The Knee 21 (2014) 1058–1062

Contents lists available at ScienceDirect

The Knee

Bristol index of patellar width to thickness (BIPWiT): A reproducible measure of patellar thickness from adult MRI

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ARTICLE INFO

Article history:
Received 6 March 2014
Received in revised form 29 June 2014
Accepted 9 July 2014

Keywords:
patellar
Patellofemoral
Resurfacing
Thickness
TKR
Width

ABSTRACT

Background: The restoration of an adequate patellar thickness is a key to the successful outcome of knee arthroplasty. This study investigated the relationship between the thickness of the native patellar and medial–lateral patellar width using magnetic resonance imaging (MRI).
Methods: 75 MRI scans of young adults, with an average age of 27 (range 16–40) were studied. Exclusion criteria included a diagnosis of degenerative joint disease, patello-femoral pathology or age under 16/over 40 (170 patients). The bony thickness of the patellar, the chondral thickness and patellar width were measured, as was the location of maximal patellar thickness. Inter/intraobserver variability was calculated and correlation analysis was performed.
Results: We found a strong correlation between patellar width and thickness (bone plus cartilage) (Pearson 0.75, $P < 0.001$). The mean width to thickness ratio was 1.8:1 (standard deviation 0.1, 95% confidence interval 1.78–1.83). Without cartilage the ratio was 2.16:1 (SD 0.15, 95% CI 2.11–2.21), correlation was moderate (Pearson 0.59, $P < 0.001$). The average maximal patellar cartilage thickness was 4.1 mm (SD 1.3).
Conclusion: The strong correlation and narrow confidence intervals for the ratio of patellar width to thickness, suggest that patellar width might be used as a guide for accurate restoration of patellar thickness during total knee or patello-femoral replacement. After removing osteophytes we would recommend a ratio of 1.8:1. Further work is required to establish whether there is a relationship between anterior knee pain post total knee arthroplasty and an abnormal patellar width:thickness ratio.
Level of evidence: Level III

1. Introduction

The treatment of the patellar in total knee arthroplasty is a perpetually debated topic in knee arthroplasty surgery. Despite the recent publication of the 5-year results of the Knee Arthroplasty Trial with regard to patellar resurfacing, controversy still remains [1]. Breeman et al. [1] reported no significant difference in functional, reoperation or economic outcomes between resurfaced and non-resurfaced patellar in total knee arthroplasty (TKA).

Patello-femoral joint (PFJ) osteoarthritis (OA) has been found in 22% of symptomatic knees, but isolated PFJOA occurs in 9.2% [2]. Trochlea dysplasia and mal-alignment contribute to PFJOA, and these may account for the frequent finding of patellar thinning and the typical 'skewed' morphology of the arthritic patellar. Consequently it is hard to assess a patient's 'normal' patellar thickness; the PFJ is a functional unit involving both patellar and trochlea, and with a dysplastic trochlea, which often predisposes to PFJ failure the lateral trochlea ridge is dominant. The patellar develops into a relatively thin structure which couples with the dysplastic trochlea. There have been many studies on patellar morphology with cadaveric, intra-operative and radiological data, but there is very little information available on the appropriate thickness of the patellar. A recent computed tomography study of patellar thickness in patients with contralateral knee PFJ OA found a bony width to thickness ratio of 2:1 [3]; whilst this study was the first of its kind, an assumption was made as to the patellar cartilage thickness and consequently this was uniform across all patellar sizes.

Success of TKA is multifactorial, but of the variables that are controllable by the surgeon, the implantation position of the two or three components is obviously critical. Despite a large volume of published research on knee kinematics and of the role of the patellar, its resurfacing is often seen as an opportunity to correct for inadequate soft tissue balance and suboptimal femoral/tibial component alignment, usually malrotation. Most worrying is the process of resurfacing the patellar for anterior knee pain in patellar-unresurfaced TKA when inadequate investigations have been performed to fully assess the existing TKA component and overall prosthetic construct positions [4]. Extensor mechanism complications account for approximately 12% of revision TKA [5].

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http://dx.doi.org/10.1016/j.knee.2014.07.007
0968-0160/

It has been suggested that a patellar which is too thick following TKA can lead to lateral patellar subluxation, increased pressure on the lateral femoral condyle and increased compression forces [6,7,8,9]. In addition this then reduces flexion which is known to correlate with worse function. However, in comparison, a patellar which is too thin will have poor strain characteristics, and this may lead to early failure [10,11]. Patello-femoral joint biomechanics illustrate that the role of the patellar is to reduce the work of the quadriceps by displacing the lever arm from the trochlea pivot point; thus a thin patellar requires greater quadricep force to cope with the demands of the joint reaction force generated.

The aim of this study was to investigate the relationship between patellar width and thickness in young adult knees using magnetic resonance imaging (MRI) and thus including the relative contribution of the patellar articular cartilage.

We hypothesise that the inclusion of accurately measured chondral thickness will affect the previously reported ratio of 2:1 width to thickness.

2. Materials and methods

We retrospectively reviewed the records and MRI scans of 245 consecutive patients who attended an acute knee clinic in the National Health Service Major Trauma Centre. Exclusion criteria included: age under 16 or over 40; degenerative joint disease; any patello-femoral pathology (170 patients). The knee MRI scans of the remaining 75 patients were reviewed using the Centricity Picture Archiving and Communication System (PACS) by two reviewers. All imaging studies were performed on a 1.5 T MRI. Axial, sagittal and coronal slices which were at 3 mm intervals were available. There were 25 females and 50 males with an average age of 27 (range 16–40). Measurements were made using T2 weighted axial and sagittal slices. The dimensions recorded included patellar thickness (with and without cartilage), patellar width at its widest point and patellar articular length (Fig. 1). The location of the thickest point, proximal to distal and medial to lateral, was also recorded.

The thickest point was found by reviewing the axial MRI slices and measuring the maximal patellar thickness. This was the thickest bone/cartilage construct in a line drawn perpendicular to the medial/lateral axis. If there was any doubt, then the thickness of the patellar on sequential slices was measured. The thickness without cartilage was then recorded. The absolute widest point of the patellar was recorded medial to lateral. We use the acronym BIPWiT (Bristol index of patellar width:thickness) for ease of description of this ratio.

The maximal length (proximal to distal) of patellar articular cartilage was measured using sagittal slices. It was then possible to measure the distance at which the thickest point lays from the proximal pole and from medial to lateral of the articular surface. This was done with side-by-side axial and sagittal images on screen and with 'cut lines' visible. This distance was then expressed as a percentage of total articular length or width.

To ensure reproducibility and accuracy, intra- and inter-observer repeat measurements were made and recorded on the first 21 scans obtained.

Pearson's correlation was used to evaluate any relationship between thickness and width measurements, and between thickness and articular cartilage length measurements. Statistical analysis was performed with Microsoft Excel XP.

3. Results

The mean ± standard deviation (95% confidence interval, 95% CI) values for patellar dimensions were: cartilage thickness 4.1 mm ± 1.2 mm (95% CI 3.8–4.3); patellar width 44.7 mm ± 3.8 (95% CI 43.8–45.5); patellar thickness without cartilage 20.4 mm ± 1.9

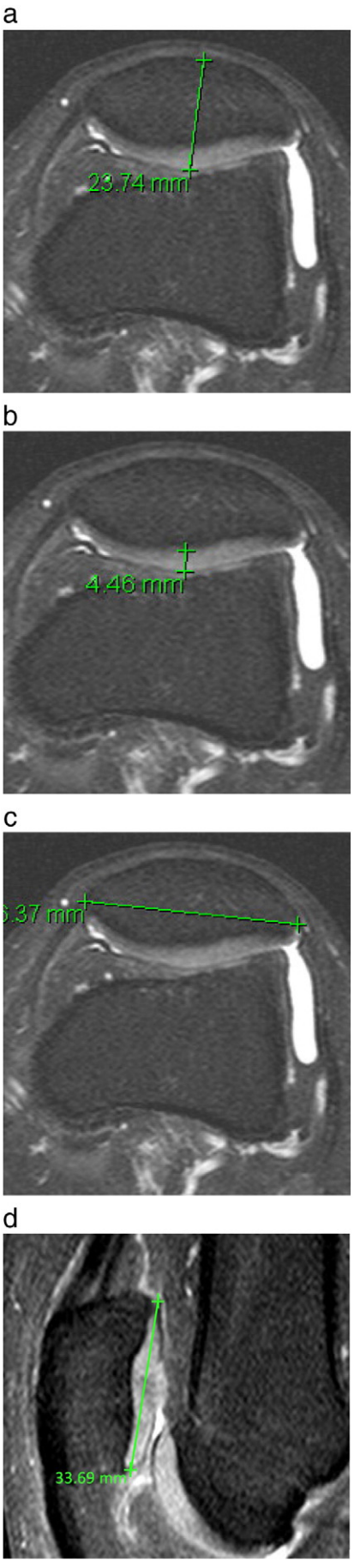

Fig. 1. Images from PACS illustrating the measurement of patellar dimensions. (a) Patellar thickness with cartilage. (b) Patellar cartilage thickness. (c) Absolute patellar width. (d) Patellar articular length.