Original Article

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Safety and Efficacy of 6.2 mm Patellar Button in Resurfacing Less than 20 mm Thin Patella: A Matched Pair Analysis

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Purpose: Restoring the native patellar thickness after patellar resurfacing provides optimal function of the knee after arthroplasty and minimises complications related to the patellofemoral articulation. The aim of this study was to assess the usefulness of a thin patellar button (6.2 mm) in patients with a patella thickness of less than 20 mm during total knee arthroplasty.
Materials and Methods: This is a retrospective case control study. A total of 54 female patients with an intraoperative patellar thickness of <20 mm, resurfaced with a patellar button of 6.2 mm in thickness were identified (group 1). They were matched with 54 patients with a patellar thickness of 20–23 mm, resurfaced with a patellar button of 8 mm (group 2), based on age, sex, body mass index, and deformity. A clinical and radiological evaluation was done at a minimum 2-year follow-up.
Results: The preoperative mean patellar thickness was 18.94±1.07 mm and was restored to 19.06±0.79 mm in group 1, as compared to 21.63±0.99 mm and 21.72±0.99 mm in group 2. The mean postoperative range of motion was 122.22°±9.25° in group 1 and 123.52°±8.72° in group 2 (p=0.13). No patellar bone or button related complications were observed in any patient in either group.
Conclusions: The 6.2 mm thin patella is useful to restore the native thickness in patients with a patellar thickness of less than 20 mm without risk of button fracture, loosening or overstuffing.

Keywords: **Knee, Arthroplasty, Patella, Resurfacing**

Introduction

Patellar preparation and composite thickness are critical for the success of knee arthroplasty[1]. Restoring patellar thickness to the preoperative height improves patellofemoral tracking and kinematics[1]. A minimum of 12–14 mm of the host patellar bone needs to be left to prevent patellar strain and fracture[2,3]. On the other hand, overstuffing the patellofemoral joint by more than 2 mm can lead to patellofemoral maltracking, increased patellofemoral contact and compression pressures, decreased range of movement, anterior knee pain and increased shear forces leading to loosening and failure of the plastic button[4-6]. The challenge of restoring preoperative patellar thickness is greater in Asian patients, in whom it is common to find a patella less than 20 mm in thickness[7,8]. The surgeon has three choices when faced with thin patellar bone stock. First, it is to cut the patella to be less than 12 mm and resurface with a standard 8 mm button, thus recreating the pre-cut thickness but risking a fracture[2,9]. Second, it is to cut the bone to be 12–14 mm and accept a 2 mm or more overstuffing with use of an 8 mm button, thus exposing the patient to a decreased range of movement and tilt[6]. Third, the option often chosen by the surgeon when encountering a thin patella of less 20 mm is to leave the patella unresurfaced, which can lead to a delayed onset of anterior knee pain[10]. This dilemma of either cutting the patella too thin or overstuffing the patella by more than 2 mm in the knee with a host bone thickness of less than 20 mm is mainly caused by the singular option of an 8 mm button

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provided by most companies. Many implant manufacturers have recently taken Asian anthropometric data into consideration while designing implants for this population which has smaller and narrower bone sizes, but the patellar button thickness has not been revised. We have investigated the use of a 6.2 mm 'thin' round, three-pegged, cross-linked polyethylene patellar button in patients with thinner patellar bone stock. The option of having a 'thin' patellar prosthetic component increases our ability to restore patellar-implant composite thickness to the preoperative level, especially in patients with a pre-cut thickness of less than 20 mm. In this study, we tested the hypothesis that a 6.2 mm patellar button is safe for clinical use and does not lead to an increased incidence of patellar button loosening or fracture.

Materials and Methods

This retrospective comparative cohort study of prospectively collected data was approved by the ethical committee of our institution. Written informed consent was obtained from patients and their guardians prior to participation according to the Declaration of Helsinki. We studied the patellar thickness, preparation, outcomes and complications in two matched groups of patients, with 54 patients in each group operated between January 2013 and March 2015. Before 2013, we followed a policy of selective resurfacing and would usually leave a patella less than 20 mm in thickness unresurfaced because it would result in either over-resection or overstuffing with an 8 mm button available to us during that period. Since 2013, we have had the option of a 6.2 mm patellar button with the Vanguard posterior stabilised system (Zimmer Biomet, Warsaw, IN, USA) and have resurfaced all patellae including those less than 20 mm with a 6.2 mm button and those with more than 20 mm with a standard 8 mm button. We have ongoing database of last 10 years of meticulous collection of all patients' variables including patellar height, thickness, tilt and patella-related complications. From our database, we identified the first group having an intraoperative patellar bone thickness of less than 20 mm (range, 16 to 19 mm) and resurfaced with a 6.2 mm button (group 1) and the second group having a host bone thickness of more than 20 mm (range, 20 to 23 mm) and resurfaced with the standard 8 mm button (group 2). All patients in the case group (patella thickness, 16–19 mm; group 1) were females and hence all patients in the control group (group 2) were matched with the same gender. Patients in both groups were matched on the basis of age (±2 years), body mass index (BMI, ±5 kg/m^2) and type of deformity (less than 20° deformity in coronal and sagittal planes). Eligibility criteria included all patients with Kellgren grade 3 or 4 knee osteoarthritis who underwent primary total knee arthroplasty (TKA) and in whom the patella was replaced. Patients with inflammatory arthritis, post-traumatic deformity, history of patellar fracture or patellectomy were excluded.

Radiographic analysis included pre- and postoperative tibiofemoral angles in the anteroposterior view, pre- and postoperative posterior offset, anterior offset, joint line in the lateral view and pre- and postoperative patellar tilt, thickness and displacement in the 45° skyline view as per the reproducible standard protocol[11,12] (Fig. 1). The patella skyline view was repeated at 2 years and reviewed for any radiolucency in zones 1–5, avascular necrosis, patellar subluxation or dislocation and patellar bone or button fractures as recommended by Knee Society radiological

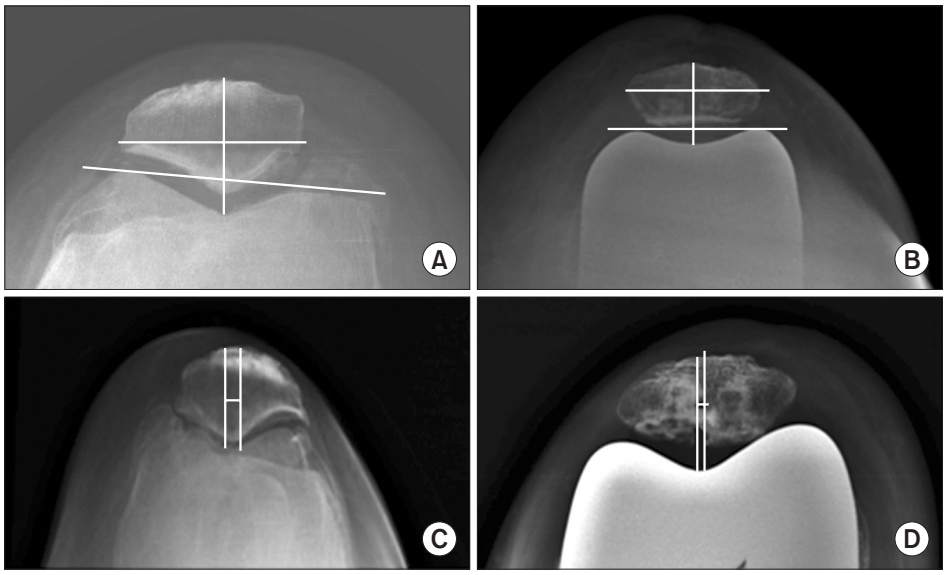

Fig. 1. Radiographic analysis of the patellar skyline view showing pre- and postoperative patellar thickness and tilt (A, B) and patellar displacement (C, D).

guidelines[13]. All postoperative measurements mentioned above were revaluated at the end of two years by the first two authors.

Clinical analysis included Knee Society score (KSS), Knee Society functional score (KSFS), Western Ontario and McMaster Universities Osteoarthritis index (WOMAC), high flexion knee score (HFKS) and range of motion (ROM), which were recorded preoperatively and at a minimum follow-up of 2 years. Patellar crepitus, clunk, anterior knee pain, patellar fracture, patellar button loosening, patellar instability, manipulation and revision for any known patellar complication were specifically evaluated and recorded.

1. Patellar Resection Technique

All patients underwent TKA by parapatellar arthrotomy under tourniquet and spinal epidural anaesthesia. All cases were operated using Vanguard posterior stabilised system (Zimmer Biomet). The patella was everted and held with a clamp parallel to the ground. The patellar height was measured with a Vernier calliper and was agreed by the first two authors (Fig. 2). The patella was resected freehand to the subchondral bone of lateral facet and base of quadriceps tendon, and care was taken not to injure the extensor mechanism[11]. The cut surface was checked in 4 quadrants and refined till the height was equal and symmetrical in all zones[14]. Minimum 12–14 mm host bone was left after resection in the patella with a thickness of less than 20 mm, and a 6.2 mm patellar button was used to restore the pre-cut thickness (Fig. 3). In the patella more than 20 mm thick, a standard 8 mm patellar button was used to restore the pre-cut thickness. Care was taken not to over-resect or cause an increased composite thickness by more than 2 mm in both groups. The patellar button was placed on the medial border of the cut surface[15] and the uncovered bone of the lateral facet was sawed off to prevent lateral facet syndrome[16]. All synovium in the supra and infra patellar region was excised to prevent patellar crepitus or clunk[17,18]. Femoral component rotation was adjusted perpendicular to Whiteside line and parallel to the transepicondylar axis in all knees. After cementation of all three components and tourniquet release, the final patellar composite height was measured (Fig. 4), patellar tracking was checked and sequential lateral release was performed if the medial facet was not in complete contact with the medial femoral condyle with no thumb test[19].

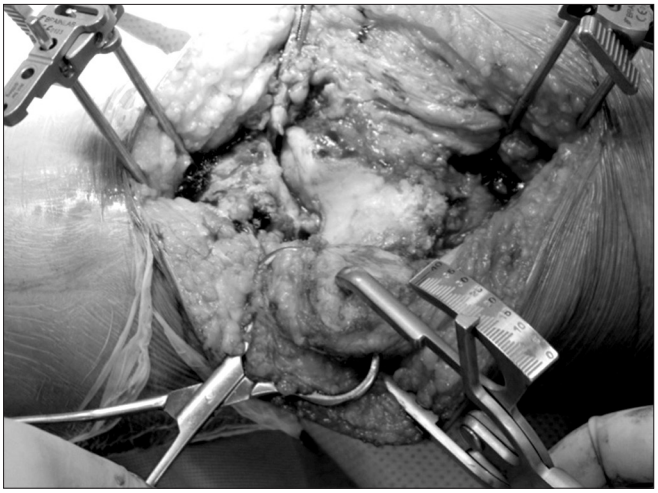

Fig. 2. Clinical image of intraoperative measurement of patellar thickness (18 mm) with Vernier calliper.

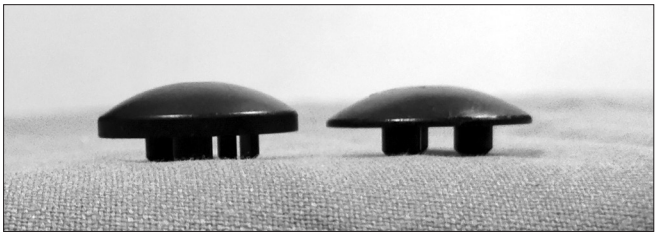

Fig. 3. Clinical image of patellar buttons with a thickness of 8 mm (left) and 6.2 mm (right).

2. Statistical Analysis

Assuming the minimum odds ratio to detect difference as 3.5 and percentage of patients exposed amongst the control group 20%, we needed 54 patients in each group at 80% power with a 5% alpha error to detect difference between the groups in a 1:1 matched case control study[20].

Continuous variables were presented as mean±standard deviation and categorical variables were presented as number (%). *T*-

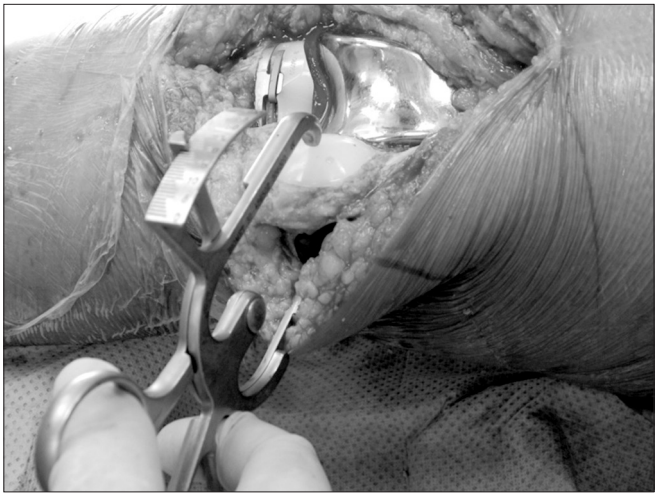

Fig. 4. Clinical image of intraoperative measurement of patellar thickness that was restored to 18 mm with use of a 6.2 mm plastic button.

Table 1. Demographic Characteristics of Patients in Case and Control Groups

Characteristic	Case (n=54)	Control (n=54)	p-value
Age (yr)	65.43±7.59 (47–85)	66.17±7.76 (49–78)	0.62
Height (cm)	151.63±5.46 (140–163)	154.35±5.93 (141–167)	0.01
Weight (kg)	64.03±7.15 (51.9–77.6)	68.76±6.68 (55–86)	<0.05
Body mass index (kg/m^2)	27.90±3.17 (21.9–35.71)	28.89±2.91 (21–33.8)	0.09
Side of knee replacement (%)			
Left	29 (53.70)	31 (57.41)	0.70
Right	25 (46.30)	23 (42.59)	
Follow-up (mo)	26.72±1.77 (24–30)	26.07±1.96 (24–30)	0.07

Values are presented as mean±standard deviation (range).

test and Fisher exact test were used appropriately to find significant difference among the two groups. A p<0.05 was considered statistically significant. All the statistical analysis was performed with STATA ver. 13 (StataCorp LP, College Station, TX, USA).

Results

The average follow-up was 26.72±1.77 months (range, 24 to 30 months) in group 1 and 26.07±1.96 months (range, 24 to 30 months) in group 2. The average BMI in group 1 was 27.90±3.17 (range, 21.9 to 35.71) as compared to 28.89±2.91 (range, 21 to 33.8) in group 2, which was not statistically significant (p=0.09) (Table 1). The mean preoperative thickness in group 1 with the host bone thickness less than 20 mm was 18.94±1.07 mm (range, 16 to 19 mm) and it was restored postoperatively to a composite thickness of 19.06±0.79 mm (range, 18 to 20 mm; p=0.20). The mean preoperative thickness in group 2 with the pre-cut thickness more than 20 mm was 21.63±0.99 mm (range, 20 to 23 mm) and it was restored to a mean thickness of 21.72±0.99 mm (range, 20 to 24 mm; p=0.13) (Table 2).

The mean post-cut residual bone thickness was 13.06±0.79 mm (range, 12 to 14 mm) in group 1 and 13.72±0.99 mm (range, 12 to 16 mm) in group 2 (p<0.05). Though we could have resected more bone in group 1 and accepted a 2 mm overstuffing with the standard 8 mm patella, we chose to stop at the level of extensor tendon, thus leaving adequate bone stock and recreating the patellar-implant composite thickness with the 'thin' 6.2 mm patella.

The mean preoperative ROM was 108.15°±19.34° (range, 40° to 140°) in group 1, which improved to 122.22°±9.25° (range, 100° to 130°) postoperatively; as compared to 117.04°±11.43° (range, 90° to 130°) in group 2, which improved to 123.52°±8.72° (range, 100° to 130°) postoperatively (Table 3).

In group 1, none of the patients were able to sit on the ground preoperatively and 14 (25.93%) were able to do so after 2 years (p<0.001) while 6 (11%) were able to sit cross-legged preoperatively and 27 (50%) postoperatively (p<0.001). In group 2, none of the patients were able to sit on the ground preoperatively and 15 (27.78%) were able to do so after 2 years (p<0.001) while 8 (14.81%) were able to sit cross-legged preoperatively and 28 (51.85%) were able to sit cross-legged after 2 years (p<0.001) (Table 3).

The preoperative posterior offset, anterior offset, joint line, femoral flexion, tibial slope in group 1 and group 2 were restored postoperatively (p>0.005). Preoperative tibial angle, femoral angle, patellar displacement, tilt in both groups were corrected significantly postoperatively (p<0.005) (Table 2). Two patients in group 1 and 3 patients in group 2 had lateral retinacular release.

There was no statistical difference in KSS, KSFS and WOMAC between groups (Table 2). We also noted HFKS in both groups which has shown to have more discriminatory power and less ceiling effect than KSS[21]. The HFKS is pertinent for our patients who perform high flexion activity routinely, and we did not find any significant difference in HFKS between both groups (p=0.74). At the minimum 2 years of follow-up, we analysed patella skyline views and noted significant improvement in patellar tilt and shift in both groups (p<0.001). There were no cases of patellar instability in either group. We also looked carefully at magnified views for any radiolucency in zones 1-5 or patellar bone fractures and did not find any in both groups (Fig. 5). Patellar implant or bone fracture, wear and loosening were critically studied in both groups and no case showed any positive sign of these complications. There was no evidence of avascular necrosis in any patient in both groups and no significant difference in lateral release in both groups. There were no cases of patellar clunk in both groups. However, there were 6 cases (11.11%) of painless crepitus and 3 cases (5.56%) of anterior knee pain in group 1 and 4 cases (7.41%) of painless crepitus and 7 cases (12.96%) of anterior knee pain in group 2, which were not statistically significant. There

Table 2. Radiological and Clinical Comparison between the Case Group and the Control Group

Characteristic	Case (n=54)	p-value	Control (n=54)	p-value	p-value for intergroup comparison
Patellar status					
Preop thickness	18.94±1.07 (16–19)	0.20	21.63±0.99 (20–23)	0.13	0.001
Postop thickness	19.06±0.79 (18–20)		21.72±0.99 (20–24)		0.001
Post-cut patellar bone thickness	13.06±0.79 (12–14)	-	13.72±0.99 (12–16)	<0.05	0.0002
Preop tilt	8.49±2.15 (5.48–18.23)	<0.001	9.30±1.73 (5.56–14.55)	<0.001	0.03
Postop tilt	2.22±0.61 (1.08–3.4)		2.35±0.61 (1.21–3.5)		0.26
Preop displacement	4.11±0.56 (2.99–5.1)	<0.001	3.69±0.78 (2.13–5.23)	<0.001	0.002
Postop displacement	1.07±0.32 (0.22–1.74)		1.17±0.24 (0.84–1.8)		0.08
Functional score					
Preop KSS	39.83±6.93 (25–57)	-	38.94±6.37 (25–52)	0.49	0.49
Postop KSS	96.67±4.92 (79–100)	-	97.52±3.61 (80–100)	0.31	0.31
Preop KSFS	16.89±4.94 (10–25)	-	18.52±6.11 (10–30)	0.13	0.13
Postop KSFS	95.61±5.12 (80–100)	-	96.39±4.80 (80–100)	0.42	0.42
Preop WOMAC	25.24±4.74 (16.6–35.4)	-	24.50±5.20 (15.5–32.5)	0.44	0.44
Postop WOMAC	97.34±3.31 (80.5–100)	-	96.84±3.07 (84.5–99)	0.42	0.42
Preop HKFS	16.43±2.98 (12–21)	-	16.20±2.81 (11–21)	0.69	0.69
Postop HKFS	39.80±1.41 (35–42)	-	39.70±1.46 (35–42)	0.74	0.74
Angle					
Preop femoral angle	87.03±4.04 (81.2–96.5)	<0.001	88.42±4.67 (81.5–97.5)	<0.05	0.09
Postop femoral angle	91.03±2.02 (87.4–95.1)		91.12±2.34 (84.9–95.2)		0.84
Preop tibial angle	84.72±4.67 (78.5–93.2)	<0.001	84.31±4.32 (77–92.5)	<0.001	0.63
Postop tibial angle	90.72±1.69 (88–93.8)		90.86±2.01 (87.1–94.7)		0.71
Preop femoral flexion	3.96±1.00 (2–6)	0.84	4.20±1.51 (0–8)	0.23	0.33
Postop femoral flexion	3.93±1.60 (1–7)		3.96±1.84 (1–7)		0.91
Preop tibial slope	86.83±2.02 (83.2–91.4)	0.36	85.59±1.53 (82.1–88.9)	0.79	0.87
Postop tibial slope	86.67±2.27 (82.5–91.5)		85.66±2.36 (81.2–89.9)		0.03
Preop anterior offset	3.78±0.86 (2–6)	1.00	3.89±1.06 (2–6)	0.80	0.55
Postop anterior offset	3.78±1.37 (2–7)		3.85±1.42 (2–7)		0.09
Preop posterior offset	25.40±1.83 (21.6–28.4)	0.84	25.56±2.02 (21.4–28.9)	0.51	0.65
Postop posterior offset	25.41±1.73 (21.5–28.9)		25.44±1.79 (22.1–28.7)		0.93
Preop joint line	25.32±1.24 (23.1–27.4)	0.65	24.84±1.21 (23.1–27.4)	0.42	0.04
Postop joint line	25.26±1.25 (23.4–28.4)		24.98±1.11 (22.4–27.1)		0.22

Values are presented as mean±standard deviation (range).
Preop: preoperative, Postop: postoperative, KSS: Knee Society score, KSFS: Knee Society functional score, WOMAC: Western Ontario and McMaster Universities Osteoarthritis index, HKFS: high flexion knee score.

were 5 cases (9.26%) in group 1 and 7 cases (12.96%) in group 2 in which lateral release was performed (p=0.54). There were no cases of manipulation or revision due to any cause in both groups (Table 4).

Discussion

The minimum thickness of patellar implants provided by most implant manufacturers is 8 mm and is considered the gold standard for patellar implant thickness. It originated from the earlier

Table 3. Functional Comparison between the Case Group and the Control Group

Characteristic	Case (n=54)	p-value	Control (n=54)	p-value	p-value for intergroup comparison
Preop ROM	108.15±19.34 (40–140)	<0.001	117.04±11.43 (90–130)	<0.05	0.003
Postop ROM	122.22±9.25 (100–130)		123.52±8.72 (100–130)		0.45
Ability to sit cross-legged (%)					
Preop	6 (11.11)	<0.001	8 (14.81)	<0.001	0.56
Postop	27 (50)		28 (51.85)		0.84
Ability to sit on the floor (%)					
Preop	0	<0.001	0	<0.001	
Postop	14 (25.93)		15 (27.78)		

Values are presented as mean±standard deviation (range).
Preop: preoperative, ROM: range of motion, Postop: postoperative.

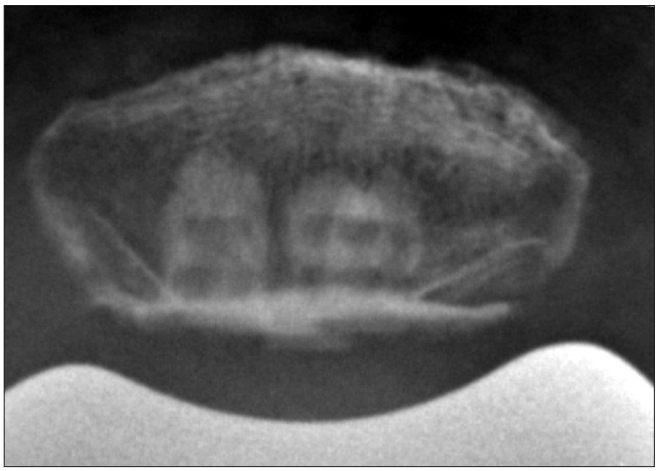

Fig. 5. Magnified skyline view of the patella used for evaluating avascular necrosis, fracture or button loosening.

Table 4. Complications in the Case Group and Control Group

Complication	Case (n=54)	Control (n=54)	p-value
Button loosening	0	0	-
Button fracture	0	0	-
Bone fracture	0	0	-
Anterior knee pain (%)	3 (5.56)	7 (12.96)	0.18
Crepitus (%)	6 (11.11)	4 (7.41)	0.51
Clunk	0	0	-
Lateral release (%)	5 (9.26)	7 (12.96)	0.54
Avascular necrosis	0	0	-
Patellar instability	0	0	-
Manipulation	0	0	
Patellar revision	0	0	-

design of knee prosthesis which had an unfriendly trochlea resulting in high contact stresses on the plastic button. Though the knee prostheses have been improved and evolved with respect to available size options, trochlear groove and patella femoral kinematics, the thickness of patellar buttons has not been revised in the last three decades. With the standard and solitary option of an 8 mm button, it is difficult to resurface the patella with a host thickness of less than 20 mm without over resecting or overstuffing, thus tempting the surgeon to leave the patella unresurfaced[22]. Literature recommends cutting the patella to a depth which restores the native patella's thickness after resurfacing[5]. This thickness is thought to provide the optimal kinematics for the patella, the implant and their interface[23]. In case of 2 mm overstuffing or more, there is 3° decrease in the ROM for each 1 mm increase in thickness, which could lead to a loss of 6° in terminal flexion[6,24] that could be crucial for a large majority of our patients who perform high flexion activities such as sitting on the floor and sitting cross-legged. Higher range of flexion, especially more than 120° after knee arthroplasty, is associated with greater satisfaction and better high flexion knee scores[25]. Moreover, an increased patellar thickness may have other important clinical consequences as biomechanical studies have shown that increasing the thickness of patella–implant composite during a TKA increases the compression and shear forces on the patella–femoral joint[4]. Early loosening and shearing of the patellar component off the host patellar bone have been reported with thick patella–polyethylene composite[3,26]. It has been shown that an increase in thickness of the patella by 4 mm led to an additional 6° of lateral tilt and an increased incidence of lateral release[1]. Similarly, patellar tracking has been found to be related to patellar thickness[6]. Hamilton et al.[27] have reported that decreasing the patellar thick-

ness by more than 2 mm increased the relative risk of developing a complication of patellar clunk, crepitus by 2.5 times. Other authors have noted the increase risk of patellar fracture in cases with a native patellar thickness less than 18 mm[2,9].What makes this 2 mm further crucial is the 174% increase in contact pressure for a patella with a 2 mm more increase than the original thickness[28].

In this study, 14.3% of our patients had a patella thickness less than 20 mm in whom we found resurfacing challenging with standard thickness patella buttons without risking overstuffing or over-resecting. Since 2013, we have been using a 6.2 mm patellar button in patients with a host thickness less than 20 mm and improved our ability to restore the patella to the pre-cut thickness accurately. Clinical results of TKA with use of the patella button have been investigated for the first time. We could accurately restore the patellar thickness in both groups and did not have patellar complications like fracture and loosening in either group. There was no patellar button fracture in the 6.2 mm 'thin' case group proving its safe clinical use with Vanguard posterior stabilised system (Zimmer Biomet). The higher rate of lateral release in both groups can be explained by all female population of our study and the fact that we performed lateral release in knees not achieving type I tracking[29]. The fact that 43% of patients in the 6.2 mm group could perform high flexion activities and subjecting their knees to high compressive forces did not lead to fracture or loosening of the 'thin' button further validates its potential clinical utility.

Our study has some limitations. First, the small number of patients in each group and short follow-up are limiting factors in terms of clinical assessment of pain, function and complications. We aimed to reduce this limitation by utilizing a vigorous matching criterion and careful radiological analysis. Second, the subjects in both groups were females, which may be subject to bias although it is well known that the patella thickness of less than 20 mm can be found mostly in women[7,22,30] and hence the control group had to be matched with the same gender. The third limitation is the possibility of interobserver and intraobserver bias for radiological and intraoperative measurements, which we aimed to decrease by employing 2 experienced surgeons to obtain agreement on intra- and postoperative measurements. The strength of this study is the retrospective comparative cohort design, reproducible technique, extensive radiographic analysis and complete follow-up in all patients. This study has been performed with one type of knee prosthesis and outcomes with other implants could be different. We acknowledge that this is a short-term study and the possible complications of wear and subsequent failure of a thin plastic button may manifest in the long term for which we will continue to follow up this cohort regularly. The results of this study could initiate testing of a 6 mm patellar button with other knee designs in experimental and clinical trials. Moreover, the possibility of using a highly cross-linked polyethylene for thinner plastic buttons can also be explored. Apart from more randomised studies, we need biomechanical and finite element analysis to determine the safe minimum thickness of patellar buttons that can be used with modern designs of primary TKA.

Conclusions

Having a 6.2 mm patellar button option was useful in restoring preoperative thickness in patients with a patellar thickness less than 20 mm. Its use did not lead to plastic fracture, button wear or failure which could be potential complications with use of a thinner plastic implant.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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