and to avoid excessive obliquity of articular surface when performing a proximal tibial osteotomy.
Inadequate correction or overcorrection are the most often discussed technical pitfalls in literature. Various methods to determine the desired amount of correction are described but none is precise. Attention must be paid during planning to joint space closure since it affects final amount of correction and may be source of under or overcorrection. Injury to the anterior tibial artery, aseptic necrosis, stress fracture of the tibial plateau may also result from technical problems; non-union or delayed union are uncommon.

Loss of correction is a rare complication if secure fixation, closing wedge osteotomy, and non-displacement of the distal fragment (to avoid setting the tibial dyaphisis under the caoncellous tibial plateau bone) are pursued. Peroneal nerve palsy may be avoided by careful surgical technique, working proximal and anterior to the nerve and with knee flexed during the procedure, as well as using soft postoperative dressings.
Cracking the apical cortex and visualization of the plateau fragment will usually prevent fracture. If a plateau fracture occurs, closure of the wedge has to be avoided until the osteotomy is complete and the apical cortex in cracked with an osteotome.

J Bone Joint Surg Am. 1987 Jan;69(1):32-8. Proximal Tibial Varus Osteotomy for Osteoarthritis of the Lateral Compartment of the Knee. M B Coventry. PMID: 3805069

Mark Coventry è stato uno dei padri fondatori del capitolo osteotomie di ginocchio e principale promotore a partire dalla fine degli anni 60 dell'osteotomia valgizzante in chiusura di tibia prossimale per il trattamento del ginocchio varo con artrosi del compartimento mediale. In questo lavoro del 1987 presenta la sua esperienza di osteotomie varizzanti in chiusura di tibia prossimale per il trattamento del ginocchio valgo con artrosi del compartimento laterale. Poiché negli ultimi anni l'assioma che il ginocchio valgo si corregga sempre sul femore è stato rimesso in discussione per tornare ad un approccio "deformity based" alle osteotomie, questo lavoro risulta di interesse estremamente attuale. Degna di nota la domanda che nell'introduzione l'autore si pone: "Where should a varus osteotomy for a valgus deformity in a knee with osteoarthritis of the lateral compartment be done? Should it be performed in the supracondylar region of the femur or through the proximal part of the tibia?"

Extended abstract

From 1960 through 1979, a closing wedge varus osteotomy of the proximal part of the tibia was performed in thirty-one knees (twenty-eight patients) for painful osteoarthritis of the lateral compartment of the knee that was associated with a valgus deformity.
All of the patients were disabled by pain that originated from the lateral tibiofemoral compartment. The degree of valgus deformity (anatomical axial alignment), as measured before the operation on a roentgenogram that was made with the patient standing, ranged from 6 to 25 degrees in all but one patient in whom it was 40 degrees. The mean valgus deformity was 13.6 degrees when the knee with the 40-degree valgus angulation was excluded from the calculation and 15.5 degrees when it was included. Preoperatively, the knee was assessed as being stable or having mild, moderate, or severe instability, based on the author experience. One knee had severe and four knees had moderate instability of the medial collateral ligament (apparently true instability). Two knees had moderate instability of the lateral collateral ligament (apparently from a lack of space-occupying cartilage).
Careful preoperative planning to determine the axial alignment and the amount of correction that are required is as essential for a varus osteotomy as it is for a valgus osteotomy. Proper roentgenograms may be difficult to make with the patient standing; they must be made with the lower limbs bearing the full weight and the knees must not be touching. If the knees are touching, they support each other medially and the true amount of valgus angulation may not be demonstrated. The amount of valgus angulation is then measured and the size of the wedge to be removed is calculated. As in valgus osteotomy, some overcorrection has been found to be

important. As in valgus osteotomy, recurrence of the deformity may be expected unless the axial alignment is overcorrected. From the experience in this study, an anatomical axial alignment of zero degree seems to be most desirable.
Surgical technique includes a medial approach, closing wedge osteotomy performed 2 centimeters distal to the joint line, proximal to the insertion of patellar ligament and tightening of the superficial portion of medial collateral ligament, which tents to loose after the removal of the wedge. Postoperatively, the knee is placed in a cotton compressive dressing and a plaster slab is placed posteriorly for 6 days; then a cast or cast-brace is applied for about 5 weeks. From the 2 day postop foot-touch weight bearing is encouraged with an assistive device; when the cast is removed, progressive weight bearing is allowed.
The patients were followed for two to seventeen years (average, 9.4 years). Twenty-four knees (77 per cent) had either no pain or only occasional mild pain at the last evaluation. Six knees had moderate pain and one, severe pain. Six knees required a subsequent total knee arthroplasty at an average of 9.8 years after the osteotomy. No patient had an infection or non-union.
Osteotomy of the proximal part of the tibia is a reasonable method of treating unicompartmental degenerative arthritis in a knee with a valgus deformity. Although some patients with as much as 20 degrees of anatomical valgus deformity obtained a good result in this series, osteotomy in the supracondylar region of the femur is probably preferable if the valgus angulation exceeds 12 degrees or if the tilt of the tibial articular surface that will result from the surgery will exceed 10 degrees. Correction beyond the normal 5 to 7 degrees of valgus angulation to zero degree of anatomical tibio femoral alignment is recommended to prevent recurrence of the valgus deformity and to decrease the load on the lateral tibiofemoral compartment

J Bone Joint Surg Br 1989 Aug;71(4):560-5. Surgical implications of varus deformity of the knee with obliquity of joint surfaces. T D Cooke 1, D Pichora, D Siu, R A Scudamore, J T Bryant

Questo articolo prende in considerazione un aspetto della pianificazione pre-operatoria che negli ultimi anni ha assunto sempre maggiore importanza: l'obliquità della superficie articolare. Già nel 1989 gli autori di questo lavoro analizzavano questa variabile sottolineandone l'elevata frequenza nella popolazione di pazienti affetti da artrosi e suggerendo l'esecuzione di un'osteotomia doppio livello per il trattamento sia della deformità che dell'orientamento articolare

Extended abstract:

Lower limb bone alignment, the integrity of capsular and ligamentous structures and articular surfaces' geometry are basic for knee stability. Instability and shifted load-bearing (medially or laterally) may predispose to osteoarthritis. Some arthritic knees with varus deformity show excessive valgus angulation of the femoral joint surface with proximal tibia vara. This causes a downward and medial inclination of the articular surfaces in the coronal plane.
The aim of this paper is to study the articular geometry of this condition and to evaluate the prevalence of this type of alignment in osteoarthritic population compared to normal volunteers.

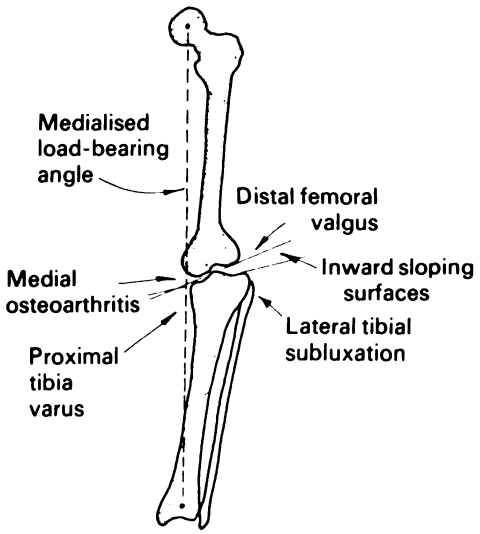
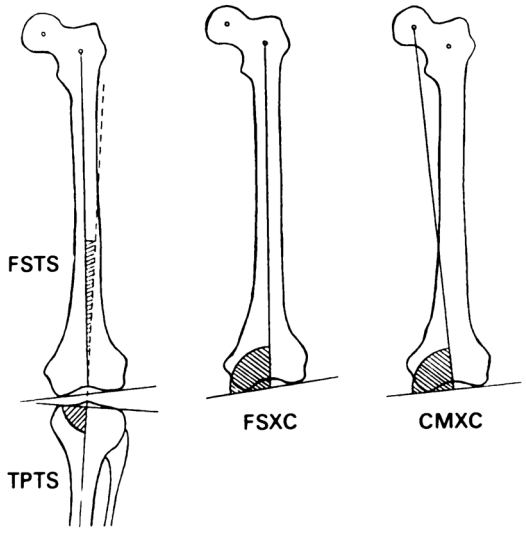


Fig. 1

For the first aim the first author selected in a period of 9 years 19 patients (38 knees) from 17 to 82 years (mean 66 years) with varus limb alignment, exaggerated distal femoral valgus, proximal tibia vara and medial compartment knee arthritis. 34 knees were included in the study, the others were excluded because of previous done osteotomy or total arthroplasty.
For the second aim, 8 patients (96 knees) aged 20 to 29 years (mean 24 years), without previous knee problems and clinical or radiographical osteoarthritis were selected for the "normal group". The "osteoarthritic"(OA) group consisted of 220 patient from 29 to 88 years, mean 66 years, presenting from 1981 and 1985; from this group, 419 knees who hadn't had osteotomy or total joint replacement were included in the study. The last 2 groups mentioned above received QPR (Questor Precision Radiographs), a standardized examination method for the lower limb in a weight-bearing position that permits to obtain anteroposterior and lateral radiographs, without changing the position of the patient, providing biplanar orthogonal assessment of knee geometry. The authors measure 4 angles: femoral shaft-tibia shaft (FSTS); femoral shaft-transcondylar (FSXC); capitomidcondylar-transcondylar (CMXC); tibial plateau-tibial shaft (TPTS).



The study group was characterized by genu varum deformity with proximal tibia vara and valgus distal femur. This pattern of deformity is characterized by FSXC major than 9° or CMXC greater than 3,8°, TPTS more negative than -3,3°, FSTS less than 3,9°. The prevalence of this type of deformity in the osteoarthritic patients was 11.5%;

Two case reports are discussed in the article: the first patient with bilateral varus knee and osteoarthritis in right medial compartment underwent double closing wedge osteotomies (varus femoral and valgus upper tibia), with excellent results in terms of pain and ROM. The second patient had a long standing history of knee pain and stiffness, with severe distal femoral valgus deformity, progressive varus deformity with lateral subluxation of the tibia; the situation worsened one year later with evidence on radiographs of loss of joint space, especially on medial side, lateral tibial subluxation and obliquity of joint line. The patient underwent left total knee replacement, but the femoral component was orientated in excessive valgus with some internal rotation following the internal axial rotation of the femoral condyles, FSXC angle was 13°, TPTS angle was -6°, on lateral radiographs view patella dislocation was evident and so a revision was required.
Although relatively uncommon, this pattern of deformity warrants special consideration. Case 1 illustrates that stabilisation may be achieved by combined femoral and tibia osteotomies to restore the slant of the joint surfaces to near horizontal, and we would anticipate a lower success rate with tibia osteotomy alone. In total knee replacement, we also advocate horizontal alignment of the articulating surfaces. However, it is possible that the femoral component becomes positioned according to the internal axial rotation of the femoral condyles, which we have noted in several such cases. This accentuates any lateral shift of the patella (predisposing to patellar subluxation) and may complicate closure of the wound.
Careful diagnostic radiology is needed to identify this pattern of deformity. A full length standing radiography is the minimum requirement, but QPR provides a standardised method.

J Bone Joint Surg Am 1989 Feb;71(2):245-8. Observations on patellar height after proximal tibial osteotomy. G R Scuderi 1, R E Windsor, J N Insall

L'altezza della rotula e la sua modifica dopo un'osteotomia di tibia prossimale rimane un argomento attuale di discussione in particolare nel confronto tra tecniche di osteotomia in chiusura e in apertura. In questo lavoro del 1989 Scuderi sottolinea già questo aspetto, in particolare in correlazione con l'eventuale necessità di protesizzazione, dimostrando quanto possano influire la tecnica chirurgica e la gestione post-operatoria

Extended abstract

Proximal tibial osteotomy has proved to be a satisfactory surgical technique for the treatment of unicompartmental osteoarthritis and angular deformity of the knee, and it does not modify the results of a subsequent total knee arthroplasty. However, it has been observed that the surgical exposure of the proximal part of the tibia and the eversion of the patella during arthroplasties that were done for a failed proximal tibial osteotomy were more difficult. The distance from the tibial tubercle to the joint line appeared to be less than normal, and the patellar ligament was shorter than in knees that had not had a proximal tibial osteotomy. The purpose of the current study was to determine if the presence of patella infera after a proximal tibial osteotomy was in any way related to the subsequent need for a total knee arthroplasty.
Sixty-six knees (sixty patients) that had a proximal tibial osteotomy were evaluated to determine if any alteration of the patellar height had occurred as a result of the operation.
These knees were treated at The Hospital for Special Surgery between 1965 and 1976.

The patellar height was measured on lateral radiographs, with the knee in 30 to 60 degrees of flexion. Both the Insall-Salvati and the Blackburne-Peel method were used to determine the height of the patella.
Twenty of the sixty-six proximal tibial osteotomies in the study group subsequently needed revision to a total knee arthroplasty. The patellar heights in this subgroup were compared with those in the over-all group.
The average preoperative patellar height in the fifty-five knees for which preoperative radiographs were available was 1.06 (range, 0.55 to 1.38) using the Insall-Salvati ratio and 0.93 (range, 049 to 1.28) using the Backburne-Peel ratio. Patella infera was found in two and one knee respectively.
The average post-operative patellar height for the sixty-six knees was 0.93 (range, 0.48 to 1.51) using the Insall-Salvati ratio, and 0.84 (range, 0.41 to 1.20) using the Blackburne-Peel ratio. Patella infera was present in eleven and five knees respectively.
After calculating the change in the patellar height after the osteotomy, 89 per cent of the patellae, as measured by the Insall-Salvati index, and 76.3 per cent, as measured by the Blackburne-Peel index, were observed to be lowered as they appeared on the postoperative lateral radiograph. No correlation could be found between the lowering of the patellar height after a proximal tibial osteotomy and the subsequent need for a total knee arthroplasty. Of the twenty osteotomies that needed revision to total knee replacement, all of knees had lowering of the patella, but only four had patella infera using the Insall-Salvati method, and only one knee had patella infera using the Blackburne-Peel method.
The true incidence of patella infera in knees that need a total knee replacement is probably between the 80% reported by Windsor et al. and the 11% reported by Staeheli et al.
In conclusion the patellar height is lowered in the knees of most patients who have a proximal tibial osteotomy. This is probably due to several factors: the fibrosis of the patellar ligament after prolonged immobilization in a cast, interstitial scarring of the patellar ligament, and new-bone formation at the site of the osteotomy in the area of insertion of the patellar ligament.
However, there was no correlation between the postoperative height of the patella and the need for subsequent revision to a total knee replacement.

Clin Orthop Relat Res 1990 Nov;(260):61-5. Late recurrence of varus deformity after proximal tibial osteotomy. M J Stuart 1, J N Grace, D M Ilstrup, C M Kelly, R A Adams, B F Morrey

La perdita della correzione e la progressione della malattia artrosica a lungo termine rimangono problematiche da considerare attentamente nella pratica clinica. Questo lavoro del 1990 mostra chiaramente la correlazione tra queste due problematiche in una casistica di 113 osteotomie tibiali valgizzanti in chiusura secondo la tecnica classica descritta da Coventry.

Extended abstract

In literature, a satisfactory result of a valgus-producing osteotomy for medial gonarthrosis and genu varum was obtained in approximately 75% of patients at five years and 60% of patients at ten years after surgery. The aim of the study was to assess the clinical and radiographic results of proximal tibial osteotomies with specific reference to the probability of varus recurrence and arthritic progression.
One hundred thirteen knees with medial gonarthrosis in 95 patients were treated by valgus-producing proximal tibial osteotomy between 1975 and 1979 and followed clinically and

radiographically for a minimum of five years (mean, 6.3 years). The average age was 58 years (range, 33-75 years). Seventy patients were men, and 25 were women.
The surgical technique involved a lateral cosing wedge osteotomy of the tibia proximal to the tubercle as described by Coventry. Fixation was obtained by one- or two-step staples and the use of a cylinder cast for approximately one month after surgery.
To assess the loss of valgus correction, the femorotibial angle was measured on preoperative and postoperative standing x-rays, while the status of the medial and lateral compartments of each knee was compared with sequential x-rays with reference to joint-space width, subchondral sclerosis, and osteophyte formation to determine arthritis progression. Recurrence of varus deformity was defined as greater than a 5° change in the femorotibial alignment achieved at surgery. Medial- and lateral- compartment arthritic progression were represented by increased degenerative changes on sequential x-rays. Clinical variables (subjective result, pain, cane use, and distance walked) were also considered.
At the final follow-up examination (average 9 years after surgery), 64 knees (57%) were pain free or had only mild discomfort when walking. The standing femorotibial angle decreased from a postoperative average of 9.3 degrees valgus to 7.8 degrees valgus at the final follow-up examination. The tendency for varus recurrence greater than 5 degrees and for medial- or lateral-compartment arthritic progression was evaluated using the Kaplan-Meier survival method. By nine years after surgery, varus recurred in 18%, lateral-compartment arthritic progression was evident in 60%, and medial-compartment arthritic progression in 83%.
The group with varus recurrence and medial-compartment arthritic progression and the group with mediolateral progression had significantly more pain when walking than the group with no significant change in alignment or arthritis.
Other studies in lieterature described recurrence of varus deformity. Coventry and Bowman reported reversion to a varus deformity as the most common complication after a mean follow-up of six years, and they concluded that a varus recurrence was due to inadequate correction at the time of surgery. A favorable result was correlated with a postoperative femorotibial angle of 7°-9° and opening of the medial joint space.
Insall stated that the most important factor contributing to the result was the passage of time and that the reason for deterioration was always a recurrence of pain.
The current study demonstrated a small average loss of correction with time (1.5°) with only a 18% probability of varus recurrence greater than 5° by nine years after surgery.
Patients with significant loss of correction all had radiographic evidence of arthritic progression and poor prognosis.
The probability of arthritic progression is much higher than the probability of significant varus recurrence in long-term radiographic follow-up studies of patients with valgus-producing proximal tibial osteotomies. A definite relationship exists between the presence of pain and varus recurrence or arthritic progression.

Noyes, FR , Barber, SD , Simon, R. : High tibial osteotomy and ligament reconstruction in varus angulated, anterior cruciate ligament-deficient knees. A two- to seven-year follow-up study. Am J Sports Med 21: 2–12, 1993

In questo lavoro del 1993 Noyes affronta il problema del ginocchio varo associato ad insufficienza del LCA nei pazienti giovani attivi e sportivi, introducendo un dibattito che rimane ancora attuale tra osteotomia isolata e osteotomia associata a ricostruzione LCA

Extended abstract

Proximal tibial osteotomy is a widely accepted procedure as a treatment option for patients with unicompartmental osteoarthritis of the knee and varus deformity of the lower extremity.
Though several studies in literature present the results of this procedure for older population, only few authors investigated the success rates of high tibial osteotomy (HTO) for younger patients, especially those aged 25 to 45. Patients with unicompartmental arthrosis occuring secondary to meniscectomy, articular fracture, joint instability, or injury can be the most difficult to treat and successfully restore lower limb function. It is still not clear if HTO allows a patient to return to athletic activities safely since some degree of joint arthrosis is usually present. Another issue is represented by an ACL deficiency, especially concerning the need for ligament reconstruction. The purpose of this report is to assess short-term treatment results for patients with varus alignment and ACL deficiency, analyzing three patient groups, two of which underwent HTO and a ligament reconstruction, and one that had HTO only.
We assessed short-term treatment results of younger patients with varus malalignment and chronic anterior cruciate ligament deficiency. Forty-one patients (mean, 32 years; range, 16 to 47) underwent a high tibial osteotomy. Because of giving way symptoms, 14 also had a lateral iliotibial band extraarticular procedure at the time of the osteotomy and 16 had an intraarticular anterior cruciate ligament allograft reconstruction after the osteotomy.
A diagnostic arthroscopy was performed just before the HTO, at which time meniscal and articular deterioration were recorded and meniscal tears appropriately treated. Thirty-seven patients (90%) had abnormal medial compartment surfaces. The lateral tibiofemoral surfaces were relatively intact. Abnormalities of the patellofemoral joint were found in 23 patients (56%).
All returned for follow up (mean, 58 months; range, 23 to 86), which included an interview for the subjective and functional analyses, an instrumented arthrometer test for the anterior-posterior displacements (KT-1000 arthrometer testing), a complete knee examination, and a radiographic evaluation. An overall rating score was calculated for each patient.
Statistically significant ($P < 0.05$) improvements were found in the mean overall rating scores for pain, swelling, and giving way. Preoperatively, 30 (73%) had pain with activities of daily living or with any sports activity; 11 (27%) could perform only light sports activities without pain. At follow up, 32 patients (78%) had no pain with activities of daily living or light sports, and 24 of 41 of the patients (59%) had returned to sports with no symptoms.
Ten of 15 patients with advanced medial tibiofemoral arthrosis (subchondral bone exposure) had significant improvements in symptoms.
Patient satisfaction was high: 88% stated they would undergo the procedure again and 78% felt their knee condition was improved. Patients who had the allograft reconstruction had significantly lower ($P < 0.05$) anterior-posterior displacements at follow-up than those who had the extraarticular procedure.
The radiographic evaluation performed in the early postoperative period showed that 37 of the 41 (90%) patients were surgically corrected with a weightbearing line between 50% and 80%, and at the final follow-up examination, 25 patients (61%) still demonstrated optimal correction.
Because of complications, three patients underwent repeat osteotomies: two settled into valgus 16 months postoperatively, one underwent loss of fixation at the site of osteotomy at the 4^{th} postoperative week.
This report is a short-term study with a mean follow-up of 58 months, so no comparison is possible with prior tibial osteotomies studies that documented the deterioration of initial short-term beneficial results over the long term.

The study's population represents the worst-case scenario, as the patients were young and athletically active, and the knees, for the most part, were seriously affected before the osteotomy. The results showed significant improvements for the population for all the symptoms analyzed, in particular regarding pain. However, patients typically modified their sports activities and did not return to vigorous or strenuous sports.
An important finding was the lack of correlation between the satisfaction questions and the overall rating scores. This indicates that patients take other variables into account. Future studies that assess general outcome should consider assessing these types of variables.
We concluded that osteotomy should be performed early in the disease process for younger athletes who experience symptoms with activity. It may be unrealistic, however, to expect continuation of sports beyond light recreational, given the joint arthrosis that is usually present and the high in vivo joint loadings with athletes. Anterior cruciate ligament reconstruction should be considered when giving way previously occurred and the patient plans to resume athletics. However, patients with advanced arthrosis can avoid anterior cruciate ligament surgery by reducing athletic activities.
Now, in most knees the osteotomy is first performed, and secondly, we perform an arthroscopically assisted ligament reconstruction. So, the patient has time to fully recover from the osteotomy, and giving-way symptoms can be assessed after the osteotomy.

Paley D., Herzenberg J.E., Tetsworth K. Deformity planning for frontal and sagittal plane corrective osteotomies. Orthop Clin North Am. 1994;25:483–498.

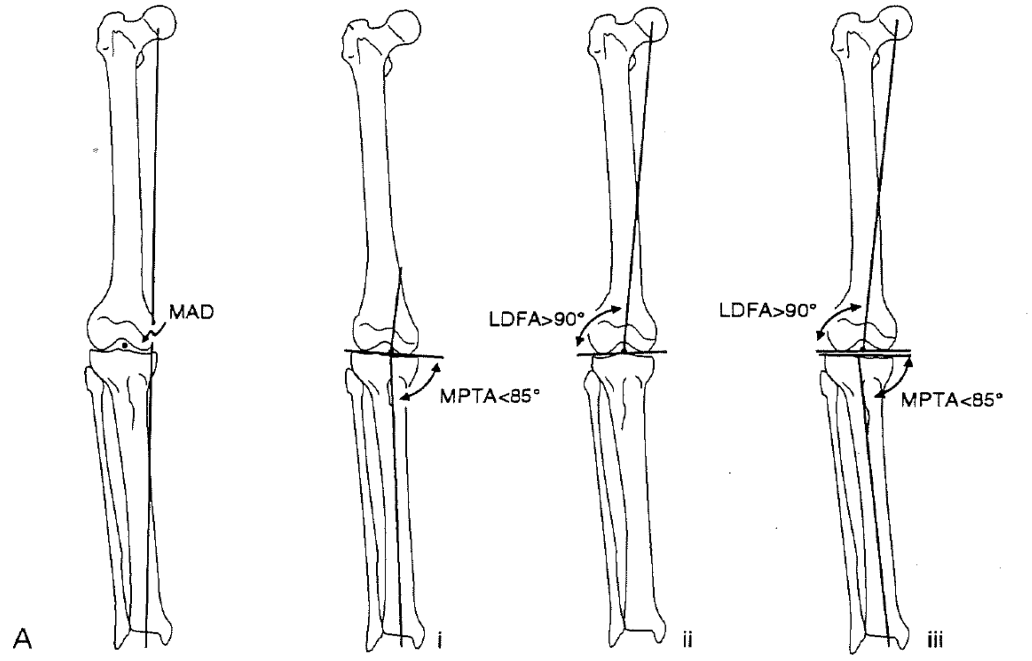
Questo lavoro del 1994 rappresenta una pietra miliare nel panorama delle osteotomie in quanto definisce in maniera chiara e riproducibile gli assi e gli angoli di riferimento che permettono di inquadrare in maniera precisa le deformità. L'applicazione a livello del ginocchio dei parametri descritti permette di identificare la sede della deformità e quindi di scegliere la sede dell'osteotomia (femore, tibia, doppio livello) nonché di distinguere una deformità articolare da una deformità ossea o mista guidando verso la scelta dell'indicazione corretta (osteotomia vs protesi)

Extended abstract

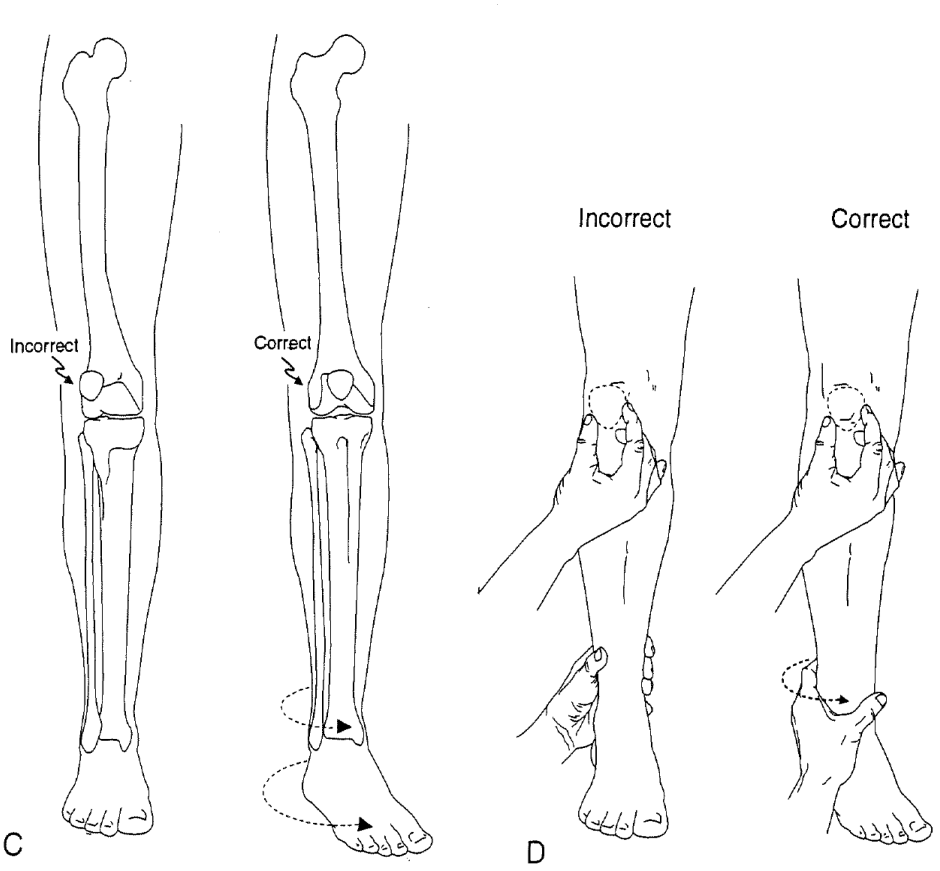
The authors have developed a universal system of geometric deformity planning based on the mechanical or anatomical axes. This type of planning is applicable to both frontal and sagittal plane deformities. Malalignment on frontal plane may be due to femoral or tibial deformities, knee joint laxity or luxation, intra-articular condylar deficiency of knee joint, or combination. The normal mechanical axis passes 10mm medial to the center of the knee joint in the region of the medial tibial spine (range 3-17mm). The malalignment test uses known normal ranges for the orientation of the knee joint relative to the femoral and tibial mechanical axis. The lateral distal femoral angle (LDFA) and medial proximal tibial angle (MPTA) have a mean of 87.5 degrees and normal range of 85 to 90 degrees. Malalignment test is used when there is pathologic mechanical axis deviation, deviations from the normale range (LDFA-MPTA 85-90°) are diagnostic for malalignment.
Malalignment test is carried out by steps:

- Step 0: draw the mechanical axis from the center of the hip to the midpoint of plafond ankle line

- Step 1: draw a line from the center of the hip to the center of the knee joint line and measure LDFA
- Step 2: draw a line from the center of the plafond ankle line to the center of the knee joint and measure MPTA (if MPTA is out of range, tibia is a source of malalignement)
- Step 3: measure the angle between the femoral condylar joint line and the tibial plateau joint line, that is the Joint Line Convergence Angle (JLCA, normal 1,75; range 0-3 medial). If the JLCA is out of range, joint convergence is a source of malalignement
- Step 4: mark the midpoint of femur and tibia→ if the points don't line up, there is medial or lateral luxation/subluxation → source of malalignment
- Step 5: examine distal femur joint line and line across the tibial plateaus, looking for any depression (intra-articular causes of malalignment)



In order to measure accurately LDFA and MPTA, AP radiographs of the knee in frontal plane with patella centered on femoral condyles (independently from feet position) are required. The frontal plane of the knee is defined as the position in which the patella is centered on the femoral condyles (patella forward position). In this position, the foot does not necessarily point forward (possible variable tibial torsion)



Limb malorientation and single bone malrotation and angular deformity, as well as sagittal plane deformities, can be thoroughly analyzed with the same rationale using the sagittal and axial plane measurements provided.