Optimising femoral component rotation using Equiflex instrumentation: a clinical review

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Received: 10 December 2006 / Accepted: 23 January 2007 / Published online: 9 March 2007
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Abstract Although there is agreement that flexion and extension spaces should be symmetrical and that rotation of the femoral component impacts outcome in a knee replacement, there is dispute over what is the ‘correct’ rotation and how best to achieve it (Akagi et al., Clin Orthop Relat Res 366:155–163, 1999; Anouchi et al., Clin Orthop Relat Res 287:170–177, 1993; Barrack et al., Clin Orthop Relat Res 392:46–55, 2001; Berger et al., Clin Orthop Relat Res 356:144–153, 1998; Jenny and Boeri, Acta Orthop Scand 75(1):74–77, 2004; Poilvache et al., Clin Orthop Relat Res 331:35–46, 1996; Siston et al., J Bone Joint Surg Am 87(10):2276–2280, 2005). Insall and Scuderi recommended placing a tensor in flexion and rotating the femoral cutting block so that its posterior edge is parallel to the cut tibia (Insall, Surgery of the knee, vol 2, 2nd edn., Churchill Livingstone, New York, 1993; Scuderi and Insall, Orthop Clin N Am 20:71–78, 1989). We feel Equiflex instrumentation will reliably achieve Insall and Scuderi’s recommendation. To evaluate early results and lateral retinacular release rates using Equiflex instrumentation for TKR, we evaluated 209 consecutive knees (31 valgus, 178 varus) using this technique from 4 April 2005 until 19 September 2006. Pre and postop American Knee Society and Oxford scores, deformity, ROM, lateral retinacular release rates and complications were recorded. We could correct alignment and achieve our technical goals in 99% of cases. A lateral retinacular release was required in only five knees (2.4%). The complications are comparable to published data. The Equiflex instrumentation

does help in equalising flexion-extension gaps, improves patellar tracking and reduces the incidence of lateral retinacular release.

Résumé Les praticiens sont tous d’accord: lors de la réalisation d’une prothèse du genou il faut réaliser celle-ci avec un espace identique en flexion et en extension par contre, le problème de la rotation est beaucoup plus discuté (Akagi et al., Clin Orthop Relat Res 366:155–163, 1999; Anouchi et al., Clin Orthop Relat Res 287:170–177, 1993; Barrack et al., Clin Orthop Relat Res 392:46–55, 2001; Berger et al., Clin Orthop Relat Res 356:144–153, 1998; Jenny and Boeri, Acta Orthop Scand 75(1):74–77, 2004; Poilvache et al., Clin Orthop Relat Res 331:35–46, 1996; Siston et al., J Bone Joint Surg Am 87(10):2276–2280, 2005). Insall et Scuderi recommandent de placer le tenseur en flexion rotation de façon à avoir une coupe des condyles postérieurs parallèles à la coupe tibiale (Insall, Surgery of the knee, vol 2, 2nd edn., Churchill Livingstone, New York, 1993; Scuderi and Insall, Orthop Clin N Am 20:71–78, 1989). Le matériel ancillaire Equiflex permet de réaliser cette préconisation d’Insall et Scuderi. Le propos de cette étude est d’évaluer les résultats précoces et le taux de release externe en utilisant cette méthode. Nous avons évalué 209 prothèses du genou consécutives (31 valgus, 178 varus) en utilisant cette technique. Ces patients ont été traités du 4 avril 05 au 19 septembre 06. Les résultats ont été évalués par le score de l’American Society et le score d’Oxford en pré et post-opératoire. La déviation axiale, la mobilité, les releases et les complications ont été également évalués. Résultat : Nous pouvons aligner correctement les genoux selon cette technique dans 99% des cas. Un release externe a été nécessaire uniquement dans 5 genoux (2.4%). Conclusions: les complications sont comparables aux données de la littérature. Finalement l’instrumentation Equiflex permet

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la réalisation d'un espace identique en flexion et en extension, améliore le fonctionnement fémoro patellaire et diminue l'importance des releases externes.

Introduction

There is general consensus that rotation of the femoral component has a bearing on the function and outcome of a knee replacement [1, 2, 4, 5, 15, 17]. However, there is some disagreement as to what constitutes the correct rotation of the femoral component and how to achieve this during surgery. There is some evidence from anatomical studies that the transepicondylar line might represent the correct rotational alignment but it is unclear how reliably this can be reproduced during surgery [21]. Various authors have suggested using the AP axis, the transepicondylar line, computer navigation or empirical external rotation dialled into the instrumentation after posterior referencing but none of these methods have been shown to reproducibly and consistently give the optimal rotation [2, 12–14, 16, 17, 21, 23]. Insall and Scuderi recommended placing a tensor in the knee in flexion and rotating the femoral cutting block so that its posterior edge is parallel to the top of the tibia [10, 20].

We feel the Equiflex instrumentation (Biomet, Bridgend, UK) designed by the senior author (IACL) and described here will reliably achieve optimal femoral rotation and improve the patellar tracking.

Design rationale

External rotation of the femoral component is generally considered desirable although the degree of rotation required varies between patients as well as between genders [4]. Olcott et al. concluded that a 3 degrees fixed external rotation was the least consistent method to produce a rectangular flexion gap [16]. There is also consensus that the flexion and extension gaps have to be equal and rectangular for optimal function [17].

Stiehl et al. used an extramedullary jig to ensure the posterior femoral cut was perpendicular to the tibial shaft axis. By doing so they reduced their incidence of lateral retinacular release from 72.2% to 28.3% [23]. If the initial tibial cut is accurately made, a femoral posterior cut that is perpendicular to the tibial shaft axis may improve the patellar tracking as well as ensuring equal and rectangular flexion extension gaps [23]. However, the initial tibial cut may not be perpendicular to the tibial shaft axis and we feel this can lead to some malrotation in some cases.

Moreover, the above methods would work only if the natural tibial plateau were at a consistent angulation to the presumed mechanical axis. The tibial plateau is assumed to be at a varus inclination of 3 degrees. Thus a cut perpendicular to the tibial axis would result in an over resection of the lateral

tibial plateau which is sought to be corrected with varying degrees of femoral component rotation. In reality the tibial varus inclination can vary from 0–6.5 degrees and the intended perpendicular cut may also be either in slight varus or slight valgus [19]. Therefore, we feel a preordained femoral component rotation by whichever method would necessarily lead to malrotation, a trapezoidal flexion gap and flexion instability in a certain percentage of cases. This was borne out by the study of Olcott and Scott. They found flexion gap asymmetry in 10–30% of cases using different methods of ascertaining femoral component rotation [16]. Some studies suggest that femoral rotation would affect stability only in flexion [2, 19]. It has also been shown that soft tissue releases carried out for ligament balancing does change the flexion and extension gaps [19]. We therefore feel that the tibial cut should be made first followed by the required soft tissue releases in extension and the femoral rotation then determined with the knee in flexion using a tensioning block which would both ensure equal flexion and extension gaps as well as a posterior femoral cut that is parallel to the cut tibial surface. This method had been advocated in the past by Insall and Scuderi and Romero et al., although it does not appear to have found wide acceptance [10, 14, 19, 20].

Hypothesis

We feel improved patellar tracking would be manifested in a lower incidence of lateral retinacular release than reported in the literature and a faster recovery enabling early discharge as well as shorter rehabilitation of the patients.

Materials and methods

The Equiflex instrumentation

The Equiflex instrumentation consists of a spacer or tensioner with two parallel plates in the shape of the cut upper surface of the tibia with a knurled ratchet to adjust the gap between these two plates from 8 mm to 22 mm (Fig. 1a,b). This arrangement is mounted on a detachable handle. The top plate is interchangeable with a sawn off version of the plate enabling it to be used with knee in flexion (Fig. 1a,b). The femoral cutting block has been redesigned to take a modular midline stem of two lengths (200 mm or 300 mm) that goes into the intramedullary femoral canal and allows calibrated movement in an anteroposterior direction through a screw driver ratchet mechanism as well as free angular motion about the stem in a horizontal plane (Fig. 2a). The cutting block has been tooled to accept an anterior referencing guide as well as anterior and posterior saw capture plates. It also includes slots for the chamfer cuts (Fig. 2b).

Fig. 1 **a** Equiflex spacer with sawn-off top-plate used for measuring flexion gap. **b** Equiflex spacer showing knurled ratchet and graduations from 8 mm–22 mm (side view)

The operative technique

A midline incision is made followed by medial parapatellar arthrotomy. The operative technique necessitates making the proximal tibial cut first. This is done in the usual fashion using extramedullary jiggling to align with the tibial

crest and middle of ankle joint with the desired degree of posterior slope dialled in. The authors prefer to do this cut with a neutral posterior slope. The tibial surface is then sized using the AGC (Anatomically Graduated Components, Biomet, Bridgend, UK) tibial sizers. The distal femur is then cut in the usual fashion using standard AGC

Fig. 2 **a** Femoral cutting block showing the modular adjustable midline stems. **b** Femoral cutting block with anterior referencing guide

intramedullary jigging. The next step is to measure the extension gap using the Equiflex spacer with the knee in full extension. Varus valgus stress is applied to see if the knee is tight on one side or the other and, if it is tight, conservative step by step releases are done until a rectangular space is obtained. The long straight rods are then inserted through the handle of the Equiflex instrumentation and the alignment is checked (Fig. 3). Proximally it should pass over the femoral pulse and distally it should point to the middle of the ankle joint. Next, a femoral cutting block of appropriate size is chosen (usually this is one size smaller than the tibial size) and placed on the distal femoral surface with the central stem in the medullary canal of the femur. The block is then moved posteriorly in a calibrated fashion using the screw driver ratchet mechanism with the anterior referencing guide preventing notching. The Equiflex spacer is then inserted into the knee and the knee gently allowed to come into extension. The knee should stabilise itself at 90 degrees with the cutting block rotating to stabilise itself parallel to the top plate of the Equiflex spacer thereby being also parallel to the cut proximal surface of the tibia (Fig. 4). As the Equiflex spacer has already been set at the measured extension gap the flexion and extension gaps will necessarily be equal. If the knee extends beyond the 90 degrees mark before stabilising then one should upsize on the femoral cutting block, and if the knee does not extend up to at least the 90 degree mark then one should downsize on the femoral cutting block. The femoral cutting block is then fixed to the femur with a central pin and medial and lateral mushroom pins. The anterior referencing guide is removed then replaced with anterior and posterior saw capture plates after which the anterior, posterior and chamfer cuts are made. The trial implants are then inserted. Tibial tray thickness is given by the gap measured by the Equiflex spacer. If there is a residual fixed flexion deformity the PCL may be recessed or a posterior capsular release carried out as thought appropriate. Medio-

Fig. 4 Assessing and balancing the flexion gap with Equiflex spacer in situ

lateral stability should be present as a rectangular space was already obtained at the stage of inserting the Equiflex spacer initially. Patellar tracking is checked for at this stage with the tourniquet still inflated using the ‘no touch’ technique

Fig. 3 Checking overall alignment after distal femoral cut and ligament balancing

(Fig. 5). Usually it is found to track well and a lateral retinacular release is very rarely required.

Clinical review of our results

The Equiflex instrumentation technique has been in use in our unit for the past few years and we reviewed the early results of 209 consecutive knee replacements using this technique between 4 April 2005 and 19 September 2006. In order to minimise surgeon to surgeon variability we evaluated only those knees which were either done by the fellow (RRK) as the main surgeon or as the first assistant. 193 (92%) of the knees were done by the fellow as the main surgeon. All cases were done by the Equiflex method as described. A tourniquet was used and no drain was used.

Patients who had a young physiological age with good quality bone and good quality cuts received an uncemented implant. All patients received the standard three doses of perioperative antibiotics. The uncemented replacements in

addition received the ‘Septocoll’ Gentamycin fleece (Biomet, Bridgend, UK). The patella was not routinely replaced; the exceptions being when it was thought that the worn-out shape of the patella contributed to any maltracking or when the knee was thought to be involved in an inflammatory arthropathy. The knee was also put through a full range of movement peroperatively and any flexion extension gap mismatch or asymmetry resulting in lift off was recorded.

As per the departmental guidelines in our hospital chemical thromboprophylaxis was only used in cases with a previous history of thromboembolism or in cases which were already anticoagulated for other medical or cardiac reasons. Mechanical prophylaxis in the form of rapid early mobilisation and aggressive physiotherapy was started from the first postoperative day in all patients.

All cases had preoperative American Knee Society [11] and Oxford scores [8] done and a postoperative score at 6 weeks. The American Knee Society generated separate Knee scores and function scores with a maximum score of 100 in each section [11]. The Oxford scores consisted of 12 questions with a best score of 12 and worst score of 60 [8]. All cases had pre- and postoperative deformity and ROM recorded.

All complications including superficial wound problems were recorded apart from catheterisation. A knee was considered to have a superficial infection if it was thought that the infection was confined to the skin and subcutaneous layer and responded promptly to antibiotics without recourse to any further operative intervention. Every patient had at least one postoperative X-ray by the 6 week mark. Postoperatively patients were discharged home if they achieved a knee flexion of at least 90 degrees, a straight leg raise, safe independent mobilisation and were free of medical problems requiring further in-patient treatment or investigation.

152 cases were available with minimum 6 week follow-up; knee scores, function scores and Oxford scores are presented for these patients. Complications are presented for the entire cohort of 209 patients.

Results

We performed a total of 209 knee replacements of which 38 (18%) were uncemented. We used the AGC posterior stabilised design (Biomet, Bridgend, UK) in four cases, the Maxim (Biomet, Bridgend, UK) in three cases and the AGC cruciate retaining design (Biomet, Bridgend, UK) in 202 cases. We had 6 weeks follow-up data on 152 patients after excluding three patients who had a stroke, one patient with a significant psychiatric history and one patient who had died following a stroke postoperatively. There were 119 female patients and 90 male patients. Average age of the patients was 71.4 years (range 49–89). 31 (14.8%) of the

Fig. 5 Checking for patellar tracking

knees were in valgus alignment preoperatively (0–25 degrees valgus) and 178 (85%) knees were in varus alignment preoperatively (0–23 degrees varus). Average preoperative alignment was 5.95 degrees of varus alignment. There were five cases of rheumatoid arthritis and the rest were cases of osteoarthritis. Average preoperative fixed flexion deformity was 7.95 degrees (range 0–30), average postoperative fixed flexion deformity was 3.86 degrees (range 0–15). Average postoperative flexion at 6 weeks follow-up was 98 degrees with 89 (58.5%) knees achieving a flexion of ≥ 100 degrees.

Average in-patient stay after excluding outliers with medical problems was 4.9 days (range 2–9). Average total in patient stay was 6.24 days (range 2–41). All patients were discharged home apart from one patient with a significant psychiatric history who was discharged to a step down supervised care facility.

121 (59%) patients went home in ≤ 5 days

41 (20%) patients went home in ≤ 3 days

17 (8%) patients went home in 2 days

Readmission within 6 weeks for any reason was 16 (7.6%) of which three did not have anything significant wrong with them. The reasons for readmission were chest pain (1), CVA (1), knee pain with no evidence of infection (3), DVT (2), PE (2), distal shin cellulitis (2), superficial infection (4), pyelonephritis (1).

A lateral retinacular release was required in only 5 out of 31 (16%) valgus knees and none of 178 varus knees giving an overall lateral retinacular release rate of 2.4%. The patella was replaced in only four cases (1.9%). We observed that using this method the appropriate femoral size was generally one size smaller than the measured tibial size. This relationship was true in all but one case.

We achieved our goal of equal and symmetrical flexion-extension gaps in all but two cases (99%).

Orthopaedic complications

1. Superficial infection = 10 (4.7%):
 - 1 *Staph aureus*
 - 1 *Proteus mirabilis*
 - 4 cases treated as infection with antibiotics but no organism grown
 - 4 cases of distal shin erythema/cellulitis
2. One case of postop pyrexia with no identified infection. Knee clinically satisfactory
3. Readmission with haemarthrosis (patient on warfarin for AF) = 2 (0.9%)
4. Stiff knee = 5 (2.3%) of which 3 had MUA
5. Thromboembolic phenomena = 13 (6.2%) of which DVTs = 9 (4.3%), PE = 5 (2.4%), and one patient had a PE as well as a DVT

6. Patella resurfaced within 1 year = 2 (0.9%)
7. Persistent pain beyond 6 months = 2 (0.9%)
8. Excessive medial release = 2 (0.9%)
9. Hairline fracture of tibial cortex in soft porotic bone, treated with a brace = 3 (1.4%)

Medical complications

1. MI = 2 (0.9%) (one postop, one at 4 weeks)
2. Pre-existing chest condition delaying discharge = 3 (1.4%)
3. GI bleed = 2 (0.9%)
4. Ca Rectum picked up postop following bleeding PR = 1
5. Pyelonephritis-readmission under physicians = 1
6. Confusion delaying discharge = 2 (0.9%)
7. CVA = 4 (1.9%) of which 3 were postop and 1 was at 6 weeks after discharge
8. Death = 1 (0.47%) resulting from one of the CVAs mentioned above

Discussion

Most authors agree that a majority of patellofemoral complications are attributable to surgical technique with component rotation being of particular importance [1, 2, 4, 5, 17]. Poilvache et al. felt the transepicondylar axis was the most reliable way to get optimal femoral rotation. However, using this method they had a lateral retinacular release rate of 72% in valgus knees and 16.8% of varus knees which we feel could be reduced further with better rotation of the femoral component [17]. Olcott and Scott, in a comparison of the transepicondylar axis method with Whiteside's line and 3 degrees empirical external rotation, found transepicondylar axis to be most reliable and 3 degrees external rotation to be least reliable. Yet they also found that the transepicondylar axis method did not yield flexion gap symmetry in 10% of varus knees and 14% of valgus knees [16]. Akagi et al. found that setting the femoral component in 3–5 degrees external rotation improved their patellar tracking manifest in a reduced lateral retinacular release rate of 6% compared to 34% in neutral position [1]. Worland et al., in a comparison of a universal and anatomical femoral component in neutral and 3 degrees external rotation, found the lateral retinacular release rate to be least at 26% with the anatomical femur in 3 degrees external rotation compared to a lateral retinacular release rate between 44% and 52% for the other groups [25]. We feel this is still a rather high figure and that the femoral rotation can be further improved. Stiehl et al. found that their lateral retinacular release rate decreased from 72% to 28% when they converted from using the posterior condylar axis method to a cut

Fig. 6 Postop results

perpendicular to the tibial shaft axis [23]. Sodha et al. found that aligning the femoral component to the transepicondylar axis reduced their lateral retinacular release rate from 24% in varus and 33% in valgus knees to 7% and 29%, respectively [22]. It would appear that the need for lateral retinacular release is related to the rotation of the femoral component and can be reduced by optimising rotation. We were required to do a lateral retinacular release only in 5 out of 31 valgus knees where the lateral structures were unusually tight and in none of our varus knees giving a low overall rate of 2.4% (SE percentage = 1.06).

We also achieved equal and symmetrical flexion-extension gaps with no lift off in 207 knees (99%). This suggests we were successful in our goal of getting optimal femoral rotation.

Asano et al., in a study to determine proper strength of soft tissue tensioning, attached a torque driver to the Monogram balancer/tensor device and found a mean distraction force of 126 N in extension and 121 N in flexion [3]. We feel further work should be done to incorporate a torque driver mechanism to the Equiflex instrumentation so that errors in assessing flexion and extension gaps can be further reduced.

Worland et al. expressed a concern that femoral external rotation may lead to over-sizing in order to avoid notching the anterolateral femur [25]. It has been our experience that the appropriate femoral size is usually one size smaller than the measured tibial size and we could implant such a size without any problems in 208 cases (99.5%).

Our patients also recovered sufficiently early enabling us to discharge 1 in 5 in less than 3 days. The readmissions for

any reason within 6 weeks of discharge do not appear to be related to early discharge with only 2.4% of the group discharged in less than 3 days coming back with a problem compared to a readmission rate of 8.9% in the group that went home after more than 3 days hospital stay.

The early recovery is also evidenced by the relatively good average knee score of 78.5 degrees seen as early as 6 weeks postop and an average knee flexion of 98 degrees with 89 (58.5%) achieving a flexion of ≥ 100 degrees at 6 weeks (see Fig. 6). This can only be expected to improve over the next several weeks to months. This correlates well with knee scores between 74.9 and 87 reported by various authors between 2.75 and 10 years of average follow-up [7, 15]. The function scores were relatively poor at 49.8 as at this stage most of the patients had not weaned themselves off crutches, thus entailing a 20 point deduction. The Oxford score too had started improving from a preoperative average of 43.4 to a postop score of 30.06. We did not observe any significant difference in outcome between cemented vs uncemented and varus vs valgus knees in the short-term (Table 1).

Whereas a six-week follow-up is too early in some respects we feel it is not too early to assess patellar tracking, lateral release incidence, flexion-extension gap symmetry as well as perioperative complications. At 6 weeks the vast majority were well enough to be discharged to the care of their primary care general practitioner who would refer back to us in the event of any problems. We do intend to follow-up the same cohort of patients at 2 years.

Table 1 Comparison of cemented vs. uncemented knees and varus vs. valgus knees at 6 weeks

Type of knee	Preop knee score	Postop knee score	Preop function score	Postop function score	Preop Oxford score	Postop Oxford score	Preop flexion	Postop flexion
Cemented	34.4 (3–79)	80.4 (36–100)	47.7 (0–80)	49.7 (0–100)	43.5 (27–64)	29.5 (13–54)	104.7 (65–130)	96.7 (60–115)
Uncemented	34.8 (4–88)	71.4 (33–92)	46.4 (0–70)	49.8 (0–90)	42.8 (27–56)	32.1 (18–53)	104.5 (75–120)	95 (40–120)
Varus	33.4 (3–88)	78.2 (33–99)	47.6 (0–80)	50.1 (0–100)	43.4 (27–64)	29.8 (13–54)	105.4 (65–130)	97.8 (40–130)
Valgus	39.3 (13–70)	79.7 (36–100)	46.6 (0–70)	48.3 (30–75)	43.6 (29–54)	31.2 (19–49)	103.2 (80–130)	98.6 (70–125)
All knees	34.5 (3–88)	78.5 (33–100)	47.5 (0–80)	49.8 (0–100)	43.4 (27–64)	30.06 (13–54)	105 (65–130)	98 (40–130)

We feel perioperative complications are probably under-reported in studies with more than 1 year follow-up. Callahan et al., in their metaanalysis of 130 studies from 1966–1992, found that many studies did not report complications that were considered minor, transient or not directly related to the prosthesis. In order to achieve consistency they did not include in their analysis complications such as delayed wound healing, wound drainage, haematoma, haemarthrosis, knee effusions, pressure sores, bowel obstruction, diarrhoea, gastrointestinal bleeding, hepatitis, pancreatitis, myocardial infarction, congestive heart failure, reflex sympathetic dystrophy, neuromas, delirium, radiographic abnormalities or urinary retention. In spite of this they found a weighted mean complication rate of 18.1% with a mortality per year of follow-up of 1.5%. Revision during 4.1 years was 3.8%. When they included in the denominator only studies that specifically looked at complications they found an average of 3.9% superficial infections, 1.7% deep infections, 6.5% DVTs, 2% pulmonary embolism and 2.1% peripheral nerve damage [6].

Warwick et al., in a study of 1,000 consecutive patients, found the incidence of radiologically confirmed thromboembolism to be 10.6% with a similar incidence in patients with and without chemical prophylaxis [24]. They also found wound problems to be higher in those having chemical prophylaxis (11.9% vs. 6.9%). Their incidence of fatal pulmonary embolism was 0.1%. We feel our incidence of thromboembolism of 6.2% compares favourably with the above reports although admittedly we were only investigating symptomatic cases.

Reilly et al. found an incidence of in-patient infection of 3.1% and out-patient infection of 2.1% (total 5.2%) in total hip and total knee arthroplasties in Glasgow [18]. Gaine et al., in a study also from Glasgow, looked at 530 primary arthroplasties and found a deep infection rate of 1.1% within 6 weeks and superficial infection in as many as 10.5% of knees. At a mean follow-up of 26 months they did not find that these superficial infections progressed to deep infections [9].

We feel it would be interesting to see how the same cohort of patients does with a longer follow-up and we intend to report back on this same group in two years time.

Conclusion

1. This is a safe, effective and reproducible procedure.
2. The complications are comparable to published data.
3. The Equiflex instrumentation does help in equalising the flexion-extension gaps, improves patellar tracking and reduces the incidence of lateral retinacular release.
4. Further biomechanical evaluation will help us quantify our results.

5. Design modification to include a calibrated quantifiable tensioner may be helpful.
6. Further follow-up of the same cohort would be desirable to get medium and long term results.

Acknowledgement The instrumentation was manufactured by Biomet (Bridgend, UK) and the department has received research funds from Biomet. All the authors are employed by the Basildon and Thurrock University Hospitals and none of the authors have received any personal incentive or payment from any commercial source.

We would like to thank Mr. J.P.G. Targett, Mr. J. Oveson, Mr. R. Wakeman, Mr. M. Shoaib and Ms. R. Grewal who have contributed patients to this project.

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