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CLINICAL PAPER

Collateral soft tissue release in primary total knee replacement

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Abstract

The aim of this study was to assess the rate of collateral soft tissue release required in navigated total knee arthroplasty (TKA) to achieve an intra-operative coronal femoral tibial mechanical axis (FTMA) in extension of $0 \pm 2^{\circ}$. The primary outcomes assessed were post-operative coronal plane alignment and rate of collateral soft tissue release. The secondary outcomes were range of motion, function, patient satisfaction, and complication rates at one-year follow-up. This is a prospective study of 224 knees. No exclusions were made on the basis of pathology or severity of deformity. Pre-operative FTMA ranged from 27° valgus to 25° varus (mean: −4.5° SD 7.6). Soft tissue release was carried out in 5 of 224 knees (2.2%). Post-operative weight-bearing radiological FTMA ranged from 7° valgus to 8° varus (mean: −0.4° SD 2.5°). Two hundred and ten knees (96%) were within $0 \pm 5^{\circ}$ of neutral. At one year, median maximum flexion was 100° (IQR 15°) and extension was 0°; mean post-operative Oxford Knee Score had improved from 42 to 23; and 91% of patients were satisfied or very satisfied, with only 2% being dissatisfied. We have found that in the vast majority of cases, including those with large pre-operative coronal deformity in extension, good outcomes in terms of coronal alignment, range of movement, function and patient satisfaction can be achieved.

Keywords

Collateral soft tissue release, computer assisted surgery, coronal alignment, femoral tibial mechanical axis, total knee replacement

History

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Introduction

Over 79,500 total knee replacements are performed annually in the UK [1]. Arthritic disease of the knee is a common condition, with arthritic deformity being produced as a result of bone dysplasia, bone erosion, osteophytes, adhesions and capsular contracture or laxity. Total knee arthroplasty (TKA) is an effective treatment which can correct deformity and replace eroded surfaces. Alignment and soft tissue balance are closely related principles which must be considered during TKA: It has been reported that malalignment and soft tissue imbalance leads to implant failure [2–7]. Bone cuts and soft tissue releases are used to create a balanced knee with a mechanical axis of near neutral.

During TKA, collateral soft tissues are often released with the aim of restoring alignment and balance to the knee. A recent study suggests the frequency of collateral release required to achieve a balanced stable knee using computer navigation can be as low as 10.75%, although conventionally it has been much higher [8].

Instruments have been developed that allow objective assessment of soft tissue balance at 90° flexion and in extension [9]. However, soft tissue balance through the knee's full range of movement is difficult to quantify intra-operatively and remains mainly dependent on a subjective assessment by the surgeon. Computer navigation allows this detail information to be examined intra-operatively. An assessment of the femoral tibial mechanical axis (FTMA) that does not deviate by more than $\pm 2^{\circ}$ throughout its full range of flexion, without application of stressing forces, may be assumed to represent real neutral [10]. This assessment has been termed the dynamic FTMA.

Collateral soft tissue release is technically a challenge and may be associated with a number of complications. Increased frequency of post-operative hematoma, wound complications and risk of infection [11] have been demonstrated, along with increased post-operative bleeding and increased average length of hospital stay [12]. Excessive soft tissue release can compromise the stability of the knee and may necessitate the use of a constrained prosthesis.

Based on our experience with computer navigation we noticed that, in many cases, coronal deformities can be corrected and soft tissue balance achieved without the need for collateral soft tissue release. The senior author (K.D.) therefore carries out collateral soft tissue release for balancing only after bone cuts have been made and coronal alignment assessed with trial implants *in situ*. A collateral release is then carried out only if the intra-operative coronal FTMA in extension is greater than $0 \pm 2^{\circ}$ and a balance has not been achieved (defined by a deviation of more than 6° on varus/valgus stress as seen with navigation).

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The aim of this study was to assess the rate of collateral soft tissue release required in navigated TKA to achieve an intra-operative coronal FTMA in extension of $0 \pm 2°$. The primary outcomes assessed were post-operative coronal plane alignment, as measured on long leg AP radiographs, and rate of collateral release. The secondary outcomes were range of motion, function, patient satisfaction and complication rates at one-year follow up.

Patients and methods

This is a retrospective analysis of prospectively collected data for all patients undergoing primary total knee replacement under the care of a single surgeon in a UK hospital between December 2007 and November 2009. No exclusions were made on the basis of pathology of joint disease or severity of deformity.

Pre-operative Oxford Knee Score (OKS) [13] and body mass index (BMI) were collected at pre-assessment clinic appointments by independent arthroplasty practitioners within 12 weeks prior to surgery (all OKSs in this paper refer to a scale from 12 to 60, with a higher score indicating poorer outcome). At this time, patients had a standing long leg AP radiograph, including hip, knee and ankle, taken to assess FTMA. All the TKAs were performed using computer navigation by a single surgeon or by his assistant in his presence. Two commercially available computer navigation systems were used: eNlite Navigation System, Navigation System II (Stryker, Mahwah, NJ) or OrthoPilot (BBraun Aesculap, Tuttlingen, Germany). Two implant designs were used: Triathlon (Stryker) (118 knees) and Columbus (BBraun) (105 knees), implanted with the Stryker and OrthoPilot navigation systems, respectively. All knees were cruciate retaining (CR) and cemented.

Operative technique

A tourniquet and a medial parapatellar approach to the knee were used in all cases. No collateral soft tissue release was made as part of the surgical exposure. Single bicortical pins were used to attach rigid bodies, for navigation trackers, to the femur and tibia. These also provide a proximal cortex stabilizing mechanism in both systems. Hip, knee and ankle centers were registered, as were anatomical landmarks of the proximal tibia and distal femur and planes. The coronal alignment of the limb was measured from full extension through to full flexion before making any bone cuts or soft tissue releases. The mechanical axis was used as a reference to make the distal femoral and proximal tibia cuts perpendicular to the axis in the coronal plane. The transepicondylar axis was used as a reference for femoral rotation and as a guide for the frontal femoral and posterior condylar cuts. The depth of the tibial cut was guided by the navigation system and a depth of 8 to 10 mm was taken from the relatively normal side. Posterior slope in the sagittal plane was accepted between 0° and 3° for the tibial cut and between 0° and 2° for the distal femoral cut. A posterior osteophyte removal was carried out behind the femoral condyles using an osteotome. After bone cuts had been made, osteophytes and remaining meniscal remnants were removed and appropriately sized trial implants inserted. Coronal alignment was assessed through the full range of flexion using the computer navigation system, and varus-valgus laxity was also assessed at this time by applying collateral stress.

Sequential collateral soft tissue releases were carried out as indicated by the residual deformity only at the time of trial if coronal FTMA in extension was not within 2° of neutral without stress or deviated more than 6° from neutral with the application of a varus or valgus stress.

Definitive components were then implanted using cement and the coronal plane alignment (dynamic FTMA) was checked and recorded again from full extension to full flexion. Patellar tracking was assessed. Osteophytes were removed from the patella, but patellar resurfacing was not carried out in any case. Peri-patellar diathermy denervation was performed. In no case was lateral patellar release found necessary.

The wound was closed in layers and dressings applied. Patients received blood transfusion post-operatively if they had a hemoglobin of 8 g/dl or less and were symptomatic. All patients received active in-patient physiotherapy post-operatively, and were then followed up at around 6 weeks (mean time to follow-up 6.4 weeks) and one year (mean time to follow-up 53 weeks) by independent arthroplasty practitioners. At the 6-week follow-up a long leg AP standing radiograph was taken and OKS recorded. At the one-year follow-up active range of movement was measured by independent arthroplasty practitioners using a goniometer, OKS was recorded, and a short leg AP and lateral radiograph taken as per departmental policy. Any complications arising during this period were recorded. At both of these appointments patient satisfaction with their knee replacement was measured using a four-point scale (very satisfied, satisfied, unsure and unsatisfied).

Results

A total of 224 primary total knee replacements (in 220 patients, 4 of which underwent bilateral TKA) were

Table I. Patient demographics and pre-operative data.

	N
Sex	119 (53%) F 105 (47%) M
Age	Mean 69 [SD 8.6]
Operated side	116 right 108 left
Diagnosis	209 (93%) osteoarthritis 7 (3%) rheumatoid arthritis 8 (4%) other inflammatory arthritis
BMI	31 [SD 4]
Pre-op. Oxford score	Mean: 42 [SD 8]
Pre-op. FTMA measured on long leg radiograph	Mean: −4.5° SD 7.6° Range: −25° to 27°
Pre-op. FTMA measured with computer navigation	Mean: −3.3° SD 6.4° Range: −20° to 24°
Kinematics	5% of knees had FTMA $0 \pm 2°$ throughout the full range of flexion

Varus: negative; valgus: positive

included in the study. Demographic data, BMI, pre-operative OKS and pre-operative alignment are shown in Table I. Data collection was over 97% complete for all radiographic alignment and demographic data; data regarding post-operative OKS and patient satisfaction was greater than 85% complete; and one-year range-of-movement data was 72% complete.

Collateral soft tissue release was carried out in 5 of 224 knees (2.2%). Four medial releases and one lateral release were needed. The characteristics of these knees are described in Table II.

Post-implant alignment

As measured with computer navigation in extension, FTMA was within 2° of neutral in 100% of patients (mean: 0.1°, SD 0.4°; range: 2° valgus to 1.5° varus). Mean post operative FTMA as measured on long leg weight-bearing radiographs was −0.4° (SD 2.5°). FTMA was greater than 3° in 11 knees and less than −3° in 24 knees. Two hundred and ten knees (96%) were within $0 \pm 5°$. Dynamic FTMA through full range of flexion remained within ±2° (True neutral) in 203 of 224 (91%) of these knees.

At one year, median maximum flexion was 100° (inter-quartile range: 15°) and median maximum extension was 0° (inter-quartile range: 0°).

Post-operative functional assessment data is shown in Table III. Mean post-operative Oxford scores were 29 and 23 at 6 weeks and 1 year, respectively. A total of 176 of 194 patients (91%) were satisfied or very satisfied at 6 weeks and 174 of 191 patients (91%) were satisfied or very satisfied at one year post-operatively. Two of 194 (1%) were dissatisfied at 6 weeks, as were 4 of 191 (2%) at one year.

Post-operative complications

Two patients were readmitted due to surgical site infection (0.9%): one with a deep infection requiring washout and change of the polyethyline liner, and one for washout of a superficial infection. Three patients received outpatient antibiotics from their general practitioner for superficial infection. One patient (0.45%) received a blood transfusion post-operatively, and one had a myocardial infarction (0.45%). No deaths were recorded.

Discussion

Rates of collateral soft tissue release in total knee replacement using computer navigation have been quoted as low as 10.75% [8]. Releases are associated with numerous complications and are best avoided if possible [11, 12]. This study of a typical and inclusive cohort has shown that good outcomes can be achieved in terms of post-operative alignment, soft tissue balance, range of movement, function and patient satisfaction, with a collateral soft tissue release frequency of 2.2%.

This study has several limitations. Objective assessment of implant position using radiographs may be one source of error [14]. Although inter-observer variability between experienced surgeons measuring FTMA on radiographs has been shown to be insignificant [14], rotational malpositioning at the time the radiograph is taken and associated flexion contracture have been shown to create a variability that is statistically significant [14, 15]. Data collection for demographic and alignment data was greater than 97% complete; data regarding post-operative OKS and patient satisfaction was greater than 85% complete; and one-year range of movement data was 72% complete. The omissions appear to be random, and the largest source of lost data was patients who did not attend follow-up appointments because of geography, as the hospital caters to patients from a very large geographical area including distant islands. Balance of the knees was assessed using computer navigation, with subjective collateral stress by the surgeon (as opposed to a quantitatively objectively measured stress), and was also based on analysis of knee kinematics and defined as balanced if FTMA did not deviate by more than ±2° throughout the full range of flexion. The limit of more than 6° with varus/valgus stress was used for deciding whether to perform collateral release. This is supported by findings from our assessment of normal knees' collateral laxity with computer navigation [16].

Picard et al. reported a medial collateral release frequency of 25% for varus knees [17], and we have shown a further reduction. They performed medial releases based on measurements of coronal alignment made intra-operatively but

Table III. Postoperative functional assessment data.

	Oxford Knee Score*	Patient satisfaction: Very satisfied	Satisfied	Unsure	Dissatisfied
6 weeks post-op.	29 [8]	136/194 70%	40/194 21%	15/194 8%	2/194 1%
1 year post-op.	23 [9]	148/191 77%	26/191 14%	13/191 7%	4/191 2%

*Mean [Standard Deviation] presented for continuous variables

Table II. Details of patients requiring collateral soft tissue release.

Patient	Sex	Age	Diagnosis	Pre-op. coronal FTMA radiographic/navigation	Release needed	Pre-op. range of coronal deformity from full extension to full flexion	Post-op. coronal FTMA radiographic/ navigation	Post-op. range of coronal deformity throughout flexion
1	M	73	Osteoarthritis	12/7.5	Lateral	6 to 14	2/0	1 to −1
2	M	75	Osteoarthritis	−8/−7	Medial	−7 to −5	−2/0	1 to −2
3	M	67	Osteoarthritis	−7/−5.5	Medial	−4 to −6	1/1	0.5 to 2
4	M	64	Osteoarthritis	−8/−7	Medial	−12 to −5	0/0	0 to −2
5	F	54	Osteoarthritis	−4/−11	Medial	−11 to −13	1/1	1 to −1

Varus: negative; Valgus: positive

prior to bone cuts being made. We assessed coronal alignment in extension after bone cuts had been made, osteophytes had been excised, and trial implants placed *in situ* before doing any collateral releases. Our cohort included knees with large coronal deformity, in which collateral soft tissue release would traditionally have been thought necessary. We found that it was not those knees at the extremes of the deformity range that ultimately required collateral releases (Table II). The number of knees in the group that required soft tissue release was too small to draw significant conclusions that would help with the pre-operative prediction of which knees will go on to require soft tissue release. This is an area where further work would be of great utility.

Demographic and pre-operative alignment data in this study is comparable with cohorts studied in the current literature. A recent meta-analysis of 3437 patients assessing coronal alignment following knee replacement had a mean patient age of 68.6 years and a mean BMI of 27.5 kg/m^2. Of the patients, 66.7% were female and the indication for surgery was osteoarthritis in 89% of cases [18]. Our series has a higher average BMI of 31 and a lower percentage of females, but otherwise demographic data are very similar. The mean pre-operative Oxford Knee Score in our cohort was 42, similar to that seen in a study, from another UK center, of 1923 knees (mean pre-operative OKS: 45) [19]. Our cohort includes patients with severe pre-operative varus and valgus deformities (range: $-25°$ to $27°$). Mean pre-operative FTMA was further from neutral than that seen in a meta-analysis of coronal alignment following knee replacement: $-4.5°$ SD $7.6°$ compared to $-2.3°$ SD $5.1°$ [20]. This highlights that even in a group of patients with larger deformity than is typical, the rate of collateral release necessary is low.

Post-operative coronal plane alignment within ±3 degrees of neutral is accepted as satisfactory; error greater than this is thought to be associated with increased rates of loosening and early failure [21]. Meta-analysis data of 3437 patients found that 91% of patients undergoing primary TKA with computer navigation and 68.2% of knees operated with conventional surgery had post-operative FTMA within $\pm3°$ [18]. In our series, 84% of knees were within this range when assessed radiographically, and 100% when assessed with computer navigation.

Satisfactory sagittal range of movement, in terms of ability to perform activities of daily living, was achieved [22]: median maximum flexion was 100° and extension 0°.

One-year post-operative average OKS had fallen from 49 to 23, and 91% of patients were satisfied or very satisfied with their knee replacement (only 2% were dissatisfied). This data compares favorably with that from the National Joint Registry of England and Wales which, in a study of over 8000 patients at one year post-surgery, found that average OKS was 25.0 and 81.8% were satisfied [23].

Complication rates in our cohort are low. According to the 2010 Annual Report of the Scottish Arthroplasty Project, the readmission rate within one year of surgery for infection following knee replacement was 1.2% [24]. Two out of 220 (0.9%) of our patients were readmitted. The estimated rate of myocardial infarction (MI) following TKA described in the current literature is 0.4 to 1.9% [25]. One patient in our cohort (0.45%) suffered an MI within 30 days of surgery. Blood transfusion was required for only one of the 220 patients (0.45%); this is lower than rates published in a study of primary TKAs which used the same transfusion protocol as we did (1.2%) [26].

In 91% of knees FTMA did not vary by more than $\pm2°$ throughout the full range of flexion. At present, the effect of different collateral releases on knee kinematics are not well understood, so in the 9% of knees in our cohort which appeared well aligned in extension but deviated from neutral as they flexed, it was difficult to decide whether one should do any collateral release, and, if so, what structures should be released and in which sequence. Soft tissue balancing based on equalizing the extension gap and flexion gap (at 90°) may fail to identify imbalance that has an impact on knee kinematics in the mid range of flexion. Further work to quantify the effect of specific collateral releases on knee kinematics and dynamic FTMA would allow the surgeon to perform precise collateral releases tailored to the knee kinematics of the individual patient.

The deformity in arthritic knees is the result of a combination of bone dysplasia, erosion of the articulating surfaces, osteophytes and capsular and collateral ligamentous adhesions. The authors believe that all these factors are taken care of, to a large extent, by the TKA surgery with bone cuts in the correct orientation, as explained in the Methods section, and osteophyte removal, in many cases without the need for release of the ligaments themselves.

This study indicates that good outcomes in TKA can be achieved in terms of alignment, balance, range of movement, OKS and patient satisfaction using computer navigation for surgery with bone cuts made using the mechanical axis and transepicondylar axis as references. The decision to perform collateral soft tissue release should be deferred until the stage of trialling the implants, at which stage the axis and balance should be measured. Using this surgical technique, collateral soft tissue release rate should be reduced dramatically, resulting in a well-aligned, balanced, functioning knee with good outcomes.

Declaration of interest

The authors report no conflicts of interest with respect to this paper; no external funding was obtained for the study.

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