Arthroplasty Today 24 (2023) 101259

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Surgical Technique

A Crossed Screw Patellar Reconstruction Technique for the Treatment of the Severely Deficient Scaphoid Shaped Patella in Total Knee Arthroplasty

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ARTICLE INFO

Article history:
Received 25 July 2023
Received in revised form
28 September 2023
Accepted 7 October 2023
Available online xxx

Keywords:
Total knee arthroplasty
Patella defect
Patella resurfacing
Reconstruction
Cement augmentation

ABSTRACT

One of the contraindications to patella resurfacing in total knee arthroplasty is a thin and severely eroded 'deficient' patella. However, such patients often present with severe patellofemoral joint arthritis, patellar lateral subluxation, and patella maltracking, which can only be treated effectively with resurfacing. While various treatments have been proposed, options remain limited.

Here we introduce a method of patella reconstruction using four 2.7-mm titanium cortical screws crossing each other into the inner shell of the patella. This provides a scaffold onto which bone cement and any standard polyethylene patellar component can be fixed. Postoperatively, the patient had no anterior knee pain, no patella maltracking, and no component loosening.

Advantages of this technique include minimization of extensor disruption, low costs, easy accessibility, reproducibility, and improved mechanical strength.

Introduction

The goal of patella resurfacing is to provide a pain-free articulation of the patella with the femur while optimizing the mechanical advantage of the extensor mechanism. In achieving this goal, there is a need for a stable fixation of the patellar component and, conversely, minimization of complications of both implant loosening, instability, and fractures.

While patella resurfacing in primary total knee arthroplasty remains a controversial topic, recent meta-analyses and large registry findings have shown decreased rates of revision surgery and anterior knee pain in patients who underwent patella resurfacing [1]. This has manifested in health guideline conferring authorities like the National Institute for Health and Care Excellence recommending patella resurfacing as a routine component of primary total knee arthroplasty procedures [2]. Apart from relieving pain, patella resurfacing can effectively restore the extensor mechanism function especially in specific patient subpopulations with severe patellofemoral joint arthritis, inflammatory arthritis, patellar subluxation, and maltracking [3]

The thinned, severely eburnated, 'scaphoid-shaped' patella frequently confers more patella instability, maltracking, extensor mechanism weakness, pain, and functional impairment. Paradoxically, it is within this particular patella profile where patella resurfacing is routinely contraindicated, as a patella thickness of less than 10-12 mm raises concerns of accelerated implant loosening and early periprosthetic fractures. [4] There are a limited variety of treatment options available to address deficient patellae, and selecting the optimal procedure remains challenging. [5]

This technical paper introduces a novel method of patella reconstruction in deficient scaphoid patellae using crossed-threaded screws to provide a reinforced cement scaffold onto which any standard polyethylene patella component can be used with reliable stable fixation. It is a modification of a Kirschner wire cement reconstruction described by Fisher at a scientific congress

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https://doi.org/10.1016/j.artd.2023.101259

with no further accounts of this technique or other similar methods in the wider peer-reviewed literature. [6]

In the following illustrative case, informed consent was prospectively taken for use of clinical data and photographs.

Surgical technique

The patient was a 63-year-old female working as an office cleaner. She presented with progressive bilateral mechanical knee pain (right worse than left) with a predominance of pain in the anterior knee. She found particular difficulty in ascending stairs and squatting. She had no known past history of patella subluxation or dislocation.

On examination, she had bilateral mildly correctable valgus knees, a negative J sign, and a positive patella grind test in the right knee. Right knee range of motion (RoM) was 10-100 degrees, and left knee RoM was 15-130 degrees. Blood tests excluded inflammatory arthropathy.

Long leg films showed mild valgus alignment (Fig. 1a), while radiographs revealed tricompartmental osteoarthritis with a severely centrally eroded patella associated with femoral trochlear dysplasia and patellar lateral subluxation. The thickness of the patella center was measured at 5 mm on both skyline view x-rays (Fig. 1b) and computed tomography scans. (Fig. 2) No prior radiographs were available for comparison.

The patient complained of significant functional limitation with difficulty attending to her daily activities and work as a cleaner. As such, a total knee replacement was planned.

Exposure of the knee joint was achieved via a midline skin incision and medial midvastus approach. Intraoperatively, the lateral femoral condyle was hypoplastic with a bone defect. The patella was deficient with a thin cortical shell of bone. This appearance has been described as a scaphoid patella. [7]

Patella neurectomy was performed using circumferential electrical cautery, and all surrounding osteophytes were removed. The chondral surface was curetted to subchondral bone. The patella height measured with calipers was a distance of 12.5 mm from the peripheral rim to apex of patella dome. (Fig. 3) The effective patella thickness was 5 mm.

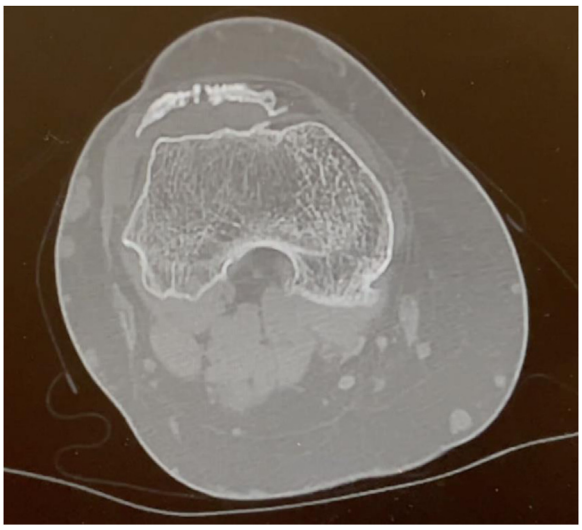

Figure 2. Representative axial cut of computer tomography showing a deficient and bowl-shaped patella.

Reconstruction of the patella was performed using four 2.7 mm titanium cortical screws (AO Synthes, Depuy); 2 screws were inserted horizontally and 2 screws vertically, such that the four screws crossed each other into the inner concavity of the patella to form a hash-shaped scaffold. (Fig. 4a). Meticulous drilling was performed at this step to prevent iatrogenic fracture. No tapping was done. The 2 vertical screws were placed anterior to the horizontal ones. Bone cement (Palacos) was mixed under vacuum with a conventional cement gun mixing kit and extruded into the inner concavity of the patella with the 4 screws in place to form a singular continuous reinforced cement surface. (Fig. 4b) A size 26, 7.5 mm thickness polyethylene patella component (Nexgen Series Patella, Zimmer Biomet, Warsaw IND) was fixed onto the cement surface and medialized to improve tracking. (Fig. 4c) Care was taken to fill the patella from apex outwards to avoid any entrained gas bubble. After patellar resurfacing, the patellar height was reconstructed to an anatomical height of 22 mm. Overstuffing is not a concern, as the

Figure 1. (a) Preoperative radiographs showing valgus alignment on long leg film. (b) Bilateral eroded and lateral subluxation of the patellae on skyline view. (c)(d) Lateral views and (e) anterior-posterior films.

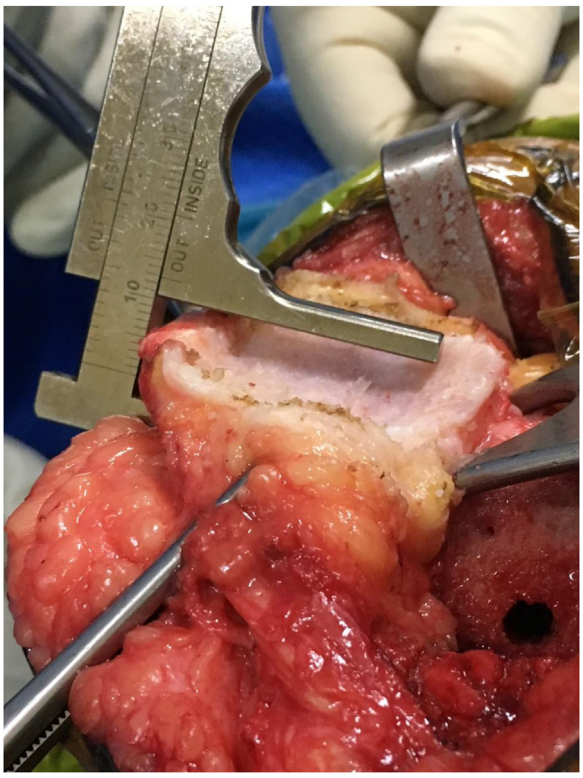

Figure 3. Intraoperative measurement of the patella showing a caliper measurement of 12 mm height at the patella rim. This figure is intended for reproduction in color for digital and physical publication.

shallow native trochlear was replaced with the femoral component. The rest of the total knee procedure was then completed with a posteriorly stabilized implant. (Nexgen Series, Zimmer Biomet, Warsaw IND). Upon closure, the patella was noted to be central with good tracking.

Postoperatively, the patient was placed on the same physiotherapy regime as conventionally done for total knee replacements at our institute. She was allowed to fully weight-bear and started on ambulatory physiotherapy from postoperative day 1. There were no limitations in RoM imposed, and she was placed on passive and active RoM exercises. The patient was discharged uneventfully, progressed well, and resumed her work 6 weeks postoperatively.

At 3 years of follow-up, the patient remained clinically well. Her right knee was pain-free; she could ambulate independently without aids and continued working as a cleaner without activity limitations. Follow-up radiographs did not show any implant or component loosening, and the patella remained enlocated. The patient's right knee RoM improved from 10-100 degrees preoperatively to 5-110 degrees postoperatively with no evidence of patella maltracking. (Fig. 5). At 5 years postoperatively, the patient declined an in-person consult due to work commitments but reported no significant knee pain or functional impairments over a teleconsult.

Discussion

The deficient patella is a rare but challenging problem in total knee arthroplasty. In cases of patients with congenitally dysplastic or hypoplastic patellae undergoing primary total knee arthroplasties, the literature suggests satisfactory patient outcomes can be achieved without patella resurfacing. The rationale for this hinges on the concomitant dysplastic rotational deformities inherent in the distal femur and proximal tibia leading to the

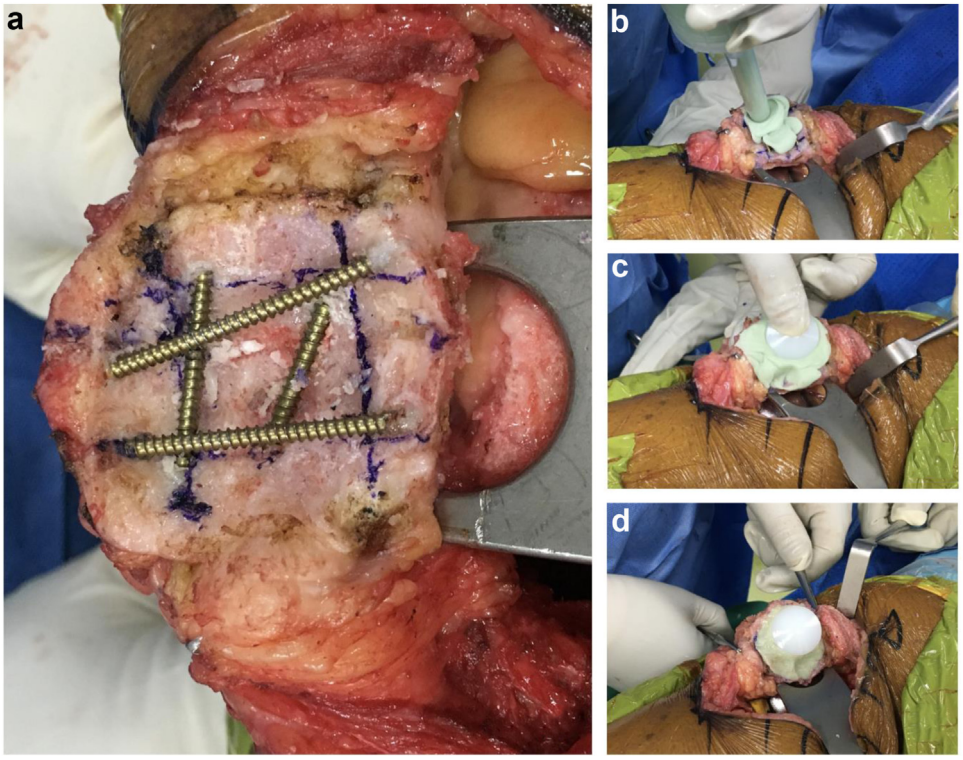

Figure 4. Intraoperative photograph showing process of cross-screw reconstruction. (a) Firstly, four 2.7 mm threaded screws are inserted into the patella shell to form a hash. (b) Next, bone cement is used to fill the defect (c) before a patella component is over laid into the reconstructed patella. (d) Final appearance of the completed construct. This figure is intended for reproduction in color for digital and physical publication.

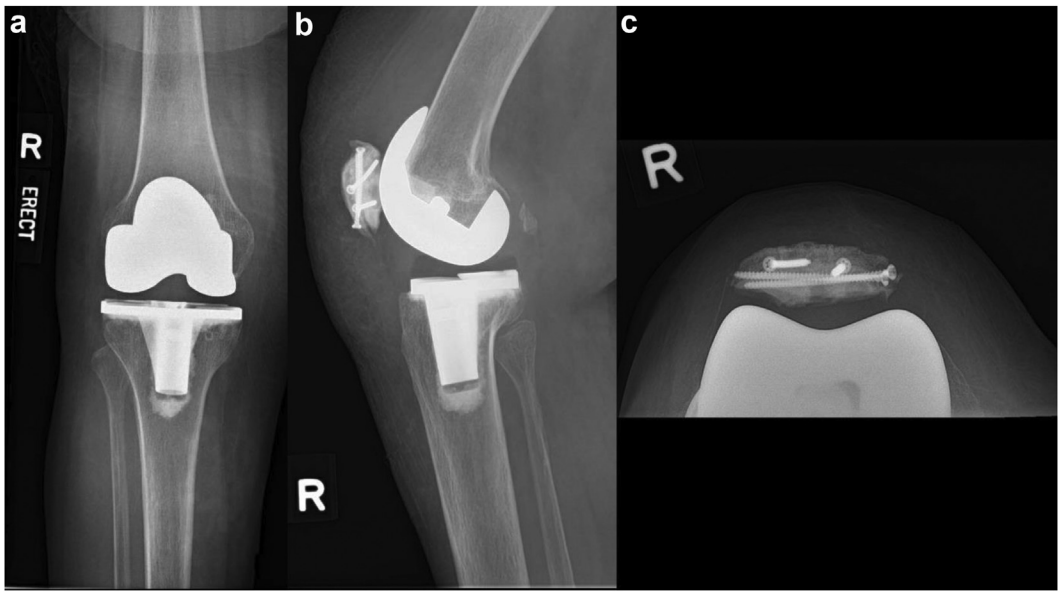

Figure 5. Postoperative radiographs at 3 years postoperation showing a central patella with no screw or cement loosening.

extension mechanism being defunctionalized as a true extensor to the knee. [8]

In contrast, a deficient patella can also occur secondary to bone loss from prior trauma, chronic subluxation, severe patellar-femoral osteoarthritis, tophaceous gout, or during revision total knee arthroplasty. [9-11] In 'secondary' patella deficiency, the patella still contributes as the extensor mechanism of the knee and, if left unmanaged, has a tendency to laterally subluxate and articulate with the lateral femoral condyle with resultant further erosion, anterior knee pain, and quadriceps weakness. [7] Hence, unlike the congenitally dysplastic patellae, restoration of patella alignment and tracking is essential to optimize outcomes.

There is currently a paucity of literature with regards to the management of patella deficiency in the primary total knee. However, multiple strategies have been developed to manage patellar bone loss in the revision knee. Published treatment strategies include patellectomies, patelloplasty, gull wing osteotomy, usage of bone grafting, and specialized biconvex or trabecular metal revision implants. [12] Patellectomy and resection patelloplasty, where the bony patella shell is retained without reconstruction, have been largely relegated to procedures of last resort as multiple studies have shown increased rates of complications, residual knee pain, and lower patient satisfaction. [13] The gull wing osteotomy was first introduced by Vince et al [14], where an

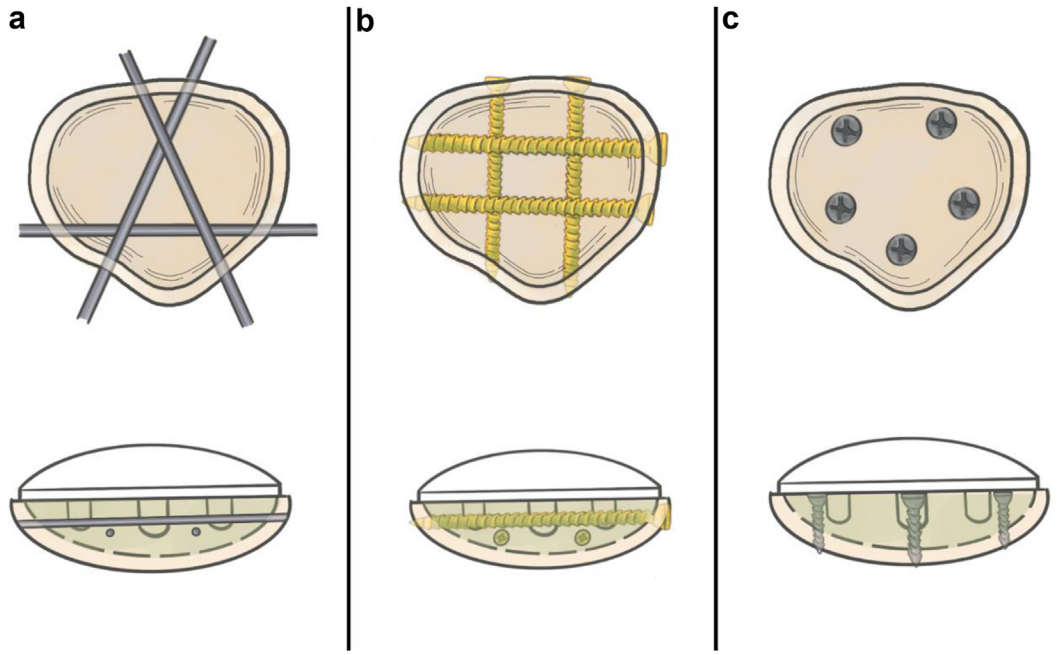

Figure 6. Illustrative diagram comparing methods of augmented cement scaffold patella reconstruction. (a) Fisher's original triangular K wire. (b) Our crossed screw method. (c) McPherson's 'rebar' screw method. This figure is intended for reproduction in color for digital and physical publication.

incomplete sagittal osteotomy was made in the articulating surface of the patella and the medial and lateral borders of the patella displaced anteriorly to form a V or 'gull wing' shape. Subsequent series by Klein et al [7] and Gililand et al [15] have shown promising results with increased knee RoM and knee society scores with minimal complications. However, concerns remain that a patella osteotomy may cause extensor mechanism disruption, vascular disruption, or nonunion. Techniques to reconstruct the patella defect include bone grafting techniques such as impaction bone grafting, where cancellous bone graft is tightly packed into the patella shell and held in place with a soft tissue envelope formed from surrounding scar tissue, fascia, allograft fascia, or synthetics. Introduced by Hanssen et al, impaction bone grafting has since been shown to have good long-term survivorship of up to 96% at 10 years with statistically significant improvements in postoperative knee flexion, knee pain, and Knee Society Score scores. However, the presence of resorption and loss of patellar height was still noted [16]. Another drawback of this technique includes the need to standby allograft bone and fascia tissues, which may not be readily available in all institutes. Lastly, specialized revision implants have also been shown to have good long-term results, including a survivorship of up to 86% at minimum of 5 years [17] though similar issues of cost and accessibility remain.

The concept of a reinforced cement construct to fill the patella bone defect and allow fixation of a polyethylene patella component was first described by Fisher in a series of 6 knees with no loosening and satisfactory outcomes on 2-5 year follow-up. [6] Three Kirschner wires were passed through the patella shell to form an intersecting triangular scaffold onto which cement and, subsequently, the polyethylene patella component was overlayed.

Our screw cement technique is a modification of Fisher's technique. By substituting the smooth and thin Kirschner wires with threaded 2.7 mm screws, our modification provides additional advantages of decreased risk of implant loosening and better mechanical interlocking of the cement plug against the patella shell. By retaining the native patella shell and structure, disruption to the extensor mechanism is minimized. There is no need for additional bone grafting, eliminating concerns of graft availability and resorption. Lastly, titanium screws are easily available and comparatively cheaper than revision implants.

The concept of reconstructing the patella defect with cement augmented by screws was also explored by McPherson et al, who inserted multiple 2.0 mm 'rebar' screws vertically from the articular surface of the patella toward the anterior surface of the patella. [18] In McPherson's series, there were no incidents of implant loosening at up to 9 years of follow-up, lending support to the mechanical strength and longevity of a cement screw construct. Furthermore, compared to McPherson's technique, where the screws are only fixed to the anterior cortex of the patella, we believe the bi-cortical catch and interlocking offered by our 'crossed screw technique' would confer additional mechanical strength though further biomechanical studies are needed. An additional advantage would be minimization of potential implant irritation to the prepatellar soft tissues. In an extremely thin patella shell, to achieve good screw fixation with McPherson's technique, the screw tips may protrude out of the anterior surface of the patella and cause irritation. While the authors report only a single incident of implant irritation requiring reoperation, the patella is a notorious site for implant prominence due to the thin soft tissue envelope overlying the patella, and we would recommend limiting any potential irritation. In our technique, the screws are placed at the side of the patella, which will not impinge on soft tissues and is far away from the skin. As such, the screws will also not affect knee RoM. A comparism of all three cement reconstruction techniques discussed are summarised in Figure 6.

There are also potential drawbacks to the crossed-screw technique. Firstly, an intact cortical rim is required to allow for robust screw fixation and cementing. Hence, applicability may be limited to contained cavitary defects. Secondly, the patella rim is severely thinned, and thus there is a potential for iatrogenic fracture of the patella. Similar concerns have been raised for techniques such as the gull wing osteotomy and rebar screw insertion, which also require drilling of multiple screw holes into the deficient patella shell. In McPherson's series, a median of 5 and up to 13 2.0-mm screws were successfully inserted at a density of 5 mm distance between either screw-to-screw or screw-to-implant without any iatrogenic fractures. [18] Thus, we recommend meticulous handling of the patella by an experienced surgeon during the drilling process to minimize risk of fracture. Lastly, the main limitation of this technique, as with prior studies, is the small sample size, which reflects the scarcity with which such severe patella defects are encountered. Nonetheless, with increased life expectancy and increased incidents of revision arthroplasty, we anticipate a corresponding increase in the number of cases of severe patella defects that will be encountered in total knee arthroplasty. As such, this technique provides a valuable additional management option that surgeons may consider when the deficient patella is encountered.

Summary

In situations of severe patellar deficiency, reconstruction of the patella using a screw-reinforced cement construct to facilitate patellar component fixation provides a safe, stable, and cost-effective treatment option.

Conflicts of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101259.

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