TECHNICAL NOTE

PRE-OPERATIVE PLANNING AND SURGICAL TECHNIQUE OF THE OPEN WEDGE SUPRACONDYLAR OSTEOTOMY FOR CORRECTION OF VALGUS KNEE AND FIXATION WITH A FIXED-ANGLE IMPLANT

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ABSTRACT

The step-by-step preoperative planning for supracondylar opening wedge osteotomy of the femur for precise correction of the load axis of the lower limb using a fixed-angle implant (95º AO blade plate) is presented. The surgical technique and the use of a bone graft from the same site for filling in the defect are also presented.

Keywords – Osteotomy; Genu Valgum; Preoperative Care

EXPLANATORY INTRODUCTION

Distal femoral osteotomy for correction of predominantly lateral genu valgum and arthrosis in patients under the age of 60 years is widely supported in the literature[(1-17)].

The procedure requires detailed planning to fulfill the necessary requisites for exact and reproducible correction. The aim is to realign the load axis, which joins together the centers of the hip, knee and ankle, so that it passes slightly medially to the medial tibial spine, i.e. a slight overcorrection, as shown by the literature for cases of arthrosis with displacement of the mechanical axis, in which the best results are those in which the deformity was slightly overcorrected[(16)].

The technique most used in the literature is medial subtraction wedge osteotomy, with fixation using a 90º blade plate[(5)].

Correction by means of supracondylar opening wedge osteotomy and fixation using a 95º blade plate was first described by Postel and Langlais[(18)]. These have been the only authors to describe a method for achieving the correction based on correct insertion of the blade in the distal femur. In their procedure, they recommend that a guidewire should be inserted 20-30 mm proximally to the lateral space, thus forming an angle with the lateral cortical bone of the femur of 95º, i.e. less than the desired correction angle. As will be demonstrated in this study, this technique is inadequate for achieving correct realignment of the load axis.

With the use of DCS, Andrade *et al*[(11)] described a technique in which the DCS screw was placed at a varus angle of 5º in relation to the tangent to the condyles in anteroposterior view, assuming that the implant, which has 5º between the screw and the plate, would go on aligning the knee adequately, thereby producing 5º of hypercorrection.

Both medial subtraction wedge osteotomy and lateral addition wedge osteotomy require careful planning in order to attain the desired exact correction.

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The preoperative planning, which is an extremely important part of the procedure when a fixed-angle implant is used (95º blade plate; DCS), has not been properly explored in the literature. There are no studies that guide surgeons in a step-by-step manner through the planning and that lead to exactness of the intended correction.

Likewise, the descriptions of the surgical technique do not detail important steps. Among these, the most important steps are the correct placement of the distal element of a fixed-angle implant, and how to avoid postoperative loss of the reduction in the medial cortical bone.

This work had the aim of providing a step-by-step dissection of the preoperative planning and the technique used for fixation with a fixed-angle plate. The AO 95º blade plate was chosen to illustrate the technique in this study, since it is inexpensive but more difficult to use, but the steps are analogous for other fixed-angle implants. In addition, a way to avoid delayed consolidation and the use of iliac grafts in the great majority of cases is described.

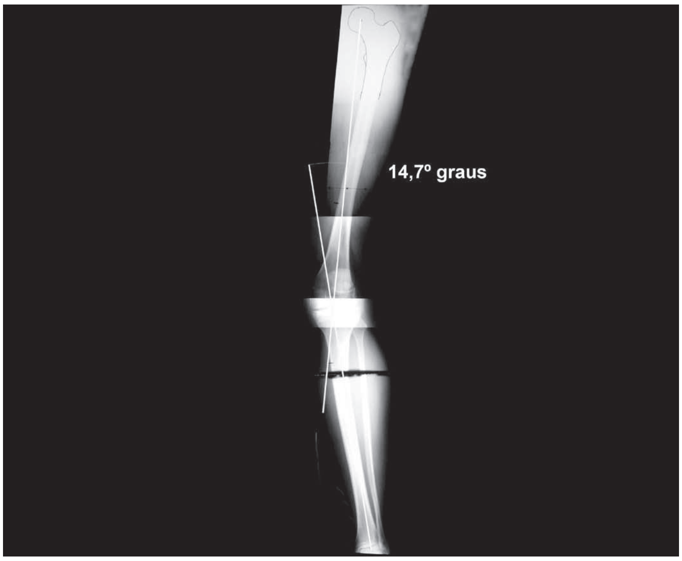

Figure 1 – Panoramic radiograph in anteroposterior view with loading of the left lower limb, taking care to keep the patella pointing forwards and the ray incidence horizontal (parallel to the floor), targeted at the knee, with the x-ray tube at a distance of 3 m. Note the large deviation of the load axis of the lower limb. Between the femoral and tibial load axes, a deviation of 14.7° can be measured.

Description of the method

The preoperative planning is based on a panoramic AP radiograph of the lower limb, with loading. The patient, in a standing position, puts his weight on the affected side. The x-ray tube is positioned behind the knee, taking care that the patella is pointing forwards (radiology techniques tend to position the foot instead of the knee). The travel of the x-ray tube should reach from the hip to the ankle (1.30 m). This is a special x-ray tube that requires film that is also special, but it could be replaced by several pieces of conventional film in series with overlapping edges, and placing some paper clips on the external surface of the x-ray tube at the overlaps between the ends of the film pieces, in order to facilitate adjustment of the film pieces in the proper positions at the time of recomposing the panoramic view (Figure 1). It is very important that the x-ray tube should be positioned at a distance of 3 m and that the ray is horizontal, i.e. parallel to the ground, pointing towards the knee. It is essential to acquire a view of the limb from the hip to the ankle, to be able to trace out the load axis of the limb (Figure 1).

The next step is to ascertain whether the deformity is in the knee, usually due to hypoplasia of the lateral condyle of the femur, or whether it is due to excessive tilting of the plateaus, or to erosion of the joint space and the lateral plateau itself, or even to curving of the diaphysis of the femur or tibia.

To ascertain whether the deformity is at knee level, or whether it is more in the femur or in the tibia, the diaphyseal axes are traced out, which should cross close to the knee. When the diaphyseal axes of the femur and tibia do not cross at the knee, other extra-articular causes should be investigated, in order to explain the genu valgum, for example curvature of the femoral or tibial diaphysis (when it is thus not possible to trace out the diaphyseal axis while keeping it on the bone). This possibility may imply the existence of an extra-articular center of deformity, and there may therefore be more than one center of deformity. This may require correction at more than one site, in order to avoid, at the end of the "correction" that the knee interline is tilted while standing upright, despite the correction made to the mechanical axis.

In the case in question (Figure 1), it can be seen that there was a mild valgus curvature to the tibia, which is common in cases of development genu valgum. However, the load axis of the tibia was very close to the diaphyseal axis, which indicates that the deformity of the tibia was small. The measured displacement of the mechanical axis was 14.7º.

The planning starts by making a paper tracing of the bone outline from the panoramic radiograph (Figure 2A). Onto this tracing, the transparency of the 95º blade plate is superimposed, such that the straight part of the plate forms an angle with the lateral cortical bone of the diaphysis of around 15º (close to the measured angle of the displacement of the mechanical axis – Figure 1). A point of entry for the blade is chosen such that this allows at least one screw to be inserted into the distal fragment, in order to avoid blade retrocession later on. Especially in the case of a DCS, this epiphyseal screw proximal to the DCS screw is important for maintaining the alignment in the sagittal plane (Figure 2B). It should also be ensured that there is sufficient thickness of distal bone to avoid the occurrence of blade penetration into the joint. The tracing of the osteotomy is then made, starting sufficiently proximally to leave enough margin of bone between the osteotomy and the first distal screw. The obliquity of the osteotomy ensures greater cut surface and less chance of consolidation disorders (Figure 2C). For this reason, the tracing is inclined to terminate close to the medial epicondyle, in a region that is rich in Sharpey fibers, which help to avoid loss of contact with the medial cortical bone.

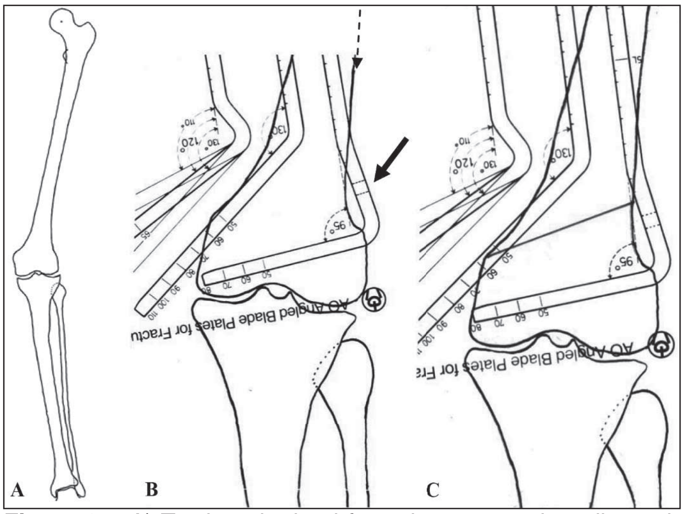

Figure 2 – A) Tracing obtained from the panoramic radiograph in AP view. B) Superimposing of the transparency of the angled plates (in this case, 95°) to estimate the size of the blade, thus ensuring the placement of a screw in the distal segment (arrow). Note that the transparency is positioned such that it forms an angle between the straight part of the plate and the femoral diaphysis that is approximately equal to the deviation angle measured on the panoramic radiograph (dotted arrow). C) Oblique tracing of the osteotomy, thus ensuring a wide surface for the osteotomy and sufficient distance from the distal screw.

Using scissors, the paper tracing of the panoramic radiograph is cut along the outline of the osteotomy (Figure 2C). The three joints (hip, knee and ankle) are aligned, taking care to provoke a slight overcorrection by making the load axis (stretched string) pass slightly medially to the medial spine of the tibia (Figure 3A). The paper is fixed in this position with adhesive tape. The opening angle on the paper at the osteotomy site is measured directly using a goniometer (Figure 3C). This is the angle of correction required during the operation to obtain the desired result (21º). It is of interest to observe that this angle is different from the one measured in Figure 1 (14.7º). This is because of the desired overcorrection, which makes the axis pass slightly medially to the medial spine of the tibia.

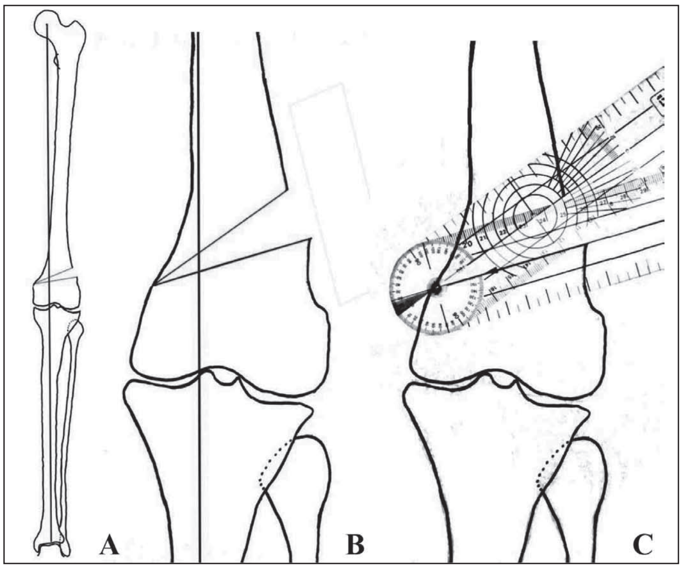

Figure 3 – A and B) Tracing of the panoramic view on paper, after cutting and aligning, so as to obtain the desired correction of the load axis, for it to pass slightly medially to the medial spine of the tibia. C) The angle measured with a goniometer furnished a reading of 21°.

With the tracing fixed using adhesive tape in the position of the desired correction, the transparency of the 95º blade plate is superimposed in such a way as to ensure the best possible adaptation of the straight part of the plate in the lateral cortical bone of the femur, and the best position for the blade, thereby ensuring that an epiphyseal screw can be inserted proximally to the blade (Figure 4A). This is necessary so that the intraoperative correction is obtained automatically when the plate is adapted to the diaphysis, after insertion of the 95º blade plate. The length of the plate is also chosen such that there will be at least four bicortical screws proximally to the osteotomy. The outline of the plate is traced out on the paper in the position chosen, and the appropriate blade is chosen (generally 60 mm).

Next, the angle formed between the blade and the tangent to the condyles is measured (Figure 4C). This angle has fundamental importance, since it indicates the entry inclination of the special osteotome (which cuts the path for the blade), in relation to the tangent to the femoral condyles distally, in frontal view. In this way, two fundamental points regarding the use of implants like 95º blade plates (or DCS) are determined: the blade insertion point (or the insertion for DCS screws) (Figure 4A); and the insertion angle in relation to the distal tangent to the condyles in AP view (Figure 4C).

The preoperative plan can finally be completed by tracing out the positions of the screws (Figure 4D). On this, the fundamental parameters for carrying out the osteotomy can be seen: the entry point for the blade; the angle between the blade and the distal tangent to the condyles in frontal view; and the osteotomy site.

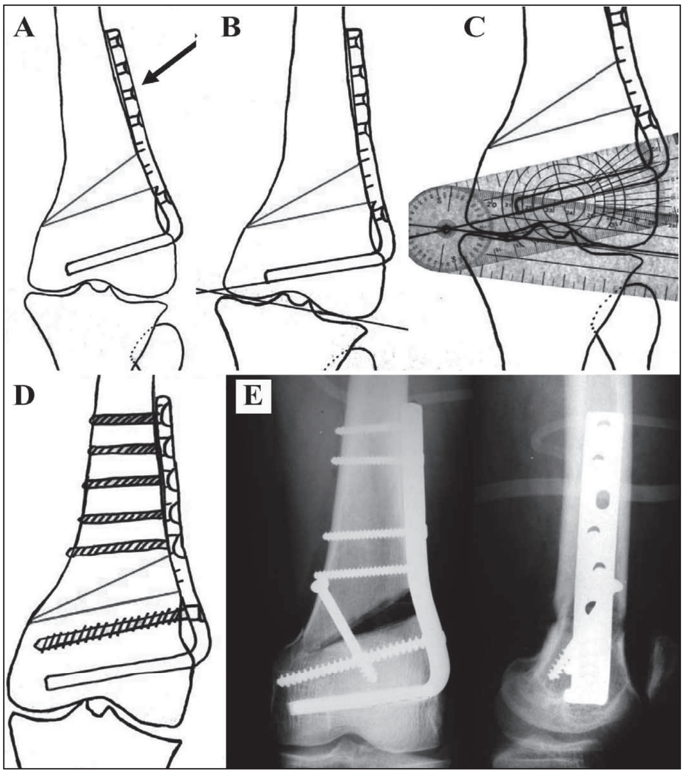

Figure 4 – A) After placing the transparency under the paper and making a drawing of the outline of the plate chosen, parallelism of the straight part of the plate with the lateral cortical bone (arrow) is maintained and the bone margin needed for the blade not to enter the joint is ensured, along with the possibility of insertion of a screw through the plate in the distal segment. B) Two straight lines are traced out: one tangentially and distally to the femoral condyles; and the other, parallel to the blade of the plate. As can be seen in this figure, the cortical bone of the distal fragment proximal to the osteotomy and under the plate usually makes it difficult to seat the plate. This salience may be judiciously removed using a saw. C) Angle measurement with a goniometer, which informs what the blade entry angle is in relation to the tangent to the condyles, in frontal view; in this case, 21°. D) Final tracing of the preoperative planning. E) Osteotomy accomplished: note the addition of an oblique medial compression screw to keep the medial cortical bone (which always fractures) in good contact, in order to avoid delayed consolidation.

We have made a point of demonstrating step-by-step the estimate for the entry angle (21º), which would result in the desired correction when the plate is adapted to the diaphysis after introduction of the blade according to this angle formed between the blade and the tangent to the condyles, distally in frontal view. Coincidentally, as can be seen in Figures 3C and 4C, it had the value of 21º. In practical terms, the entry angle of the blade should form an angle with the tangent to the condyles distally that is exactly equal to what was measured on the cut and corrected paper (21º).

Figure 5 shows the four-month postoperative control on the same patient (Figure 1) who was used to give an example of the planning presented here. It should be noted that although a fracture of the medial cortical bone occurred while the osteotomy was being performed (this is a very common occurrence), this did not represent a problem regarding consolidation, which was already

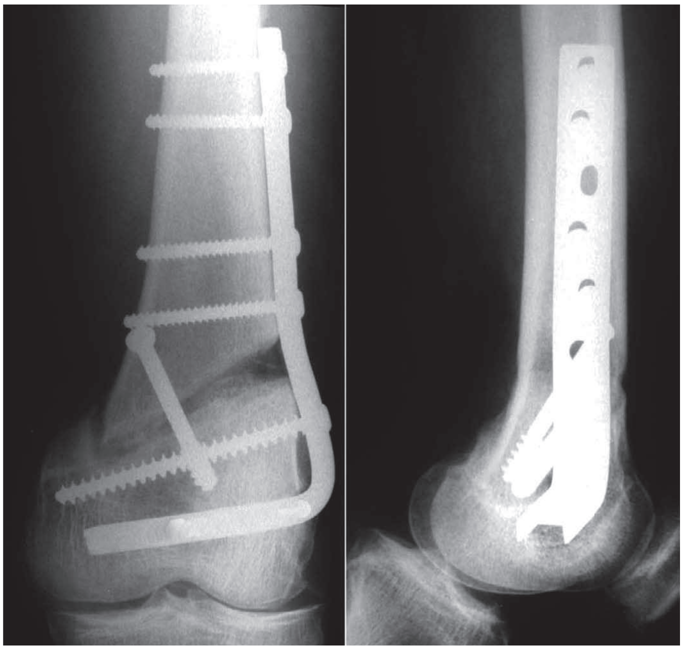

Figure 5 – Control produced four months after the operation, on the patient whose preoperative planning was used here. Both the medial cortical bone and the osteotomy have already consolidated.

well advanced and the patient was already bearing the full load of his weight.

Hence, the preoperative planning can be summarized thus:

1. A panoramic radiograph of the lower limb in AP view, with load-bearing, is obtained;
2. The outlines of the bones on the panoramic radiograph are drawn out on a long piece of tracing paper;
3. The mechanical axes of the femur and tibia are traced out, and the angle between them is measured;

4. The site of the osteotomy is marked on the tracing paper, using a transparency of the 95º blade plate, such that the straight part of the plate forms an angle with the diaphysis of the femur that is approximately equal to the angle measured between the mechanical axes. The outline of the cut is drawn obliquely such that it is possible to insert a screw into the distal fragment, as well as the blade, and terminating medially in the medial epicondyle;
5. The paper is cut at the site marked for the osteotomy and the tracing is aligned such that the load axis (stretched string) passes slightly medially to the medial spine (slight overcorrection);
6. The paper is fixed in this position with adhesive tape and the opening angle needed to obtain the desired alignment is measured on the paper. This should be the entry angle of the blade in relation to the tangent to the condyles, distally, in frontal view;
7. The transparency of the 95º blade plate is placed under the paper, so that the diaphyseal part of the plate adapts well to the lateral cortical bone of the femur and so that it is possible to place a screw in the distal part, as well as the blade, with a margin of distal bone to avoid penetration of the blade into the knee;
8. The outline of the plate and screws is drawn. In general, a plate with seven holes is chosen (Figure 5D).

Thus, the important points within the planning are determined:

- Entry point of the blade;
- Angle between the blade and the distal tangent to the condyles;
- Site of the osteotomy.

Surgical procedure

The patient is placed on a radiotransparent table that allows radioscopic viewing from the hip to the ankle.

The use of a tourniquet is highly recommended for good viewing and to avoid significant blood loss, which is common in this type of surgery when performed without a tourniquet.

The viability of using a pneumatic tourniquet should be assessed: this requires a thigh that is sufficiently long and absence of excessive obesity.

In patients with a short thigh or who are obese, it is still possible to use a tourniquet. For this, patients should be prepared as if for hip surgery. A Schanz pin is inserted into the lateral cortical bone of the subtrochanteric region, so as to enable proximal anchorage of successive oblique wrappings of an Esmarch band of 10 cm in width. Through this, sufficient length of thigh distally to the tourniquet is obtained, in order to allow adequate access.

The foot and distal half of the lower leg are isolated in sterile fields, while the knee remains free.

The skin is opened from the Gerdy tubercle (in line with the iliotibial band in the projection of the posterolateral septum, to 15 cm proximally.

The fascia lata is opened longitudinally, immediately anteriorly to the posterolateral septum and iliotibial band.

The vastus lateralis muscle is moved away forwards, so as to preserve the periosteum inserted in the bone and avoid damaging the fat that is present anteriorly under the quadriceps. In the supracondylar region, the superior genicular artery and vein should be identified and sectioned after cauterization. The vastus lateralis muscled is progressively deinserted from its insertions in the septum and bone, in the proximal direction, while taking care to identify and cauterize the perforating vessels before sectioning them.

The joint capsule of the knee is opened in line with the incision, taking care with the insertion of the ligaments in the epicondyle and with the tendon of the popliteus. It is useful to open the capsule in order to inspect the lateral meniscus and the lateral compartment of the knee, and also to inspect and palpate the facies patellaris and prevent possible penetration of the blades into the joint.

The insertion point for the blade is determined according to the preoperative plane and with the aid of an image intensifier. At this site, a rectangular window is opened for a blade measuring 1.5 cm in height by 5 mm in width to be introduced.

The usual reference wires for insertion of a 95º blade plate are positioned with the knee flexed at 45 to 60º. The first wire is tangential to the femoral condyles distally, in frontal view (its position is checked using the image intensifier) and another wire is tangential to the facies patellaris anteriorly. The soft tissues keep these wires in place, provide that they have been placed by means of transfixion.

A third reference wire is passed halfway between the window made for the blade and the joint margin. This wire should be parallel, in the sagittal plane, to the wire tangential to the facies patellaris anteriorly. In the coronal plane, the wire should be inserted inclined distally, in relation to the wire that is tangential to the condyles and in accordance with the angle measured in Figure 5C. This is the main reference wire for introducing the blade and is only removed after the plate has been definitely introduced. For its correct insertion, metal wedges should be available for measuring the angle formed with the wire that is tangential to the condyles distally. The other wires can then be removed.

The blade is then inserted using appropriate tools, noting the parallelism with the reference wire and the position of the guide in relation to the diaphysis, in order to avoid divergence of the plate in the lateral plane, in relation to the diaphysis.

Since these bones are often in young people, it is prudent to insert the blade guide a few millimeters and then to partially remove it, insert it again a little more, remove it again, and so on, thus dividing the process into two or three stages. This avoids trapping the guide in the good-quality bone of these patients, which could lead to great difficulty in removing it. At the end of constructing the path for the blade, the guide is removed.

The design for the osteotomy is then drawn on the anterior cortical bone with the aid of an intensifier and the preoperative plan (Figure 4B), using an electrocautery, thereby avoiding sectioning the fat under the quadriceps. This is parsimoniously elevated with the periosteum and protected with appropriate Hohmann. The posterior periosteum in the line of the osteotomy is elevated and a Hohmann is placed to protect the posterior structures in the line of the osteotomy.

Three parallel Kirschner wires of 1.5 mm in diameter are introduced through the lateral cortical bone, following the outline of the osteotomy as far as the medial cortical bone, under radioscopic monitoring. These serve to support the saw blade. The saw blade is introduced cranially and tangentially to these wires, which avoid inadvertent deviation of the blade from the markings that might be directed towards the joint.

The osteotomy is undertaken along the markings, while taking care to provide continual irrigation with saline, in order to avoid excessive heating and thermal bone death. The advance of the saw blade is monitored radioscopically. The saw blade should reach a position around 1 cm from the medial limit. During the osteotomy, an assistant exerts slight varus tension on the knee to avoid trapping the blade in the osteotomy and to feel when this has been completed, with fracturing of the medial cortical bone. To section the posterior cortical bone, the knee should be flexed at around 45º in order to relax the posterior structures. During this step, nothing should be pressing the posterior soft tissues forwards at the level of the osteotomy.

The plate chosen is then inserted in the path of the blade that was previously constructed, by means of light taps with a hammer, while attentively observing the Kirschner guidewire, thus introducing the blade along the previously constructed path. It is very important that, while tapping the blade in, an assistant should exert vigorous medial support, so that loss of the reduction of the medial cortical bone is avoided.

Shortly before the final insertion of the blade, it may be necessary to remove the salience of the lateral cortical bone in the distal segment, which impedes good seating of the end of the plate (Figure 4B). This can easily be done with a saw.

The first screw to be inserted is the epiphyseal screw, following the parallelism with the blade. It is recommended that a fully threaded 6.5 mm spongy screw should be used. This type of screw will avoid retrocession of the blade and provide greater control over the epiphyseal segment in the sagittal plane.

The final alignment of the limb is done with the knee extended and the electrocautery wire stretched. The knee is placed in alignment with the center of the femoral head and the center of the ankle, and this is checked radioscopically. The wire should then pass slightly medially to the medial tibial spine (slight overcorrection). Fine adjustment of the desired alignment is achieved through maneuvers performed by an assistant, applying slight varus force on the knee. It is important to ensure that the correction of the valgus takes place only in the osteotomy and not (in part) at the cost of lateral opening of the ligament. For this, at the same time as an assistant exerts mild force in varus, the osteotomy is forced open with two wide osteotomes, which ensures closure of the lateral joint space and thus ensures that the correction only occurs in the osteotomy.

It is sometimes seen that the iliotibial band and the posterolateral intermuscular septum resist and impede the corrective maneuvers. In these cases, stretching of the band and the septum may be done through multiple small transverse nicks cut using a no. 15 scalpel blade at different levels, thus causing the different fiber bundles to slide against each other in such a way that their continuity is not lost.

After achieving this alignment, the first proximal cortical screw is inserted, adjacent to the osteotomy.

The yellow DCP compression guide is used in inverted position (neutralization position), in order to impede the opening of the osteotomy with consequent loss of the correction.

The alignment of the three joints is again checked. If all is well, the other screws are introduced, starting with the most cranial screw, in bicortical manner. All of the screws should be inserted in the neutralization position (eccentric yellow guide inverted in the drilling).

As a preventive measure to avoid loss of the reduction of the medial cortical bone, which could result in delayed consolidation, insertion of a compression screw acting on the medial cortical bone is effective[19]. The use of a cannulated screw greatly facilitates this step. The guidewire is inserted into the medial cortical bone of the femur percutaneously, and the wire is directed laterally and slightly rearwards, so that it does not collide with the blade or reach the posterior part of the lateral condyle (Figure 5).

After concluding the fixation, attention is given to the space created with the bone defect in the osteotomy. As a rule, unless this space is excessively large (more than 20 mm), which would be exceptional, it can be filled with gelatin foam (Gelfoam). At the level of the cortical bone, an autologous graft of spongy bone removed from the two surfaces of the osteotomy cut is placed on the Gelfoam surface (Figure 6), so that there can be rapid reconstitution of the cortical bone. This graft is carefully removed from the spongy surfaces of the osteotomy cut surfaces, using a sharp osteotome and removing small slivers of 2-3 mm in thickness. The gelatin foam not only helps the hemostasis but also maintains the grafts at the level of the cortical bone.

The fat below the quadriceps is sutured so as to contain the fragments of spongy bone. The tourniquet is removed.

After achieving meticulous hemostasis, the wound is closed in layers, leaving suction drains in the submuscular space. These are removed within 24 hours. The knee is put into a flexed position at 90º.

Postoperative care

The patient is placed with the operated limb in a position that keeps the knee and hip flexed at 90º, which should be the preferential position for resting during the first two weeks, in order to avoid adherence of the quadriceps in the extended position, with resultant difficulty in recovering the flexion.

After removal of the drains, the patient can be released, using a walking frame, with authorization for loads of up to 20 kg, which are learned by using a balance. Exercises for increasing the range of motion are taught to the patient twice a day. The patient is instructed to keep the knee flexed at more than 60º for most of the day, in order to avoid adherence of the quadriceps in the extended position, with subsequent great difficulty in achieving extension.

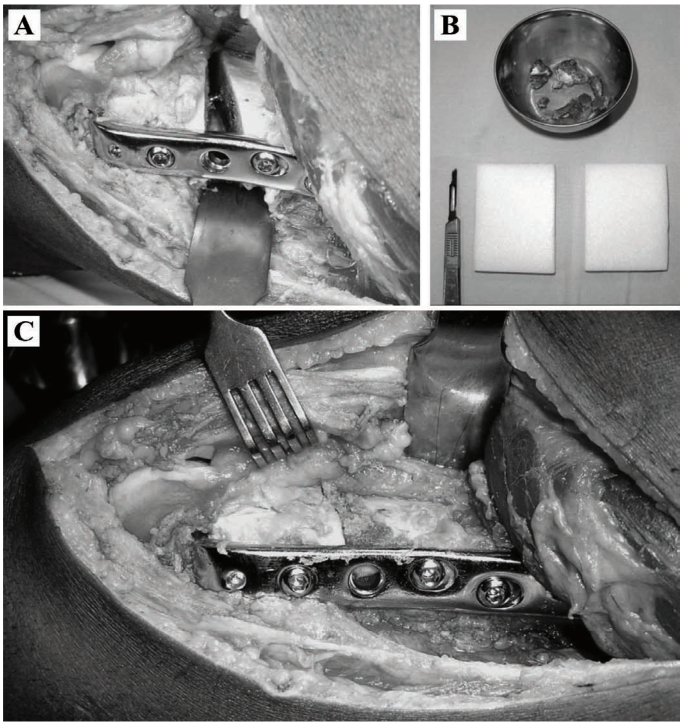

Figure 6 – A) Fixed osteotomy, showing the cut surfaces of the osteotomy, from which slivers of spongy bone of 2-3 mm in thickness are removed from each side, with the aid of a sharp osteotome. B) The bone that was removed and the Gelfoam that is to be inserted in the space after moistening. (C) The Gelfoam already inserted and the spongy bone placed at the level of the cortical bone.

The bone defect left by the osteotomy is closed slowly from medially to laterally, over a period of several months or years.

Careful stretching in extension and flexion, done twice a day by the patient himself, is enough to increase the range of motion in the great majority of patients. There may be a need for assistance from a physiotherapist.

If all goes well, the first follow-up radiograph is done after eight weeks, when the medial cortical bone should have consolidated. Load-bearing can then be progressively increased, and the external supports can be removed as this becomes tolerable.

The plate may remain prominent at its elbow, especially among thin patients. Removal of the plate can only be considered safe when at least 50% of the width of the osteotomy in AP view is filled with bone, which takes around two years.

Since the plate remains prominent under the iliotibial tract, it may exceptionally originate discomfort for some patients. However, the plate should not be removed before reaching two years, because of the risk of fracture at the bone defect site. During this period, relief measures such as local or systemic use of anti-inflammatory agents and, every three months, corticoid infiltration, may help to alleviate such discomfort until the plate is removed.

FINAL COMMENTS

Lateral opening wedge osteotomy to correct genu valgum has the advantage of allowing small adjustments for greater or smaller opening of the wedge during the operation. On the other hand, it is very problematic to remedy medial subtraction wedge osteotomy when the wedge removal is not perfect. Another advantage of lateral opening osteotomy is the ease of access, which is the same as commonly used for fixation of supracondylar fractures.

Distal osteotomy of the femur with fixed-angle implants requires rigorous and systematic preoperative planning when it is desired to obtain precise corrections. It is desirable to slightly overcorrect poor alignment[5-7,17].

The AO 95º blade plate has the advantage, if placed correctly, of ensuring the precise correction desired. We did not find in the literature the necessary detailing for this difficult planning. For this reason, we deemed it appropriate and opportune to publish this method, which in our hands has led to great precision and reproducibility.

The method described by Postel and Langlais[18], in which simply adding 95º to the desired correction angle was recommended as the reference for blade entry in relation to the diaphyseal axis presupposes that tilting of the femoral interline is the sole cause of the valgus. In the example shown in Figure 1, the usual curvature of the tibia and the narrowing of the lateral space are seen, which are not taken into account in those authors' method.

Andrade *et al*[11] were concerned about causing around 5º overcorrection when they recommended entering the DCS screw at a varus angle of 5º in relation to the tangent distally to the femoral condyles. However, they did not take into account the possibility that there might be a deformity component in addition to the distal femur, which would certainly lead to inadequate realignment of the axis.

The only way of correctly estimating the deviation angle is by means of panoramic radiography in AP view with loading. As demonstrated in our planning, the correction angle should be measured on the panoramic radiograph with the addition of 3-7º in order to cause a slight overcorrection. The blade entry angle should be such that it enables perfect adaptation of the straight part of the plate in the diaphysis, when the axis is at the desired alignment. To achieve this, there is nothing better than making the desired correction on a paper drawing and then superimposing a transparency of the implant with perfect adaptation to the lateral diaphysis.

The principal for the fixation is based on adequate adaptation of the plate to the diaphysis, which should occur only at the corrected position. If not, the correction is unpredictable. For this reason, the blade entry angle of the 95º plate or DCS screw, in relation to the tangent to the femoral condyles distally, is so critical.

The necessary correction of poor alignment should not be based only on measurement of the angle formed between the load axes of the femur and tibia (Figure 1). The correct measurement is only obtained after cutting the paper along the likely line for the osteotomy and correcting the load axis on the paper drawing obtained from the panoramic view, thus making a correction on the axis so as to obtain an axis passing slightly medially to the medial tibial spine (slight overcorrection). In our example chosen for illustration, the difference was 14.7º to 21º, which would cause an important error if only the deviation of the load axis of the lower limb measured from the load axes of the femur and tibia were followed.

Another point that contributes towards error is that, on radiographs with loading, the medial space may be widened through any medial ligament weakness that might exist. Hence the need to cause a slight overcorrection, which favors medial closure during load-bearing, as well as effective load transfer to the medial compartment, which is better preserved. However, the joint fissure angle, which is usually 0-2º, when increased medially, should be subtracted from the calculated correction, given that the medial line will close because of the overcorrection. If this characteristic is not taken into consideration, this may imply a false estimate of the correction, with consequent overcorrection in cases of medial ligament weakness. Unless the joint fissure angle is very much increased medially, small adjustments can be achieved during the operation simply by slightly opening or closing the cleft of the osteotomy.

The choice of implant depends on the surgeon's preference and on implant availability. However, independent of implant type, planning with the corresponding transparency is essential when a fixed-angle implant is used (95º blade plate; DCS), in which the most important fixation element of the distal part has to be inserted with high precision. Other implants such as Tomofix or the Puddu plate are more liberal regarding planning, since they will adapt to the correction achieved through intraoperative maneuvers. Unfortunately, this advantage may not be much, when the lower degree of adherence to the distal fragment and lower control over positioning (both in the sagittal and in the frontal plane) with fixation using these implants are taken into consideration.

Even with the use of implants with a robust fixed angle such as the DCS or the 95º blade plate, maintenance of the reduction in the medial cortical bone cannot be assured. For this reason, the addition of a compression screw to keep the opposite cortical bone closed is very important[19].

Furthermore, there is a vital need to insert a screw in the segment distal to the plate, beyond the blade, especially in the case of the DCS screw, in order to control the distal segment in the sagittal plane.

Spongy grafts removed from the osteotomy itself have been used in our clinic for a long time, with excellent results. When the defect in the lateral cortical bone is not more than 15 mm, this technique is fully satisfactory. Questions may arise regarding the loss of filling consequent to the defect due to the bone removal. This may occur, but it is irrelevant provided that the medial part of the osteotomy consolidates. If this does not occur, even if the defect is completely filled with graft material or other bone substitute, it will not be enough to avoid pseudarthrosis[19]. For this reason, the technique of using a medial cannulated screw, performing compression and keeping the medial cortical bone well juxtaposed is essential for avoiding this complication. We have used this principle for all osteotomy procedures performed around the knee, especially in open wedge cases, as a way of avoiding pseudarthrosis and delay.

Impaction of the medial cortical bone into the distal fragment, as a means of diminishing the defect and the risk of pseudarthrosis, as recommended by Postel and Langlais(18) has the inconvenience of generating a step just above the facies patellaris, thus creating difficulty in sliding movement for the patella, along with shortening of the limb.

As a final conclusion, we would say that osteotomy of the distal femur to treat genu valgum and predominantly lateral arthrosis of the knee should be meticulously planned: not only to make a correct estimate of the need for correction, but also, especially, to ensure that the procedure is adequately accomplished, particularly when fixed-angle devices are used.

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