Implanting the Prosthetic Components Based on Radiologic Planning in Deformities of the Knee in Valgus

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The present study evaluates the radiologic particularities of deformities in valgus that are necessary for a correct positioning in frontal and rotational plane of the prosthetic components and for a long term life of the polyethylene and the prosthetic implant. Long leg X-ray performed in orthostatism can evaluate the type and degree of the deformity in frontal plane, it can establish the osteotomy cuts and the necessity of ligament release. The anterior-posterior radiologic incidence of the knee in flexion of 90^0 evaluates the individual rotational profile by calculating the torsion of the distal femoral. Although the frequency of deformity in valgus is more reduced, it presents important clinical and radiologic particularities for the surgical technique.

Keywords: knee arthroplasty, genu valgum, distal femoral torsion

Any deviation from the neutral alignment of the mechanical axes of the inferior limb determines a modification of the action forces bearing on the joint with excessive load on one of the two internal or external compartments causing the occurrence and evolution of arthritic phenomena. *Genu valgum* is more rarely encountered than *genu varum,* the incidence reported in the specialty literature being less than 10% [1, 2].

The deformities associated to arthritis that require knee arthroplasty imply a carefully led *planning* and a specific and particular approach so that the therapeutic outcome will be a stable and properly aligned knee. Any malpositioning and malrotation determine short term consequences (limitation of functional re-education, anterior pain, instability in flexion and/or extension in walking, patellar *maltracking*) and long term consequences (early wear of the polyethylene, aseptic loosening) [3].

Genu valgum associates important structural changes: contracture of soft lateral parts, internal laxity, hypoplasia of the external femoral condyle and sometimes the subluxation of the patella. All these elements increase the difficulty of implanting the femoral and tibial prosthetic components, the ligament *release* being quite difficult to perform and requiring an external para-patellar surgical approach (in irreducible deformities). The hypoplasia of the lateral femoral condyle requires an increased attention during the execution of the posterior femoral osteotomy in order to avoid the positioning in *internal malrotation* of the femoral component.

The present study evaluates the radiologic particularities of the deformities in valgus that are necessary for a correct positioning in frontal and rotational plane of the prosthetic components.

Experimental part

The experimental study was conducted on a group of 67 patients that benefitted from knee endoprosthetic arthroplasty during 01.10.2004 – 30.09.2015. The follow-up examination was 3 months after surgery. The radiologic protocol requires the performance of a long leg X-ray and profile and anterior-posterior incidences of the knee in flexion of 90^0 (seated view).

Long leg X-ray in orthostatism can evaluate the type and degree of deformity in frontal plane and it can evaluate the osteotomy cuts and the necessity for ligament release. The value of deformity is calculated using the medial angle HKA (hip-knee-ankle) formed by the mechanical axis of the femur (the line uniting the centre of the femoral head with the centre of the femoral notch) and the mechanical axis of the tibia (uniting the centre of the tibial spines with the middle part of the ankle) (fig. 1. a., b.). The anatomic

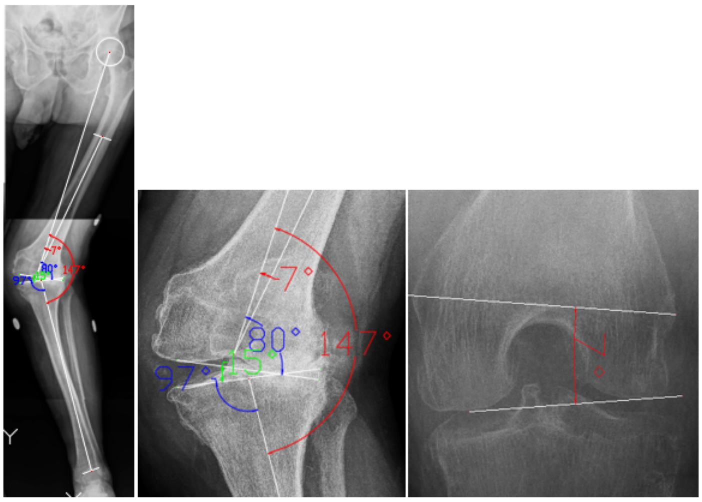

Fig. 1 Genu valgum: a. long leg X-ray; b. zoom on the knee joint: HKA=213^0, IM=7^0, LDFA= 80^0, MPTA= 97^0, ligament instability =15^0; c. seated view: PCA= 7^0

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axis of the femur unites the centre of the inter-condylar *notch* with half the distance between the internal and external cortical of the femur at the level of the isthmus in two collinear points. The angle between the anatomic axis and the femoral mechanical one (intramedullary – IM) (fig. 1. a., b.) is important in establishing the distal femoral cut that has to be in a certain ((IM) angle of valgus from the intramedullary guide, in order to be perpendicular on the mechanical axis of the femur.

The femoral and tibial deformity responsible for the global affectation of the alignment of the inferior limb is highlighted by the angles LDFA and MPTA [4]. LDFA is the lateral angle formed by the mechanical axis of the femur and the tangent to the external femoral condyle (fig. 1.a, b). MPTA is the medial angle between the mechanical axis of the tibia and the tangent to the internal tibial plateaux (fig. 1a, b). These two angles can provide orientation for the osteotomy cuts in frontal plane, the size of the femoral and tibial bone cuts with the purpose of creating a rectangular extension gap necessary for the re-establishment of the neutral axis of the inferior limb. The femoral deformity in *varus* is given by the value of LDFA higher than 90^0 and thus requiring a more significant bone cut of the external femoral condyle [4]. The tibial deformity in *varus* is given by the value of MPTA lower than 85^0 requiring a larger bone cut at the level of the external tibial plateaux [4].

The joint instability caused by the ligament laxity can be shown by increasing the angle between the tangent to the femoral condyle and the tangent to the tibial plateau to more than 3^0 and indicates the necessity for ligament release [4].

The anterior-posterior radiologic incidence of the knee in flexion of 90^0 (seated view) shows the anatomic landmarks (fig. 1.c): the medial and lateral epicondyle necessary to trace the trans-epicondylar axis (TEA) and the posterior condyles showing the posterior condylar line (PCL) [5, 6]. The angle between the two axes calculates the torsion of the distal femoral (posterior condylar angle = PCA) with inter-individual variability. The correct axial positioning of the femoral component is achieved by posterior osteotomy parallel to TEA, that is in a specific angle (PCA – calculated postoperatively) of external rotation to PCL.

Rersults and discussions

Observing the long leg X-rays performed on our patients, we noticed a predominance of the deformity in *varus* (86.56%) as compared to *valgus* (13.43%); the results are similar to those recorded in the specialty literature, the frequency of the deformities slightly varying between analyses depending on the number of subjects included in the study [1, 2, 7, 8].

The average degree of the deformity was 18.02^0, the angle of HKA ranging between 136^0 and 213^0. All patients with *genu valgum* exhibited an important malalignment with a value above 15^0. The same degree of deformity was registered in the category of patients with *varus* in just 33% of the cases.

Genu varum mainly comes from the deformity of the tibia in *varus* and it is well known the fact that the upper extremity of the tibia is naturally positioned in an angle of 3^0 to the mechanical axis [9]. The accentuation of the tibial *varus* determines global misalignment in *varus* of the joint. The patients with *genu varum* included in our study presented an average value of MPTA of 85.53^0 and LDFA of 88.94^0 (fig. 2). Analysing the data, we notice that the joints with global misalignment in *varus* also present a tibial deformity mainly in *varus (93*%) and a minor effect on the inferior extremity of the femur, especially in *valgus* (46%). On the other hand, global misalignment in *valgus* has an impact on both bony surfaces causing the specific femoral genu valgum correction (LDFA = 83.03^0) and tibial genu varum correction (MPTA = 94.81^0) (fig. 2).

Ligament instability was registered in all patients with *genu valgum* with an average value of 8.92^0 (5^0 – 15^0) and in 90% of the patients with *genu varum* with an average value of 5.78^0 (4 – 12^0) (fig. 2). The results of the study show a more significant affectation of the ligament structures in *genu valgum,* as it is also shown in the specialty literature (8), the contracture of the external compartment and the laxity of the internal compartment requiring a special surgical approach (Keblish), the *release* being much more difficult to execute in this case than in *genu varum* [10].

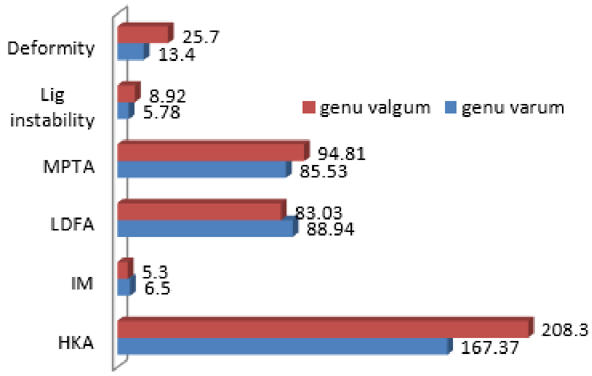

Fig.2 Average values of the angles necessary for a correct positioning in frontal plane

The last variable calculated on the long leg X-ray is the value of the angle to the physiological femoral *valgus* (IM). This angle is important in performing the femoral distal bone cut perpendicular to the mechanical axis. The cutting block is attached to the intramedullary guide in an angle of *valgus* in accordance with IM as measured preoperatively. IM has a high inter-individual variability [11, 12] as also shown in our study, the average value being 6.28^0 with a minimum value of 3^0 and a maximum of 9^0. In the cases with deformities in *varus,* the recorded average value of IM was 6.5^0, while in the cases with *genu valgum* the value of the angle was 5.3^0 (fig. 2). The execution of the distal femoral cut in a fixed angle of 5 – 6^0 [13] can cause a postoperative *malalignment* in frontal plane higher than 3^0 in 20% of the cases [14]. In a study conducted on 493 patients, Nam documented a physiologic angle of *valgus* outside the normal limits of 5 ± 2^0 in a percentage of 28.6% [11]. The same author underlines the fact that executing an endoprosthetic knee arthroplasty without performing a long leg X-ray to establish the exact IM angle will cause femoral malpositioning and thus will lead to early loosening [11].

The *seated view* radiologic incidence allowed measuring the distal femoral torsion using the PCA angle between the trans-epicondylar axis and the tangent to the posterior condyles (fig. 1.c, fig. 3.a). The rotational positioning of the tibial and femoral components is the second element with an impact on the early and long term evolution of the total knee arthroplasty (fig. 3.b, c). Any malrotation of one of the components causes post-operative anterior pain, patellar maltracking with patellar instability and ligament laxity in flexion [15, 16] leading to the wear of the polyethylene and early loosening [17]. Berger used CT imaging to monitor the rotational positioning and the relation to femoral-tibial instability [18]. The degree

Table 1
ANOVA CORRELATION BETWEEN PREOPERATIVE PCA AND THE GRADE OF DEFORMITY, HKA, IM, LDFA

ANOVA	*Coefficients*	*Standard Error*	*t Stat*	*P-value*
Intercept	4.847515	0.488674	9.919737	1.1 E-12.
Grade deformity	0.02373	0.035214	0.673888	0.503989
Intercept	1.893243	3.510586	0.539295	0.592465
HKA	0.018746	0.020263	0.925142	0.360055
Intercept	5.113187	1.154285	4.429745	6.39 E-05
IM	0.003203	0.179396	0.017857	0.985836
Intercept	6.06	5.81	1.04	0.30
LDFA	-0.01	0.07	-0.21	0.01

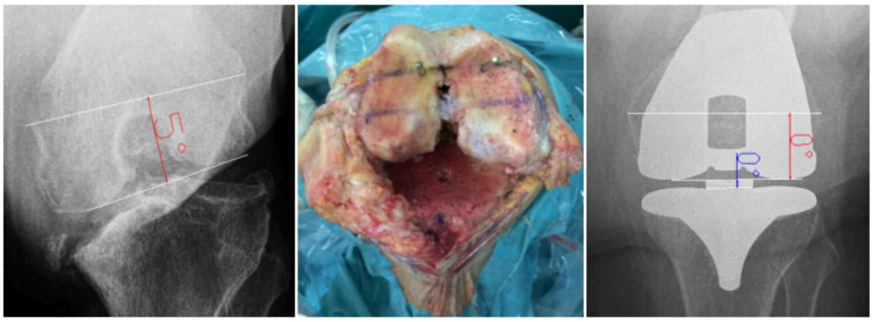

Fig. 3. Verifying the PCA a. preoperative radiology, b. intraoperative tracing of TEA axis, c. postoperative radiology

of femoral-patellar instability has been directly linked to the value of the internal rotation of the prosthetic components, using as landmarks the trans-epicondylar axis for the femoral component and the anterior tibial tuberosity for the tibial component [18].

92.53% of the total number of patients included in the study presented internal femoral torsion with values ranging from 3^0 to 11^0, the mean value of the internal rotation being 5.57^0. There were no patients with external torsion. The results obtained in the study match those documented by the specialty literature [19, 20]. In a study from 2001, Tanavalle claimed that aTEA is the axis of reference for the correct femoral rotation, while sTEA causes a smaller rotation with implications for the patellar maltracking [20]. The same author reports a value of aPCA of 5.7 ± 1.7^0 [20].

In our study, the frequency of patients with internal femoral rotation higher or equal to 5^0 is 77.61% and it contradicts the classic theory according to which the necessary external femoral rotation is 3^0 by annulling the physiologic *varus* of the upper extremity of the tibia [9].

Dividing the preoperative registered result of PCA on the type of deformity in frontal plane, we notice an increased average value in *genu valgum* (6^0) as compared to *genu varum* (5^0), with no significant correlation between the two variables. On the other hand, Matsuda documents the increase of PCA in *genu valgum* due to the hypoplasia of the external posterior femoral condyle [21]. Aglietti confirms the data from the previous study documenting a $p=0.001$ when describing the impact of *valgus* on PCA [22].

Trying to evaluate which of the variables discovered on radiologic images have an impact on the PCA we managed to prove an increase of its value as the femoral bone *valgus* is more accentuated (LDFA < 90^0) without being influenced by the degree of deformity or the angle of physiologic *valgus* of the femur (IM).

Speaking about the torsion of the distal femur it is important to establish whether this inter-individual variable is in an inter-independent relation with the type and degree of the femoral bone deformity. The results obtained in the statistical study show the increase of the value of PCA with the accentuation of the femoral bone *valgus* (LDFA < 90^0) (table 1). The tibial deformity does not establish a causative relation with PCA ($p=0.875843$).

Conclusions

Although the incidence of global deformity in valgus is lower than that in varus, the patient experiences a more important degree of malalignment with an impact on the positioning of the femoral and tibial prosthetic implant by ligament and bony lesional association. The radiologic planning is therefore essential for a correct execution of bone cuts in frontal plane (long leg X-ray) and rotational plane (seated view) in order to provide long term survival of the polyethylene and the prosthetic implant.

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