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ORIGINAL STUDY

Impaction bone grafting for tibial defects in knee replacement surgery. *Results at two years*

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Bone loss with large defects poses a complex and challenging problem in primary and revision knee arthroplasty. The defects are often irregular and difficult to quantify. One of the techniques available to restore bone in such cases is Knee Impaction Bone Grafting (KIBG) ; however, the clinical literature to support this technique is weak. Since 2006 we have used impaction bone grafting for contained and uncontained large tibial defects in primary and revision total knee arthroplasty.

We have prospectively studied 11 patients with large tibial defects treated at the Exeter Knee Reconstruction Unit with KIBG using a short cemented stem following the Slooff-Ling philosophy. Average age was 66 years (41-86 years). Minimum follow-up was 2 years. The Knee Society Scores improved from 27.4 to 89.2 on average, with Knee Society Function score and WOMAC increasing by 26.3 and 23.2 points respectively. The mean post-operative flexion was 112 degrees. The average gain in motion over preoperative value was 20 degrees. At two years there were no mechanical failures. None of the patients have required secondary procedures or further revisions. All radiographs showed incorporation and remodelling of the graft. The only complication was a superficial dysaesthesia around the operative scar. Although being time consuming and technically demanding, KIBG for substantial tibial bone loss has shown excellent versatility and good short term results , providing a stable construct with immediate weight bearing post operatively. In view of previous concerns regarding early incorporation and stability of impaction bone grafting in the tibia, we present our early results at 2 years. This technique has become our preferred technique for treating substantial bone loss in tibial defects seen in primary and revision knee arthroplasty surgery.

Keywords : knee ; impaction bone grafting ; revision ; reconstruction.

INTRODUCTION

The management of bone defects of tibia and femur in knee surgery is challenging. Although clinical results of primary total knee replacement (TKR) continue to be excellent, the number of revision procedures however is expected to rise substantially (*7,17*).

Bone loss around the knee in primary and revision knee surgery is often underestimated preoperatively (*20*) ; for this reason, surgeons need implants and techniques that are versatile.

Of the different techniques to reconstruct defects in primary and revision knee surgery, structural allografts and Knee Impaction Bone Grafting (KIBG)

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are the only ones that have potential for restoring and reconstituting bone stock in bone defects (28).

Use of structural allografts in the revision situation has shown variable results (8,9,33), with reports of collapse of the graft and unpredictable union. There has also been difficulty encountered in using it for irregular defects, along with costs and availability issues.

The use of impaction bone grafting to restore bone stock in total hip replacement is well reported in literature and has been shown to be an excellent method based on mechanical (12,16), clinical, histological and radiological studies (5,10,11,24,25,26). Although well established in hip arthroplasty, impaction grafting in knee arthroplasty is still a relatively unproven technique with the published experience being limited (28).

The use of morselised bone grafting in knee arthroplasty has been variable in terms of patient selection, technique and results. The reports are mainly clinical, with small numbers and short follow-up (14,30). The techniques in these studies are mostly not based on the Slooff Ling philosophy (i.e short stem fully surrounded by graft and cemented) which has proved so successful in the hip. These techniques therefore failed to emulate the experience in the hip, which is that the graft alone, when sufficiently compacted can achieve a stable bed for an implant without the use of a bypassing stem.

There have also been some concerns raised about the stability of KIBG on the tibial side (31). The authors discouraged the use in the tibia, suggesting that it was insufficiently stable to provide enough support in the tibia. Recent laboratory based biomechanical work has shown that sufficient stability can be achieved on the tibial side using specially developed impaction bone grafting instruments (27, 29).

A recent clinical study (18) has reported encouraging results of impaction grafting using a similar technique to that of the Slooff-Ling technique, incorporating both femur and tibial defects in the series. However the scientific literature so far is still short of a study purely on large tibial defects.

Our study was designed to look at the results of KIBG in large tibial defects using a short cemented stem surrounded by bone graft, for both contained and uncontained defects, followed with early unrestricted weight bearing.

We report our results at two years minimum follow-up addressing the above concerns with tibial defects.

PATIENTS AND METHODS

From 2006, we prospectively followed 11 knees in 11 patients with only tibial defects that were operated using KIBG. There was no control series for comparison. The average age of patients was 66 years (41-86 years). There were 5 males and 6 females. No patients were lost to follow-up.

The tibial bone defects were classified according to the Anderson bone defect classification (AORI) (32) :

Type 1. Intact metaphyseal bone : minor bone defects that do not compromise the stability of the component.

Type 2. Damaged metaphyseal bone : loss of cancellous bone in the metaphyseal segment that necessitates an area of cement fill, augments, or bone graft to restore a reasonable joint line level. These defects can occur in one femoral condyle or plateau (2A) or both (2B).

Type 3. Deficient metaphyseal segment : bone loss that compromises a major portion of either condyle or plateau. These defects are occasionally associated with collateral or patellar ligament detachment and usually require bone grafts or custom implants.

The classification is applied separately to the femur (F) or the tibia (T).

Intraoperatively defects were classified as Large T2 in 10 patients and T3 defect in one. The assessment and indication for bone grafting was made by the senior author.

The patients were scored preoperatively and then followed up at 6 weeks, 6 months, one year and two years. This cohort is intended to be followed up further in the future to judge the long term results of KIBG for tibial defects. To address the earlier concerns of KIBG on the tibial side, the outcome of this cohort was assessed at 2 year mark and is being presented.

The Knee Society Scores, WOMAC, Knee society Function Scores, Range of motion and Value added range of motion (15) (total range of movement gained over pre op range) status were used as assessment tools. Standard AP and lateral radiographs (Fig. 1 & 2)) were taken at follow-up and assessed post operatively. The radiographic assessment was performed by an independent assessor in clinic to look for any features of failure like fractures, malalignment, subsidence and metalwork issues.

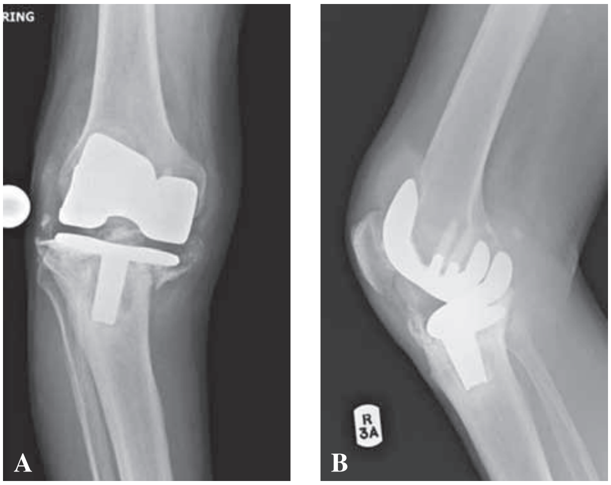

Fig. 1. — a : Pre op radiograph AP view ; b : Pre op radiograph Lateral view.

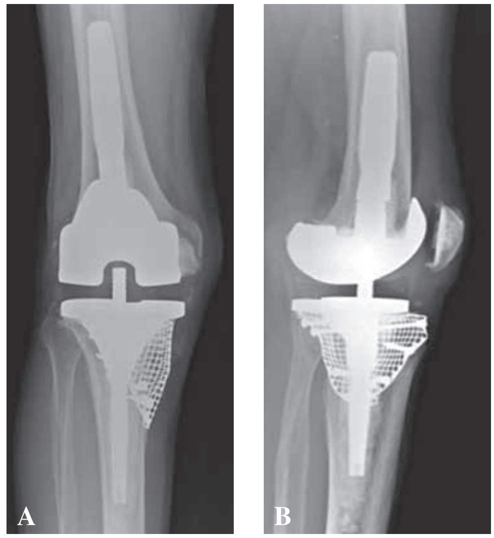

Fig. 2. — a : Post op radiograph AP view ; b : Post op radiograph Lateral view.

TECHNICAL OPERATIVE HIGHLIGHTS

The defects are quantified and carefully burred back to a solid base bone. For uncontained defects a wire mesh (Stryker® X-Change acetabular mesh) augmentation is used and fixed with screws from the AO small fragment set, as many as required to achieve a stable construct, usually 3 on each side of the defect.

Fresh frozen femoral head allografts are ground to fine and coarse chips using a manually operated bone mill (Noviomagus® bone mill, Spierings Orthopedics BV, Nijmegen, NL) and washed with saline.

The tibial medullary canal is reamed and prepared. The preparation of the canal is based on the Slooff Ling philosophy (stem cemented in compacted bone graft) (Fig. 3). There is no intention of achieving a pressfit of the stem in the tibia. The Stryker® X-Change Reconstruction system is used. A cement restrictor with attached central guide wire is inserted leaving 2 cm from the tip of the intended stem. Morselised bone graft is introduced and compacted using distal impactors in an incremental manner (increasing diameter sizes of impactors, from distal to proximal) to produce a firm distal graft plug. A trial stem 2 mm larger than the intended stem (the standard modular cemented stem from the revision system) is introduced to provide space for a 2 mm cement mantle. The morselised graft is tightly packed and compacted around this stem using a combination of tamps from the KIBG instrumentation. A new medullary canal is hence reconstructed by the use of impacted graft. Coarse morselised graft is used more to reconstruct the proximal defect and compacted using appropriate tamps. Care is taken to ensure the trial stem is positioned exactly aligned as the final component. The impaction process is done in stages from distal to proximal. Bone cement is injected and pressurised into the space for the stem and also placed on top of the compacted graft. The final stemmed component is positioned into the tibia.

We have used Scorpio TS or MRH (Stryker®) systems in our series using short cemented stems that are fully surrounded by compacted morselised graft.

RESULTS

The Knee Society Scores improved on average by 61.8 points (from mean pre op 27.4 to 89.2 post op). The Function Scores and WOMAC although influenced by various general health factors increased by an average of 26.3 points and 23.2 points respectively. The average post-operative flexion

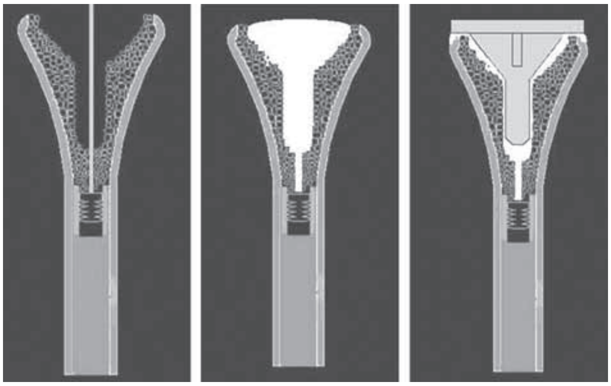

Fig. 3. — Slooff Ling technique.

was 107° (range : 90-135°) with the value added motion (*15*) (VAM) being 20° (range : 10-50).

There have been no infections. There have also been no mechanical failures (malalignment of implants, fractures or metalwork issues) requiring revision for any reason. One patient developed dysaesthesia around the scar and required neuropathic pain medication and input from the pain management team. Radiographs at two years were satisfactory, not showing any fractures, metalwork failure, loosening or malalignment of implants.

DISCUSSION

The management of large defects in primary and revision knee arthroplasty poses a significant problem, and the early results are an important determinant of long term outcome.

Bone loss around the knee may occur as a result of the original disease process, the design of the prosthesis, the mechanism of failure, a technical error at the initial procedure or at the time of implant extraction during the revision procedure ; it is often underestimated.

With large defects encountered at primary or revision surgery, the aim is to address the failure mechanism, minimise further bone loss, and produce a stable platform with good load transfer to the underlying bone, whilst relieving pain and maintaining good function.

When selecting the method of reconstruction of large defects, the potential for future further revision must also be considered, together with the life expectancy and functional demand of the patient. Restoration of bone stock is preferable, particularly if further revision is considered likely.

The options for the management of bone loss in knee surgery include the use of cement, modular augments, custom implants and bone grafting in either structural or morselised form. However the literature is not clear on which technique is best. Our previous review paper (*32*) has discussed this topic in detail.

The use of bone graft allows augmentation of residual bone stock. The ability to contour the graft at the time of operation and the capacity of the graft to transfer load in a physiological manner are significant advantages. The disadvantages of allografts include unpredictable union, the theoretical transmission of viral, bacterial and prion disease (*3,6*) and their expense and availability, which is not universal.

The use of structural allografts has shown variable results. Technical difficulties have been faced with fitting structural bone grafts in irregular bone defects and often more native bone has to be sacrificed to fit the graft. The use of morsellised graft in this respect appears a more advantageous option.

New innovations include the use of metaphyseal filling metal cones. These may help the surgeon to achieve improved stability of the implant in patients with larger bone defects (*4,19,21,22,24*). Although these cones may provide structural support they will not reconstitute bone stock and may need to be cemented to the prosthesis to ensure stable fixation. The medium- and long-term outcome of this technique is unknown. Further revision surgery after their use may become technically difficult due to the bone ingrowth, and further loss of bone at the time of their removal should be expected.

All of the above mentioned biological and non-biological techniques have a role to play in knee surgery, both in primary and revision situations, although more limited in application than others.

In spite of the apparent advantages of impaction grafting using morsellised graft and its success in hip surgery there have been some concerns with its use on the tibial side, based on a histological study.

We have tried to address the concern about stability with impaction grafting by performing biomechanical laboratory testing to produce a reliable technique and then incorporate that into clinical practice and now at 2 years the results are satisfactory.

Uncertainty about stability has forced many authors to use long pressfit stems in tibia in the past, which although ensuring greater initial stability, largely bypass the graft causing significant stress shielding (*1,2*). This unfortunately reduces one of the major advantage of morselised bone graft which is early incorporation as compared with structural bone grafts.

As early stability has been a major concern in the tibia treated with impaction grafting, we present early results at 2 years in this series of patients who underwent impaction bone grafting for substantial bone loss. The results reported in this series are comparable to the results of patients who have undergone total knee revisions without substantial bone loss (*13*) and other series comprising of femur and tibial defects (*18*). In contrast to the latter series, there has been no major complication or need for revision surgery in our series. In the above series a complication rate of 14% was reported which included infection (5%), periprosthetic fractures (2 patients, with one going onto non union) and patellar clunk syndrome (2 patients, requiring open partial synovectomy). In our series with the technique as described earlier the complication rate was seen to be much lower at 5.2% (1 patient) in the form of neuropathic pain around the scar area, which responded to neuropathic pain management. We however acknowledge the follow-up at 2 years in our series is shorter than the above series.

To date, no patient has failed because of mechanical and technical problems or loosening, while showing improvement in post operative range of movement and outcome scores.

We acknowledge the lack of a formal control group as a shortcoming in our study. In revision knee arthroplasty this is almost impossible to achieve. The technique is without doubt technically demanding and time consuming and requires special equipment. The uncontained defects can be particularly challenging.

Radiographic outcome particularly needs better definition with clearer parameters to define early signs of failure and correlation between radiographic and histologic changes that may be relevant in clinical practice. At present there are no accepted and established criteria to report the bone graft incorporation. Most of the studies including ours report complications, technical failure or need for repeat surgery as a gauge of success or failure of this method. We intend to follow this cohort through in the long term to fully test the true potential of this technique.

This technique remains our preferred standard technique for managing primary and revision total knees with large bone defects on both sides of the knee joint articulation.

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