4 Preoperative Planning in Distal Femur Fractures

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4.1 Conservative Versus Surgical Treatment

Fractures of the distal femur are uncommon as they represent between 0.5 and 6% of all fractures and account for less than 3% of those affecting the femur [1, 2]. There is a bimodal distribution, with most commonly young men and older women being affected [1]. Nonoperative management options include the use of casting, traction, or a combination of both and have had some good results reported in the literature [3, 4]. Early studies even suggested that conservative was superior to operative management of these injuries [3–5]. However these older studies suffered from a selection bias where conservative treatment was more likely to occur in undisplaced fractures, and poorer techniques and implants for internal fixation were used in operative management. It is accepted that in general, casts are poorly tolerated and can result in pressure sores and joint stiffness [6]. Thus today, most of these fractures are treated surgically to prevent joint stiffness, achieve early mobilization, and prevent complications associated with prolonged recumbency [7]. Having said this, nonoperative management may still have a role in selected cases, where patients are unfit for surgery or were already immobile prior to injury.

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4.1.1 Periprosthetic Fractures of the Distal Femur

The phenomenon of a periprosthetic distal femur fracture deserves special attention, as its management will obviously differ due to the presence of a knee replacement. There are more and more total knee replacements (TKRs) being performed each year worldwide. Whilst it is difficult to estimate the incidence of periprosthetic fractures, it stands to reason that their incidence will also be increasing. The literature suggests a periprosthetic fracture risk of between 0.2 and 2% following primary total knee replacement and an even higher rate following revision TKR procedures [8–11]. There is much in the literature discussing their management; however, treatment options are increasing with innovation.

Most of these fractures occur following a low-energy fall and in elderly women [8, 12]. Other risk factors include inflammatory arthritis, chronic use of steroids, and osteopenia [13]. The phenomenon of femoral notching following TKR was initially thought to be a contributor, but now

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is controversial, as a potential risk factor. Biomechanical studies seem to support its inclusion as a risk factor; however, clinical studies have demonstrated that most patients presenting with a fracture don't actually have femoral notching [14, 15]. This is despite notching being quite common in asymptomatic patients with TKRs [9].

Traditionally, conservative management was the treatment of choice, which involved traction, casting, or a combination of both [16, 17]. However, non-weight bearing may be poorly tolerated, and prolonged recumbency was associated with high rates of pneumonia, pressure sores, and thromboembolic events [18, 19].

Mortality at 1-year has been documented to be 22%, with 9% of elderly patients having a late above knee amputation [18, 19]. This relatively high mortality rate means these patients are not dissimilar to those with a fracture of the proximal femur. The general consensus in fracture neck of femur patients is to operate, with the aim to allowing full immediate weight bearing in order to improve survival, and increase mobility, independence, and quality of life [20]. However internal fixation in this elderly group of patients is not without their complications. Poorer bone stock and the greater likelihood of grossly comminuted fractures mean that internal fixation is more likely to fail [21]. In the event of a fracture with a loose implant, revision or tumour prostheses have been used. These have the added advantage of allowing immediate weight bearing and an earlier restoration of function [22–24]. However their use involves resection of large amounts of bone, and failure may more likely result in amputation [25, 26]. Therefore, it is imperative that the most appropriate operative intervention be undertaken based on individual patient circumstances.

4.2 Timing of Surgical Treatment

Once surgical intervention has been decided upon, one should aim to undertake it as soon as possible to prevent medical deterioration of the patient from basal atelectasis, pneumonia, and venous stasis from immobility leading to thromboembolic events. However, one must also ensure that adequate planning has first been done to ensure the best possible outcome for the patient. This involves ensuring the patient is properly worked up for surgery and the relevant equipment and surgical team are available to perform the required operation. This may mean a delay of a couple of days but should not extend beyond a week. The exception is open fractures, which should be rushed to theatre early. However their operative management is very different from closed fractures and is done according to national and international guidelines [27].

4.3 Preoperative Planning

Planning is paramount and should consist of a history and examination followed by investigations. There are a number of salient points that should be considered in the history. Preoperative immobility and serious concomitant medical conditions may suggest nonoperative management might be more appropriate. For example, serious medical conditions, which significantly increase the risk of perioperative death or a history of malignancy with a short life expectancy, may indicate conservative management might be more suitable. Preoperative knee pain may give clues that the knee replacement was poorly functioning or even loose, suggesting that a revision procedure should be undertaken rather than fixation.

Examination of the limb, which follows after excluding other more life-threatening injuries, should always commence with a neurovascular examination, followed by an inspection of the fracture site to ensure that the fracture is not open. Open fractures are managed using a completely different treatment algorithm in order to minimize the risk of infection and to maximize the chance of preserving the limb [27]. The skin should also be inspected carefully as patients with friable skin, such as those on long-term steroids, may develop significant skin tears, necrosis, and tissue loss if placed for any length of time in traction/plasters.

Further investigations, including plain orthogonal radiographs of the knee and entire femur, should follow, and a computed tomography (CT) scan of the distal femur may be appropriate to ascertain whether the fracture is intra-articular and to assess whether the knee replacement is well fixed or loose. Radiographs are also useful in assessing bone stock, which can aid decision-making as to which implant should be used if operative intervention is considered. If surgery is considered to be the best option, then it should aim to restore the mechanical alignment of the limb with a well-fixed and balanced knee replacement, if one is present, and in order to give the best chance of restoring function. Ideally one should try to aim to choose operative options, which allow immediate full weight bearing in order to reduce the chance of perioperative complications and a quicker restoration of quality of life.

4.3.1 Planning for Intramedullary Nailing of Distal Femoral Fractures

Nailing of distal femoral fractures can be done ante- or retrograde. Antegrade nailing, however, may not bypass very distal fractures as the nail is unlikely to reach the most distal end of the femur. Furthermore, most antegrade nails have only two or three locking holes, at various distances from the tip of the nail. Thus the distal fragment is not as rigidly held as when a retrograde nail is used. Thus in general, retrograde nailing is preferred over antegrade nailing. Intramedullary nails provide relative fixation and thus fractures unite via secondary bone healing and callus formation. Thus open and absolute fracture reduction is not required if the fracture is extra-articular. In most circumstances, their use allows for early weight bearing and commencement of rehabilitation. They can be used effectively in simple or comminuted fractures. In isolation, they are generally not used with intra-articular fractures as displaced fractures should be reduced and internally fixed to prevent secondary bone healing and callus at the joint surface. Undisplaced fractures also carry the risk of becoming displaced on insertion of the nail. One could consider open reduction and internal fixation with screws and then nailing the fracture, but this is extremely difficult when retrograde nailing, as the screws are likely to interfere with nail insertion. It may be possible to do this with long spiral fractures, which enter into the knee. In this circumstance, it may be possible to put screws across the femoral condyles to prevent fracture displacement prior to inserting an antegrade femoral nail.

When selecting the nail diameter, one should try to ensure you chose the largest diameter that will be accommodated in the medullary canal. This provides more rotational stability to the construct. In turn this reduces stresses at the screw nail interfaces and those at the tip of the nail stem, thus reducing the risk of implant failure or periprosthetic fractures [28] (See Fig. 4.1).

In very capacious canals, where adequate cortical fit cannot be achieved, or there is cortical thinning due to severe osteoporosis, additional cement can be used to provide increased nail rotational stability whilst allowing better purchase of locking screws [28]. However care should be taken that the fracture is well reduced and that cement does not leak out of the fracture site. Cement extrusion may lead to thermal damage of near-by soft tissues and prevent fracture healing by becoming interposed between the fracture ends. Therefore, under these circumstances and when using cement for additional fixation, we recommend that the fracture site is firstly exposed and secondly perfectly reduced and cabled, to inspect for and reduce the likelihood of cement escape. We would also recommend that pressurization of cement not be performed for the same reasons.

4.3.2 Planning for Intramedullary Nailing of Periprosthetic Distal Femoral Fractures

Retrograde femoral nailing of these fractures has been reported to result in the highest rates of fracture healing [12]. This may be because fractures that lend themselves to this technique generally

Fig. 4.1 Distal femoral fracture treated with retrograde femoral nailing

have more distal bone stock or because the soft tissues around the fracture sites are less likely to be significantly disturbed during this type surgery. In addition, reaming of the femur generates bone graft and stimulation for fracture healing [28, 29]. Technically, retrograde femoral nailing of these fractures is similar to those without a TKR. There are however a few caveats which should be borne in mind. Very few intra-articular fractures will have well-fixed TKR implants. Therefore if an intra-articular fracture is present, reconsider whether your implant is loose and whether a revision arthroplasty solution is more appropriate. In the event of an intra-articular fracture with a stable TKR, such as condylar fractures, which do not affect the implant cement mantle, condylar compression screws should be used to reduce fragments and prevent further comminution when inserting the nail. Care must be taken when placing these screws to avoid entering the knee joint or blocking the path for the insertion of the retrograde nail.

Furthermore the use of a retrograde nail is only possible with cruciate sparing knee replacements and those with a wide enough intercondylar notch distance to allow a nail to pass. Posterior cruciate sacrificing TKRs have a closed box design preventing a nail from being used. In these circumstances, plating and revision arthroplasty are the only surgical options available. It is imperative that post total knee radiographs, which have been taken prior to fracture, are studied carefully. A lateralized or flexed femoral component may make nail insertion impossible, as the notch will be eccentric to the longitudinal axis of the femur in the coronal or sagittal plane [30]. Slight flexion of the femoral component may not be deemed to be much of a problem initially but can be if the knee is very stiff and cannot flex to 90 degrees. Thus pre-fracture range of motion needs to be established and a gentle examination under anaesthesia of the knee is a good idea, prior to making ones incision. If the knee is found to be too stiff, then one should be prepared to plate the fracture instead (See Fig. 4.2).

Another factor to consider is whether the patient has an ipsilateral total hip replacement or proximal intramedullary device. Retrograde nails have the additional risk of introducing stress risers between the tip of the nail and the stem of a hip replacement, which can result in further fractures. Therefore these inter-prosthetic fractures may be better managed with internal fixation using a robust plate which overlaps both implants [30] (See Fig. 4.3).

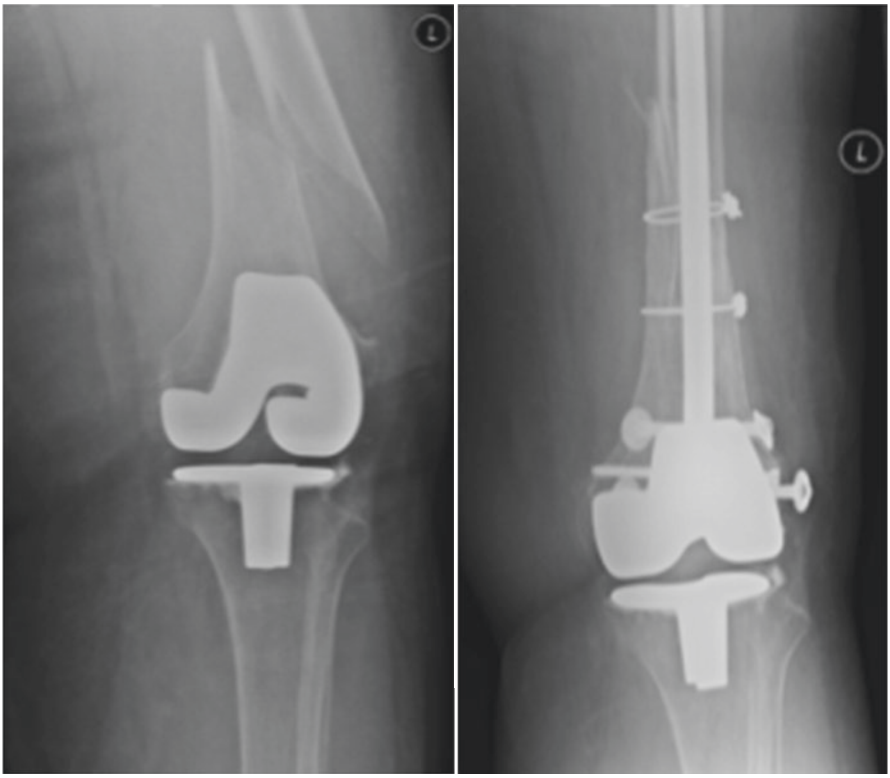

Fig. 4.2 Distal femoral periprosthetic fracture treated with retrograde femoral nailing

If you are fortunate enough to have a TKR, which can accommodate a nail passing through it, one must not forget about the polyethylene bearing and be prepared in case it needs to be replaced, prevents nail insertion, or becomes damaged. Therefore it is paramount that the brand of TKR is identified, the appropriate polyethylene extraction tools are obtained, and the full range of inserts are available should it need to be replaced and to achieve a balanced knee.

4.3.3 Planning for Internal Fixation of Distal Femoral Fractures

There are a number of implant types available when internally fixing these fractures. However some of the older implant designs have largely been abandoned today. Angled blade plates, dynamic condylar screws, and condylar buttress plates were either technically demanding to insert, weaker in construct, or had poor hold in the distal fragment [31]. Contemporary locking plates have been found to be biomechanically superior to non-locked designs and are responsible for the improvement of outcomes when performing internal fixation of these fractures [32]. They are designed to allow a submuscular insertion, thereby reducing tissue stripping around the fracture site. Screws are designed such that the heads are threaded and can lock into the plate. Thus, once all the screws are seated, the implant forms a fixed angle construct, which greatly increases its pull out strength and reduces the risk of implant failure in osteoporotic bone. A good working length should however be achieved between the fracture and nearest screw to allow for micro-motion of the fracture site and enable the best chance of bony union (See Fig. 4.3).

Fig. 4.3 Distal femoral fracture treated with a locking plate

4.3.4 Planning for Internal Fixation of Periprosthetic Distal Femoral Fractures

Contemporary locking plates are far superior to non-locked designs and are responsible for the improvement of outcomes when performing internal fixation of these fractures [12, 33, 34].

If a cemented THR is present, proximal fixation can be achieved through bicortical screws, which go through the cement mantle. At the level of the stem, uni-cortical locking screws can be used or bicortical screws can also be used if one can squeeze them past the tapered tip of the stem. Cables can also provide additional fixation. Polyaxial locking plates, which allow screws to be angled in different directions whilst still locking into the plate, are particularly useful when trying to navigate screws past femoral stems. Usefully these polyaxial plates sometimes have built-in holes to accommodate cables which prevent their displacement after insertion and when the patient commences rehabilitation (see Fig. 4.4).

Cortical strut grafts provide initial stability and a matrix the body can use to bridge the fracture gap. However, an isolated cortical strut graft, cabled or wired at the fracture site, is insufficient in providing the required stability in these fractures [35]. A locking plate is still required and an orthogonally placed strut graft may have a role in preventing fixation failure

Fig. 4.4 Distal femoral periprosthetic fracture treated with a locking plate

prior to fracture union. Certainly, non-locked plates should not be used for these types of fractures where one is undoubtedly faced with osteoporotic and deficient bone [12].

4.3.5 Planning for Revision Arthroplasty of Periprosthetic Distal Femoral Fractures

For low-demand patients, and in the presence of poor femoral bone stock, ligamentous instability, or loose TKR implants, the revision arthroplasty is the ideal surgical treatment choice [25, 36]. In severe situations, a distal femoral replacement may even be indicated. The operative technique does not differ greatly whether a total knee replacement is present or not, as the distal femur is resected. The only real difference occurs when dealing with the proximal tibial component, which may be well fixed. Care must be taken to preserve as much bone as possible on the tibial side and when removing cement. These procedures are best undertaken by those with experience in using these endo-prostheses.

In summary, unfortunately, the literature lacks strong enough evidence to determine whether locking plates, nails, or revision knee replacements are best for treating these fractures. A meta-analysis of retrospective evidence attempted to shed light on this question but found no difference in union rates between the use of locking plates or retrograde femoral nails [12]. Thus, it seems prudent that treatment decisions are made based on the availability of expertise, equipment, and patient-related variables. As such, there is no panacea for treating these injuries, and they should be treated with the general principles of relieving pain, restoring function, whilst reducing the possibility of complications associated with prolonged immobility.

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