ADVANCES IN THE SURGICAL TREATMENT OF DISTAL FEMORAL FRACTURES

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Abstract: *In the last decade, the treatment of distal femoral fractures remains a challenge for the orthopedic surgeon, despite the evolution of surgical techniques and implants. The relative high incidence of intraoperative and postoperative complications has led to improved surgical techniques – surgical approaches, reduction techniques, as well as to more adapted, dedicated implants. These two directions have developed in parallel and are highly interdependent. The use of minimal invasive techniques has led to the development of adapted surgical implants in order to facilitate the submuscular insertion of the plate and the percutaneous insertion of locking screws - for plate osteosynthesis and intramedullary nails. On the other hand, the rapid evolution of technology allowed the fabrication of more resistant implants in general, or with equal resistance at smaller sizes, or with a particular distribution of holes for the locked screws/interlocking bolts without impairing the global strength of the implant. Consecutively, the reduction and temporary fixation techniques had to be improved. The evolution led to indirect, percutaneous reduction techniques. Last but not least, surgical techniques and implants had to adapt to the increasing number of patients with moderate to severe osteoporosis, with fragility fractures of the distal femur. These patients need minimal approaches, adapted reduction techniques and angular stable implants. In conclusion, the choice of an implant depends on: type of fracture, bone quality, but also on the availability, surgical technique difficulty and surgeon's preference. Nowadays, the treatment of distal femoral fractures shows a continuous improvement, regarding the surgical techniques and the stabilization methods. This fact proofs that the ideal solution has not yet been found.*

Cuvinte cheie: *fracturi femur distal, osteosinteză, tehnici minim-invazive*

Rezumat: *Fracturile femurului distal rămân o provocare pentru chirurgul ortoped, în ciuda evoluţiei tehnicilor chirurgicale şi a materialelor de osteosinteză. Rata relativ ridicată a incidentelor intraoperatorii şi a complicaţiilor postoperatorii a incitat la ameliorarea tehnicilor chirurgicale – căi de abord, tehnici de reducere – precum şi a metodelor de osteosinteză utilizate. Aceste două tendinţe s-au manifestat în paralel, într-o strânsă interdependenţă. Utilizarea tehnicilor minim-invazive a dus la imaginarea si dezvoltarea de implanturi adaptate, care să uşureze introducerea submusculară a plăcilor şi introducerea percutană a şuruburilor locking (pentru plăci) sau a şuruburilor de zăvorâre (pentru tijele centromedulare). Pe de altă parte, ameliorarea posibilităţilor tehnologice şi de fabricaţie a permis producerea de implanturi mai rezistente în general, sau cu rezistenţe egale la diametre mai mici, sau cu o distribuţie particulară a orificiilor de zăvorâre/introducere a şuruburilor de zăvorâre, fără ca rezistenţa globală a implantului să aibă de suferit. În mod consecutiv, au trebuit ameliorate tehnicile de reducere si stabilizare provizorie a fracturilor, care au evoluat către tehnici indirecte, percutanate. Nu în ultimul rând, tehnicile si implanturile au trebuit sa se adapteze numărului crescând al pacienţilor cu osteoporoză moderată si severă ce prezintă fracturi de extremitate distală de femur de fragilitate. Aceştia necesită căi de abord minimale, tehnici adaptate de reducere si implanturi cu stabilitate angulară. In concluzie, alegerea implantului depinde de mai mulţi factori: tipul de fractură, calitatea osului, dar şi de disponibilitate, dificultatea tehnicii de implantare, preferinţa chirurgului. Tratamentul fracturilor extremităţii distale de femur continuă să se imbunătăţească în prezent, atât în ceea ce priveşte tehnicile de reducere cât şi metodele de fixare. Aceasta dovedeste faptul că soluţia perfectă nu a fost încă găsită.*

In the last decade, the treatment of distal femoral fractures remains a challenge for the orthopaedic surgeon, despite the evolution of surgical techniques and implants.

Regarding the etiology, these lesions may be the result of a high energy trauma or of a simple fall from a standing height. This etiology leads to a bimodal distribution of the patients per age groups: the young patients – sustaining, usually, a high energy trauma (which occurs either after car accidents or after a fall from a height) and the elderly population (age between 70 and 100 years old) which sustains low energy trauma. In both situations, comminution of metaphyseal flare or intraarticular component is frequent. Comminution degree is

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directly dependent on the amount of the absorbed energy for the first category of patients or on the degree of osteoporosis for the second one. Less commonly, one or more coronal plane fractures (Hoffa fractures) may have a direct extension in the articular surface, affecting the congruency of femuro-tibial joint.

The most used classification for distal femoral fractures is the AO classification, an alpha-numeric classification system. In its "philosophy'", three questions are required to classify the intra-articular fractures: 1. Does the fracture involve the articular surface? If the answer is no, the fracture is defined as an "extra-articular" and classified as a 33 – A fractures (33 – the alpha - numeric code for the distal femur). If the articular surface is involved, the next question is: 2. Is there an articular fragment still in continuity with the metaphysis? If the answer is yes, the fractures are defined as "partial articular"- type 33-B. On the contrary, if the articular component is completely separated from the metaphyseal part, the fracture is classified as a 33-C fracture and, in this situation, the last question we need to answer to is: 3. Is there a comminution of the articular and/or metapyseal component of the distal femoral fracture or not? On the answer of these question depends the subgroup classification of a 33-C fracture: (C1 – articular simple, metaphyseal simple, C2 -articular simple, metaphyseal complex, C3 – articular complex, metaphyseal complex).

Over the time, the implants used for distal femoral fracture stabilisation have evolved. The 95º blade-plate is a fixed-angle, one-piece device which offers an excellent rotational stability, being also stable in frontal and sagital planes, for distal, articular fragment. The main disadvantage of this implant is the relatively high demanding technique; any small inaccuracy in the three-planar placement of the blade in distal, articular fragment leads to an incorrect position of the plate on the diaphysis. The technique has a relatively long learning curve and is usually reserved for experienced surgeons. The second important disadvantage of the technique is the necessity for large periosteal stripping, especially for diaphyseal fragment, in order to allow the placement of the plate in direct contact with the bone. Minimal-invasive techniques have been imagined for blade-plate insertion, but these are extremely difficult with low reproducibility. The 95º blade-plate remains an useful implant for the treatment of distal femoral fractures, but especially for selected cases of supracondylar non-unions.

The first disadvantage encountered for the blade-plate – demanding surgical technique – has been partially improved by inventing a new implant – the DCS (Dynamic Condilar Screw). For the accurate implantation of this, there is no longer necessary to take into account three planes – but only two – because the condylar screw can be freely rotated into distal, condylar fragment. This way, the surgeon can easily adjust the position of the plate on the lateral diaphyseal cortex. The DCS is also a fixed angular device, but the amount of bone removed for the condylar screw insertion is considerably higher, and so the cutting-out phenomenon is frequent. Minimal-invasive insertion is possible and is less difficult, if we compare it with the blade plate, because the implant is not a one-piece device (it has two distinct pieces – the condylar screw and the lateral plate). The position of the plate is still the same – in direct contact with the bone – so periosteal stripping is still necessary.

The LISS system (Less Invasive Stabilisation System) was designed as an internal fixation. This plate has an anatomical design – left/right, is positioned away from the bone (this way, the periost can remain attached to the bone, and theoretically, the bone blood supply is preserved), and the screws are locked into the plate, obtaining an angular stable construct (figure no. 1).

This feature is obtained by engaging the outer thread of the screw head into the inner thread of a special hole of the plate. The pull-out strength of the screws is considerably improved. This way, the osteoporotic bone is a good indication for using this implant. The position of the locked screws into the distal and proximal fragments is predefined, unique, and can be a disadvantage for certain type of fractures, with a special configuration. There is no feed-back for a good screw attachment into the bone, because the tightening sensation is provided by locking the screw into the plate, and not by the correct screw positioning in the far cortex or in the cancelous bone. "The philosophy" of the LISS system presumes a prior reduction of the fracture. The plate can rarely succeed cases in helping the indirect reduction of the fracture, but it is a demanding technique, which requires experience and an accurate preoperative planning. Due to the fact that the system was designed for the MIPO technique (minimal invasive plate osteosynthesis), it has a radiolucent insertion guide for the percutaneous screw insertion. The surgeon must be able to use the indirect reduction techniques for the metaphyseal or diaphyseal fracture component, such as the use of the AO distractor technique, or the provisional external fixation, the joystick technique, or the lag screw reduction technique. Most of the times, the articular component of the fracture is reduced with a direct, open technique, through a parapatelar incision, and fixed with interfragmentary compression screws, prior to the LISS plate insertion.

Figure no. 1. Distal femoral fracture. LISS plate osteosynthesis

The NCB system (Non-Contact Bridging for distal femur) seems to be a step forward in the complex distal femoral fracture fixation (Figure no. 2). The system is designed for the percutaneous, minimal-invasive, submuscular insertion, without extensive periosteal stripping, using a radiolucent targeting device for the percutaneous diaphyseal screw insertion. As against the LISS plate, the diaphyseal screws are angled at 8º in an alternating pattern for pull-out resistance and in order to reduce the stress risers. In the Distal Femur MIS Guide, the metaphyseal screws are allowed 30º of freedom. The NCB screw is secured into the plate with a locking cap that permits a range of 0º – 15º off-centre, or a 30º cone of polyaxiality, for the cases in which we want to "stay away" from certain regions, or if we want to "target" specific areas or fragments. As the locking process is the last step of the surgical technique, the screw (cortical or cancelous) can be used as a lag screw through the plate, with the presence of the tightening sensation. Different spacers are available (1mm, 2mm and 3mm) to be used during the procedure, to hold the plate off the bone and to avoid the periosteal crushing. When the whole construct is locked, the spacers are removed, resulting an internal fixator.

Regarding the intramedullary osteosynthesis, this remains a valid treatment option for the distal femoral fractures. The supracondylar nail was designed to improve fixation in

comparison with the classic retrograde nail. Distal locking bolts are placed very close to the distal extremity of the nail, and closer one to another, to improve fixation in the distal, condylar fragment, when the fracture is very close to the articular surface. The supracondylar nail (SCN) - T2 (Stryker) has 4 distal locking holes in 3 planes (for increased stability), placed into a 32mm area, while the most distal hole is placed at only 6 mm from the distal end of the nail. The condylar screws have adjustable pre-attached washers, to fit better to the lateral cortex of the condyle during the lateral compression and to avoid the crushing of the cortex in the presence of severe osteoporosis. Up to 7 mm of medio-lateral compression is possible, for largely displaced intercondylar fractures. During the bone healing process, we can obtain an axial compression in the metaphyseal area, by using an oblong hole in the proximal area. For short SCN, all locking screws can be inserted via a targeting device.

Figure no. 2. Distal femoral fracture. NCB plate osteosynthesis

Other types of retrograde nails, such as the Expert System (Synthes) also offer a distal locking option with a screw and a spiral blade, which improves the purchase of the implant into the distal fragment, especially in the osteoporotic bone.

The treatment indications for all these available implants for distal femoral fracture fixation are overlapping only partially. For extra-articular fractures (type 33-A regarding the AO classification), especially for A1 and A2 (without severe metaphyseal comminution), the supracondylar nail introduced percutaneosly, without opening the fracture site, is the method of choice. In the presence of poor bone stock, the use of a multiplanar locking nail or a spiral-blade locking nail can be a good option. In the presence of important methaphyseal comminution (A 3 fractures), the surgeon can choose a MIPO technique, the LISS technique for example. For simple articular fractures (type C1), both fixation methods (intramedullar and paracortical) remain possible, but the articular component must be perfectly reduced, percutaneosly or through a parapatelar incision. When articular and/or metaphyseal comminution is present, plate fixation is mandatory. Minimal-invasive systems allow a "biological" osteosynthesis, and angular stability and, eventually, polyaxial locking screws provide to the surgeon a wide range of possibilities for fracture reduction and fixation.

In conclusion, the choice of implant depends on several factors: type of fracture, bone quality, but also on the availability of implants, difficulty of surgical technique and surgeon's preference. Distal femoral fracture treatment continues to evolve nowadays, too concerning the reduction techniques, as well as the fixation implants. This is a proof that the perfect solution has not yet been found.

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