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Patella alta and patellar subluxation might lead to early failure with inlay patello-femoral joint arthroplasty

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Abstract

Purpose With the growing interest in resurfacing procedures, several new implants have been recently introduced for isolated patello-femoral joint arthroplasty (PFA). However, not much data are available for these new techniques or about the right indications for each type of implant.

Methods Out of a retrospective cohort of 20 inlay PFA, 11 PFA with an elevated Insall–Salvati index and an increased patello-femoral congruence angle showed an initial satisfactory result, but presented thereafter with recurrent pain and "clunk" phenomena. They were all revised after a median time of 25 months (range 8–28 months) into an onlay technique PFA and analyzed for their failure mode and revision technique.

Results Clinical symptoms such as clunking, as well as abraded areas craniolateral of the inlay implant found intraoperatively, were the main observations of this study. The modified Insall–Salvati index (mISI) was significantly higher in the revised knees compared to the unrevised (median 1.8 versus 1.6; $p = 0.041$). VAS and KSS significantly improved after revision (median VAS reduction in pain of 4.0 points, median KSS improvement of 20.0 points; $p < 0.05$).

Conclusion Patients with high-normal patellar height index or patella alta, as well as a craniolateral type of arthritis with additional lateralization, should be considered contra-indicated for an inlay technique PFA. They could be considered for a PFA system reaching further proximal into the distal femur. An onlay PFA can be an option for early revision of failed inlay implants. The clinical relevance of this study is that patella alta and patellar subluxation are more difficult to adjust for with an inlay PFJ component.

Level of evidence Level IV.

Keywords Patello-femoral arthroplasty · Onlay · Inlay · Revision · Patella alta

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Introduction

Approximately 10% of patients with osteoarthritis (OA) of the knee have unicompartmental OA confined to the patello-femoral joint (PFJ). This is predominantly observed in younger women [12]. The main surgical options available if conservative treatment failed, are total knee arthroplasty (TKA) or patello-femoral arthroplasty (PFA). PFA has many advantages over TKA, such as being less invasive, preserving the unaffected compartments of the knee, allowing faster recovery, better range of motion and functional outcome with high return to sports activity and even cost effective [1, 3, 10, 20, 21, 34]. Indications for PFA are isolated patello-femoral joint (PFJ) arthritis where conservative treatment has failed, joint preserving options are unauspicious and relative or absolute contraindications are ruled out [4, 21, 22, 24, 26].

The outcome of PFA varies [3, 7, 9, 17, 19, 39] and failure rates are still high according to arthroplasty registries [28, 29]. The most common reason for revision seems to be unexplained pain or progression of femorotibial arthritis [16, 17, 27]. These high revision rates are probably influenced by small numbers of PFA performed per surgeon with therefore limited individual experience. Another reason for more revisions could be the lower threshold to revision because surgeons perceive revision of PFA into primary TKA an easier surgery. A lower threshold for revision, as well as a higher revision rate in low-volume surgeons are both issues comparable to the experience with unicompartmental knee arthroplasty (UKA) [33]. Similarly to UKA, outcomes for PFA are very promising in centers performing higher numbers [2, 3, 9, 30] and revision arthroplasty of PFA into TKA seems to perform comparable to primary TKA [11, 18, 38]. However, a most recent study found that developer publications do not seem to be biased in PFA [32]. Aside from these aforementioned reasons, another cause for revision could be the design of the PF implants, in spite of important improvements to the newer generation of arthroplasties [7, 25, 27, 34]. The Australian registry shows a higher early failure rate among implants which are inlay than for onlay designs [29], which is probably related to a higher incidence of patellar maltracking, catching, popping and pain with the inlay technique. The recently introduced inlay technique covers the central part of the trochlea with the implant being surrounded by a cartilage border, whereas the onlay designs proceed with an anterior bone cut and extend more craniolaterally allowing rotational adjustments.

Since PFA gained popularity like other types of partial knee replacement, several new implants have been introduced into the market, being either more anatomical, smaller or with an inlay technique. However, not much data are available about these new inlay techniques [14, 40]. The same dilemma exists for the question whether different types of patello-femoral osteoarthritis (PFOA) should be treated with different types of implants.

The hypothesis of this single-surgeon retrospective study was that preoperative patellar height and the patello-femoral tracking pattern from proximal to distal into the trochlear groove influences success after an inlay design PFA. Furthermore, it was hypothesized that failed inlay PFA can be revised with onlay PFA.

Materials and methods

This study is a retrospective cohort of 20 inlay PFA (cementless HemiCAP® Wave, Arthrosurface, Franklin, USA) implanted between 2013 and 2015 by a single surgeon (JB). This surgeon has an important experience with inlay and onlay PFA (30 cases/year).

Within this study cohort, 11 inlay PFA implanted in 9 patients (3 knees in 3 males, 8 knees in 6 females) with a median age of 46.4 (range 40–52) years needed revision. All patients reported initial satisfactory results for several months (range 6–34 months) and presented thereafter with recurrent pain and "clunk" phenomena (Table 1). As the time between first implantation and revision PFA ranged between 8 and 44 months, 1-year results after the primary PFA cannot be provided for all patients hence. Patients were revised after a median time of 25 (range 8–28) months into an onlay technique PFA (cemented Partial PFJ®, DePuy Synthes, Warsaw, USA). All patients received the same implant system by the same surgeon, under general anesthesia with a laryngeal mask combined with Local Infiltration Analgesia (LIA) for pain control and IV tranexamic acid for

Table 1 Scores

	Preop. prim. PFA	12 months FU	Preop. rev. PFA	Postop. rev. PFA	*p*
VAS median	7.0$^{*,€}$	2,0^{*,**,π}	7.0**,***	3.0**,***	< 0.001*
(SD, range)	(0.8, 6–8)	(0.8, 1–4)	(1.0, 5–8)	(1.0, 1–4)	< 0.001**
Revised PFA	(*n* = 11)	(*n* = 9)	(*n* = 11)	(*n* = 11)	< 0.001***
VAS median	7.0$^{€,&}$	2.0$^{&,π}$	–	–	n.s.$^{€}$
(SD, range)	(1.0, 6–9)	(0.9, 1–3)			n.s.^{π}
Unrevised PFA	(*n* = 9)	(*n* = 9)			< 0.001$^{&}$
KSS median	60.0$^{#,$}$	90.0$^{#,##,%}$	60.0$^{##,###}$	90.0$^{##,###}$	= 0.006$^{#}$
(SD, range)	(4.7, 60–70)	(8.3, 70–90)	(5.2, 60–70)	(8.2, 70–90)	= 0.006$^{##}$
Revised PFA	(*n* = 11)	(*n* = 9)	(*n* = 11)	(*n* = 11)	= 0.003$^{###}$
KSS median	60.0$^{$,§}$	90.0$^{§,%}$	–	–	n.s.$^{$}$
(SD range)	(5.3, 60–70)	(5.3, 80–90)			n.s.$^{%}$
Unrevised PFA	(*n* = 9)	(*n* = 9)			= 0.007§

n.s. not statistically significant, *VAS* Visual Analogue Scale, *KSS* Knee Society Score, *preop.* preoperatively, *postop.* postoperatively, *rev.* revision, *prim.* primary, *PFA*: patello-femoral arthroplasty

$^{*,**,***,€,π,&,§,$,%,#,##,###}$ all represent corresponding groups tested for statistical significance

blood loss control. No drains or tourniquet were used and all patients had the same postoperative treatment protocol. Full weight-bearing with crutches as needed, as well as mobilization according to pain and comfort. Physiotherapy was started immediately after surgery and continued for several weeks if needed. Low molecular weight heparins (LMWH) were given for 2 weeks postoperatively.

Revision was done through a medial mini-parapatellar approach. The cementless inlay PFA could easily be removed with an osteotome without the creation of any further bone defects and the central screw was easily drilled out. Conversion of the broader inlay PFA into a distally smaller onlay PFA resulted in a 2–3 mm mediolateral and 5–8 mm craniolateral uncovered rim of the trochlea medially as well as laterally, which received microfracture drilling. The central screw hole of the inlay PFA was filled with cancellous bone of the anterior onlay cut. The new onlay femoral component was positioned parallel to the anatomical transepicondylar axis (TEA) allowing for a few degrees of more external rotation optimizing patello-femoral tracking. The patella was revised in all cases by resecting the damaged implant with one central peg at the cement–polyethylene interface keeping the remaining patella thickness above 11 mm. The unresurfaced cartilage around the inlay patella of the index surgery was removed with this cut. The new patellar button was a three-peg onlay component with a symmetrical design. Patello-femoral tracking was judged with the no thumb test and any lateral tilt or maltracking was not allowed. In case it was observed, an outside-in lateral release would be performed while preserving the patellar vascularization or in extreme cases a tuberosity transposition would have been performed.

Visual Analogue Scale (VAS) and Knee Society Score (KSS) outcomes were collected after revision. The preoperative and postoperative range of motion was observed. Surgical time was measured on the anesthesiologists computer program and any complications were noted in the patient's medical file. Preoperative and postoperative radiographs were compared for patellar height. All measurements were carried out by two different investigators and in case of discrepancy the mean was built between measurements. Merchant views were utilized to confirm adequate patellar tracking.

The study was approved by the ethic committee of the local state medical council (Approv. No. F-2018-016) and describes a retrospective cohort and routine controls and does not interfere with GCP and ethical standards.

Statistical analysis

Data were tested for normal distribution by Shapiro–Wilk tests with $\alpha = 5\%$ for significance. Further testing was done by paired and unpaired Student's t test and a Wilcoxon test was performed to reveal differences between not normally distributed groups. A value of $p < 0.05$ was considered significant. The statistical value, however, is certainly limited due to the small number of patients. Due to only very few discrepancies in radiographical measurements, no test–retest reliability testing was performed. SPSS for Windows (version 12.0) was used for statistical calculation. A post hoc calculation for Insall–Salvati index with mean groups of 1.7 and 1.6, respectively (Software G-Power 3.1—effect size 1.0, α-error 0.05, power 0.85) revealed a sample size of 11.

Results

Visual Analogue Scale (VAS) and Knee Society Score (KSS) significantly improved after revision. A median VAS reduction in pain of 4.0 points (SD 1.1, range 2–6) and median KSS improvement of 20.0 points (SD 7.5, range 10–30) could be found ($p < 0.001$; Table 1). The aim of this paper is to report early failure. As one knee was revised after 8 months and one at 12 months' follow-up, the 1-year results of the remaining and only later revised 9 knees were a median VAS of 2.0 (SD 0.8, range 1–4) and a median KSS of 90.0 (SD 8.3, range 70–90). Scores were comparable between revised and unrevised PFA preoperatively, as well as at 12 months postoperatively (n.s.; Table 1).

Median time to revision surgery after the index procedure was 25.0 months (range 8–28 months). The median time after index procedure of the remaining unrevised 9 knees is 29.0 months (range 21–42).

Median surgical time of the index inlay PFA procedure was 35.0 min (range 30–43 min). The median revision surgical time was 44.0 min (range 36–47 min). Marked polyethylene defects and clunking, as well as abraded areas craniolateral of the inlay implant were found intraoperatively (Fig. 1a, b).

Median preoperative Caton–Deschamps index was 1.2 (SD 0.1, range 1.0–1.3) for all 20 knees and 1.2 (SD 0.1, range 1.0–1.3) for the revised knees. The patello-femoral congruence angle was clearly elevated with a median of 15.0° (SD 8.2, range 0–30) for all 20 knees and 20° (SD 7.1, range 10–30) for the revised knees. All patellae were Wiberg I (60%) and II (40%) and several (9 of 20) showed trochlear dysplasia according to Dejour type A (6 of 20) and B (3 of 20), with slightly more abnormality in the revised knees.

The 11 revised knees had a median modified Insall–Salvati index (mISI) of 1.8 (SD 0.1, range 1.6–1.9) preoperatively, a median index of 1.7 (SD 0.1, range 1.6–1.8) after the first PFA which was not statistically significant (n.s.; Table 2). The difference between the preoperative mISI and the median mISI of 1.7 (SD 0.1, range 1.5–1.7) after revision PFA, however, was statistically significant ($p = 0.005$; Table 2). Lateral X-rays of the first and revision PFA of one

female patient (Fig. 2a, b). Furthermore, median mISI of the unrevised remaining 9 knees was 1.6 (SD 0.1, range 1.5–1.8) preoperatively and 1.6 (SD 0.1, range 1.5–1.7) after the first PFA which was not statistically significant (n.s.; Table 2). The difference between the preoperative mISI of the revised PFA and the mISI of the unrevised PFA, however, was statistically significant ($p = 0.041$; Table 2).

Discussion

The most important finding of this retrospective cohort study was that the patello-femoral tracking pattern from proximal to distal into the trochlear groove ("approach path") should have a crucial influence in the decision on the type of PFA to be used for each patient. Patients with high-normal patellar height index or patella alta, as well as a craniolateral types of arthritis should be considered for a PFA system that covers the proximal part of the patellar tracking, therefore reaching further proximal onto the distal femur. Further caution might be advised if additional lateralization is obvious. This cranial area is not covered by the lately introduced inlay

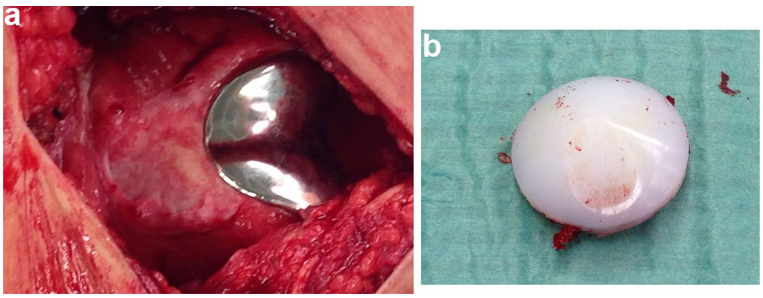

Fig. 1 **a** Intraoperative finding with abraded area craniolateral of the inlay implant. **b** Intraoperative finding with marked polyethylene defect

Table 2 Modified Insall–Salvati index (mISI)

	Preop. prim. PFA	12 months FU	Preop. rev. PFA	Postop. rev. PFA	*p*
mISI median	1.8*,€	1.7*	1.7**	1.7**	n.s.*
(SD, range)	(0.1, 1.6–1.9)	(0.1, 1.6–1.8)	(0.1, 1.6–1.8)	(0.1, 1.5–1.7)	=0.005**
Revised PFA ($n = 11$)					
mISI median	1.6#,€	1.6#	–	–	n.s.
(SD, range)	(0.1, 1.6–1.9)	(0.1, 1.5–1.6)			=0.041€
Unrevised PFA ($n = 9$)					

n.s. not statistically significant, *FU* follow-up, *preop*. preoperatively, *postop*. postoperatively, *rev*. revision, *prim*. primary, *PFA* patello-femoral arthroplasty

*,**,€,# all represent corresponding groups tested for statistical significance

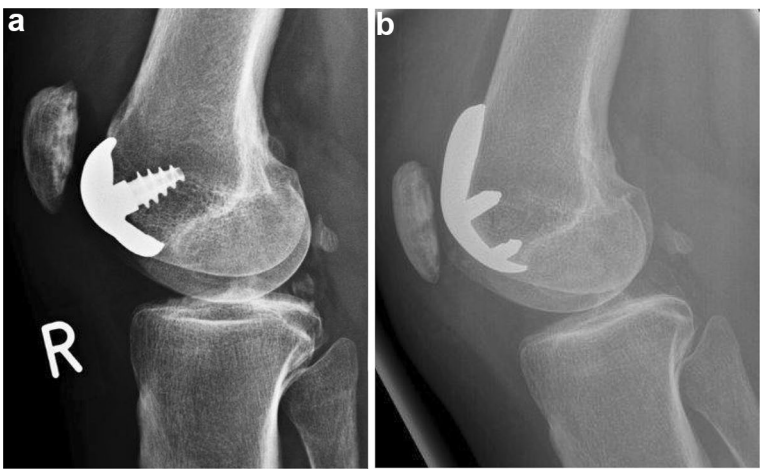

Fig. 2 **a** Radiograph: lateral view of inlay PFA prior to revision. **b** Radiograph: lateral view after revision PFA of same patient

techniques, which only cover the central part of the trochlea with the implant being surrounded by a cartilage border. The described clunk phenomena then occured when abrasion had eliminated the border and "inlay" turned into "onlay". An index as the (modified) Insall–Salvati index (ISI) or the Caton–Deschamps index (CDI) therefore should be incorporated into the decisional algorithm of particularly inlay PFA. Furthermore, as the inlay technique follows the normal anatomy of the trochlea, internal rotation position occurs in dysplastic trochleae and leaves residual dysplastic anatomy proximally. However, as the clinical findings (clunking and pain) were so obvious, we did not carry out CT scans to calculate the rotation.

No consensus has yet been reached on a "gold standard" method for patellar height and there is insufficient evidence to determine the reliability, validity, sensitivity or specificity of most of the tests [23, 31, 35]. Conflicting results in literature and the interobserver variability among the different indices has led to efforts to define new indices, e.g., the patellotrochlear index defined on sagittal MRI [6]. Therefore, we focused on one index which is said to be easy to identify. Due to the relatively small number of the presented cohort it cannot be concluded to a clear cut-off point. However, we suggest not to consider a PFJ device solely covering central areas as the described inlay technique for patients with indices in the upper norm range, even less if above (therefore being true patella alta). Further caution might be advised if additional lateralization is obvious.

Another study by Hendrix et al. described the exchange of a first generation into a second-generation PFA in 14 knees in 11 patients, where the primary procedure failure was due to component malpositioning, subluxation, polyethylene wear, or overstuffing. Postoperatively, improved outcome scores were also observed [15]. In this study, the same satisfactory functional outcome after revision was obtained. Due to the unacceptable high revision rate described here, the inlay device is only further used for very rare indications of central grade IV cartilage lesions or OA. Furthermore, particularly those knees with higher ISI are considered contraindications for inlay PFA.

Beitzel et al. analyzed patellar height by the CDI in a prospective study of 25 onlay technique PFA and found a significant decrease of the index postoperatively [5]. The cohort described in this paper also had a high modified ISI, which also lowered postoperatively but still was remarkably high. Patella alta goes together with trochlear dysplasia, which is often at the origin of PFOA.

Callies et al. found in an in vitro model when using a PF prosthesis that one must be aware of altered pressures of the retropatellar surface compared to the physiological situation. The elevated peak pressures and reduced contact area may be an argument against patella resurfacing and the problems of edge loading show that careful implantation of the device should avoid implant overhang [8]. Furthermore, as described by Thienpont and Lonner, aligning the trochlear component with the AP-axis in the coronal plane avoids maltracking and optimally utilizes the design features of the implant [36]. These findings can be confirmed by the described intraoperative findings of this study. With the inlay technique, neither rotation nor coronal alignment can be corrected since the native anatomy is followed during the surgical technique. Dirisamer et al. described that the exact analysis of the underlying pathological biomechanical relationships is the basis for every therapeutic decision and that treatment might include additional realignment or stabilization procedures, but that the main decision lies in the choice of the implant type [13]. In this context, these study findings support Lonner et al. who stated that postoperative patello-femoral dysfunction should be reduced by using a trochlear component that engages the patella within the trochlear groove and articulates with the patella completely in extension, but which is relatively unconstrained in extension and has a sagittal radius of curvature that fits well with the native distal femur [24]. This study confirms this finding since the lack of proximal tracking engagement was probably the cause of the early failures noticed in this series.

It is known, that in some patients with important trochlear dysplasia the medial superior condyle is too small and reduced in surface area and that the lateral condyle is larger and extends anterolaterally. In these cases, a quite large implant which covers the "approach path" craniolaterally, therefore mainly larger in cranio-caudal dimension, is needed. A new inlay implant has therefore been developed by the company of the failed inlay device described that is much larger in these dimensions and therefore can guide the patella when entering the proximal trochlea. This type of design might solve the issues for specific anatomical cases as described in this cohort study but the issue is less important when an onlay implant that extends sufficiently proximally is used. In consequence, authors use the described inlay design PFA solely for very rare indications.

Feucht et al. matched 15 patients with an onlay technique with 15 patients with an inlay technique with the same implant as described in this study [14]. They found that isolated PFA using either a second-generation onlay or an inlay trochlear component significantly improved functional outcome scores and pain. Similarly and most recent, Zicaro et al. describe mainly satisfactory results with the same implant and an average follow-up of 35.2 months [40]. The same was observed initially in this cohort study, but only temporarily by the use of an inlay technique in patients with patella alta. However, although Zicaro et al. report no mechanical implant failure at a minimum 2-year follow-up, they also report patello-femoral dysplasia or patellar maltracking as poor prognostic factors for this type of implant [40]. Feucht et al. further found that the theoretical

advantages of an inlay design did not result in better clinical outcome scores, but that progression of tibiofemoral OA was significantly less common in patients with an inlay trochlear component. This finding cannot be confirmed in this study despite that the time frame was comparable to the 25 months described in the matched pair analysis [14]. This could be related to the disease pattern of the osteoarthritic patients indicated for PFA [37].

There are several limitations to this study. A first and important limitation is the short follow-up; both after the primary procedure and the revision PFA. We cannot provide long-term follow-up on the outcome of the revision implants but the majority is beyond 2-year follow-up. The reason for this short follow-up was the observation of early failure after the index procedure and the wish to inform the orthopaedic world about this issue. A second limitation is the small study group. However, PFA is more rare than total knee arthroplasty and the surgeon performing these PFA has a lot of experience with this type of surgery. Probably, his technical level allowed him to perform the revision with an onlay design allowing him to avoid TKA in these young and active patients. Finally, the radiological measurements for the ISI were performed by one observer not allowing us to determine the interobserver variability, but we believe the observation of a reduction in patellar height by the revision PFA was more important than small differences in patellar height measurements.

The strength of this study lies in the single surgeon group that was operated by the same surgeon both for their index procedure and revision PFA. This allowed us to observe the preoperative as well as intraoperative findings explaining the complaints of the patients and identifying patient groups at risk for this type of surgery. Well knowing the lower threshold to revision because of the perception of an easier revision into primary TKA, revision due to unexplained "pain" might otherwise just be the only reason to detect in e.g. arthroplasty registries.

As the clinical relevance of this study, the authors want emphasize to preoperatively adjust patellar height and patello-femoral tracking pattern from proximal to distal into the trochlear groove as it influences success after PFA.

Conclusion

The tracking pattern of the patella evaluated by the area of surface damage in PFJ arthritis and lateralization as well as preoperative patellar height should be considered in the indication of inlay PFA versus the utilization of an onlay design. Wrong indication can lead to early failure, but conversion of inlay PFA to onlay PFA remains possible. The latter is a low invasive solution of revision allowing good functional outcome with minimal bone loss and retention of uninvolved compartments.

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Compliance with ethical standards

Conflict of interest All authors disclose any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations that could inappropriately influence, or be perceived to influence, this work.

Ethical approval The study was approved by the ethic committee of the local state medical council (Approv. No. F-2018-016) and describes a retrospective cohort and routine controls and does not interfere with GCP and ethical standards.

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