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# Survivorship and functional outcomes of patellofemoral arthroplasty: a systematic review

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## Abstract

*Purpose* Historically poor results of survivorship and functional outcomes of patellofemoral arthroplasty (PFA) have been reported in the setting of isolated patellofemoral osteoarthritis. More recently, however, fairly good results of PFA were reported, but the current status of PFA outcomes is unknown. Therefore, a systematic review was performed to assess overall PFA survivorship and functional outcomes.

*Methods* A search was performed using PubMed, Embase and Cochrane systems, and the registries were searched. Twenty-three cohort studies and one registry reported survivorship using Kaplan–Meier curve, while 51 cohort studies reported functional outcomes of PFA.

*Results* Twelve studies were level II studies, while 45 studies were level III or IV studies. Heterogeneity was mainly seen in type of prosthesis and year the cohort started. Nine hundred revisions in 9619 PFAs were reported yielding 5-, 10-, 15- and 20-year PFA survivorships of 91.7, 83.3, 74.9 and 66.6 %, respectively, and an annual

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revision rate of 2.18. Functional outcomes were reported in 2587 PFAs with an overall score of 82.2 % of the maximum score. KSS and Knee Function Score were 87.5 and 81.6 %, respectively.

*Conclusion* This systematic review showed that fairly good results of PFA survivorship and functional outcomes were reported at short- and midterm follow-up in the setting of isolated patellofemoral osteoarthritis. Heterogeneity existed mainly in prosthesis design and year the cohort started.

*Clinical relevance* These results provide a clear overview of the current status of PFA in the setting of isolated patellofemoral osteoarthritis.

Level of evidence IV.

# Introduction

Isolated patellofemoral osteoarthritis (OA) is a common degenerative knee disease and accounts for 10–24 % of all patients presenting with knee pain [23, 26, 61, 91]. Joint replacement treatments for isolated patellofemoral OA include patellofemoral arthroplasty (PFA) and total knee arthroplasty (TKA). In 1979, the first results of PFA were presented and although patellofemoral pain was alleviated, the reoperation rates were high (35 %) [12, 60]. In the following years, satisfaction results of 20–72 % had been reported after PFA [5, 8, 44, 82, 85, 100]. Many surgeons therefore advocate the use of total knee arthroplasty (TKA) over PFA in the setting of isolated patellofemoral OA [21, 63, 69, 80].

Controversy, however, remains if an invasive procedure such as TKA is justified in young patients with isolated patellofemoral OA [27, 41, 43, 59, 97]. This is of particular interest due to the higher risk of TKA revision in younger patients [28, 35, 48, 62], the predicted increase in TKA revisions [81] and inevitable bone loss with each subsequent revision [42]. PFA is correlated with less blood loss [19], shorter hospital stay [19], preservation of bone stock and ligaments [76] and better functional outcomes and stair climbing abilities [54] when compared to TKA. Moreover, it has been shown that second-generation PFA implants had equivalent reoperation and revision rates, pain and mechanical complications when compared to TKA [27].

In order to optimize the outcomes of PFA for isolated patellofemoral OA, it is important to accurately characterize the survivorship and functional outcomes of PFA. To our knowledge, however, studies assessing overall survivorship and functional outcomes of PFA are lacking. Therefore, a systematic review was performed to assess survivorship, revision rates and functional outcomes of PFA. The purpose of this study was to (1) assess survivorship in cohort studies and registries, (2) determine whether revision rates are lower in the more recent studies and (3) evaluate the functional outcomes of PFA. The hypothesis of the study was that fairly good 10-year survivorship could be achieved with good functional outcomes and that more recent studies had lower revision rates than older studies.

# Materials and methods

A systematic search in the electronic databases PubMed, Embase and Cochrane Library was performed for studies reporting survivorship and functional outcomes of PFA. The search terms were "arthroplasty AND (patellofemoral OR PF OR PFA OR PFR) AND (outcome OR functional outcome OR scores OR results OR revision OR revision rate OR reoperation OR treatment failure OR prosthesis failure OR failure OR failure rate OR survivorship OR survival)". Two authors (JPL and HC) independently scanned all identified studies by title and abstract. Eligible studies were subsequently scanned for the full text on the inclusion and exclusion criteria. In addition, the references of the scanned articles were checked for any missed studies, and annual registries were scanned for survivorship and functional outcomes. If a disagreement existed between authors, a third author (HAZ) was consulted. Consensus was reached on the inclusion and exclusion of all articles.

Inclusions criteria consisted of studies that (I) reported survivorship, revision rates or functional outcomes, (II) were published between 1995 and 2015 and (III) were minimum level IV case series using adjusted Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence [74, 101]. Exclusion criteria consisted of (I) studies that regarded patellar subluxation as primary surgery indication, (II) studies that had acute concurrent knee pathology (e.g. patella tendon ruptures, anterior cruciate ligament injuries), (III) case reports, systematic reviews and expert opinions and (IV) studies using the same database.

All data were collected in a datasheet in Excel 2011 (Microsoft Corp., Redmond, WA, USA). Parameters collected included study authors, year of publication, year the cohort started and ended, total number of PFA, total number of failures, Kaplan–Meier survivorship, reported functional outcomes and mean follow-up.

Outcomes in this study included Kaplan-Meier survivorship, revision rate, annual revision rate and functional outcomes. Survivorship was included for all studies that reported their outcomes using a Kaplan-Meier estimation [46]. All studies were compiled in a scatter plot and a trend line was added to calculate the survivorship at 5, 10, 15 and 20 years of follow-up. Revision rates of all studies were calculated by dividing the number of failures by the total number of PFA at follow-up. Annual revision rate was calculated with the parameter "revision rate per 100 observed component years", which is used by several orthopaedic studies [53, 77, 78, 86]. This parameter enables comparison of revision rates between different studies or subgroups with varying follow-up intervals. The annual revision rate was used to compare the revision rates of cohort studies and registries and to compare studies published before 2010 with studies published since 2010. Finally, all functional outcomes were collected, and scores were reported as the percentage of the maximum score. This enabled comparison of different functional outcomes and calculation of a mean overall score.

#### Statistical analysis

Statistical analysis was performed using Excel 2011 and SPSS Statistics 21.0 (SPSS Inc., Armonk, NY, USA). A Chi-square test was used to compare annual revision rate of studies published before 2010 and since 2010. No statistical analysis could be performed when comparing annual revision rates [53, 77, 78, 86]. The statistical analysis was two-sided, and a difference was considered significant when p < 0.05.

## Results

## Search results

After removing of duplicates and reviewing title, abstract and full text of the articles, a total of 57 cohort studies [1–3, 6, 7, 10, 11, 13, 15–20, 22, 24, 25, 30–34, 37–40,

#### Fig. 1 Flow chart of the search



45, 47, 50, 51, 55, 57, 58, 63-68, 70, 71, 73, 75, 84, 88-90, 92-96, 98, 99, 102-104] and three registries [4, 9, 72] were included in this study (Fig. 1). Twenty-three cohort studies [1-3, 6, 16-18, 20, 32, 33, 39, 40, 50, 57, 64, 70, 71, 75, 84, 88, 92, 96, 102] and one registry [4] reported survivorship using Kaplan-Meier analysis. Fortytwo cohort studies [1-3, 6, 11, 13, 15-18, 20, 22, 24, 25, 30-33, 37, 39, 40, 45, 50, 51, 55, 57, 64, 65, 67, 70, 71, 73, 75, 84, 88–90, 92, 96, 98, 99, 102] and three registries [4, 9, 72] reported revision rates of which 22 cohort studies were published between 1995 and 2009 [1, 6, 13, 15, 16, 18, 24, 25, 32, 45, 50, 51, 55, 64, 65, 67, 73, 88–90, 92, 98] and 20 were published since 2010 [2, 3, 11, 17, 20, 22, 30, 31, 33, 37, 39, 40, 57, 70, 71, 75, 84, 96, 99, 102]. Finally, a total of 51 cohort studies reported functional outcomes [1-3, 6, 7, 10, 11, 15-20, 22, 25, 30-34, 37-40, 45, 47, 50, 51, 55, 57, 58, 63-66, 68, 70, 71, 75, 84, 88-90, 92-95, 98, 102-104].

## **Quality of studies**

Twelve studies were level II prospective studies [1, 3, 7, 22, 38, 55, 63, 68, 73, 90, 92, 102], while 45 studies were level III retrospective studies or level IV case series [2, 6, 10, 11, 13, 15-20, 24, 25, 30-34, 37, 39, 40, 45, 47, 50, 51, 57, 58, 64-67, 70, 71, 75, 84, 88, 89, 93-96, 98, 99, 103, 104]. No level I studies were identified, and none of the studies were blinded or randomized. Heterogeneity mainly existed in the type of prosthesis and year the cohort started.

#### **PFA** survivorship

Twenty-three cohort studies reported survivorship of 1326 PFAs, and one registry reported survivorship of 2495 PFAs. The trend line of cohort studies showed 5-, 10-, 15- and 20-year PFA survivorships of 91.7, 83.3, 74.9 and 66.6 %, respectively. The trend line of the annual registry showed 5- and 10-year survivorships of 84.7 and 71.4 %, respectively (Fig. 2).

#### **Revision rates**

A total of 900 revisions in 9619 PFAs were identified, yielding a revision rate of 9.4 % and an annual revision rate of 2.18 (Table 1; Fig. 3). Registries reported a slightly higher annual revision rate than cohort studies (2.19 vs. 2.14). Cohort studies published since 2010 revealed a lower annual revision rate than more recent cohort studies (1.93 vs. 2.33) (Table 1).

#### **Functional outcomes**

Fifty-one cohort studies reported functional outcomes for 2587 PFAs using eleven different scoring systems. Most of the functional outcome scores (70 %) were reported within the first 5 years (Table 2; Fig. 4). The average functional outcome score was 82.2 %. Good to excellent knee function was reported in 87.3 %, and Knee Society Score and Knee Function Score were 87.5 and 81.6 %, respectively.



Fig. 2 All studies reporting patellofemoral arthroplasty (PFA) survivorship using the Kaplan-Meier method

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Type study/year of publication	No. of studies	No. of PFA	No. of revisions	Revision rate (%)	Mean FU (years)	Observed years	Annual revision rate
Cohort studies	42	2197	289	13.2	6.15	13,508.5	2.14
1995-2009	22	1123	163	14.5	6.23	6991.9	2.33
2010-2015	20	1075	126	11.7	6.06	6516.6	1.93
Registries	3	7421	611	8.2	3.75	27,862.2	2.19
Total	45	9619	900	9.4	5.29	41,370.7	2.18

Table 1 Number of studies that reported revision rates of patellofemoral arthroplasty

The annual revision rate is the revision rate corrected for the follow-up time (observed years)

Studies between 1995 and 2009 [1, 6, 13, 15, 16, 18, 24, 25, 32, 45, 50, 51, 55, 64, 65, 67, 73, 88–90, 92, 98], studies between 2000 and 2015 [2, 3, 11, 17, 20, 22, 30, 31, 33, 37, 39, 40, 57, 70, 71, 75, 84, 96, 99, 102] and registries [4, 9, 72]

No. number, PFA patellofemoral arthroplasty, FU follow-up



Fig. 3 All studies reporting patellofemoral arthroplasty (PFA) revision rates

rU (y)	References	No. of PFA	Oxford Score	Melbourne Score	HKS	% Good/ excellent	SSH	WOMAC	KSS total <sup>a</sup>	KSS Knee	KSS Function	KSS Pain	Bristol Pain Score	Overall average
_	[2, 11, 18, 34, 58, 66, 94, 102]	348	67.7	82.3	95.0	88.0	93.1	79.2	80.5	84.0	77.1			78.1
2	[1, 2, 10, 17, 19, 22, 30, 33, 57, 90, 93, 104]	497	73.5	85.3	90.0	86.8	90.06	73.0	86.2	89.6	83.2	9.96	87.5	83.9
~	[2, 3, 38, 39, 55, 65, 71]	343	74.7		90.0	86.8			72.6	82.7	62.8	67.6		78.9
+	[2, 20, 31, 47, 58, 63, 68, 89, 95]	356	79.2		87.5	89.2	90.06		88.8	90.3	83.0	90.6		86.9
10	[1, 2, 7, 11, 15, 64, 75, 84, 98, 103]	360	77.1	86.7	80.0	89.4	90.5	72.7	93.2	90.2	93.8		95.0	86.2
\C	[2, 32, 40, 51, 88]	166	59.2		75.0	92.5			83.4	91.0	89.0			84.2
7	[2, 70]	104	61.7		80.0				84.5	87.0	82.0			79.0
~	[2, 45, 92]	154	57.1		85.0				81.5	88.0	75.0		75.0	76.9
•	[2]	61	60.4		80.0									70.2
01	[2, 16]	168	70.8		70.0	77.0								72.6
11	[25]	21				76.2			84.0	90.06	78.0			82.0
12	[37]	85	83.3			82.4								82.8
16	[6]	29							79.9	78.5	81.2	78.5		79.5
(7	[50]	35							83.0					83.0
No. PFAs			1407	391	610	636	115	89	760	795	831	207	280	
Mean score (%)	Ð	2658	71.2	85.6	83.3	87.3	90.8	74.1	84.3	87.5	81.6	84.8	85.8	82.2
PFA patelle	ofemoral arthroplasty, $FU(y)$ follow-up in years,	HKS Hunger	ford and K	enna Score, H	SS Hos	pital for Spe	cial Sı	urgery Scon	e, KSS ]	Knee Sc	ciety Score,	MOM	4C Western Or	itario and

Table 2 Percentage of maximum scores of different functional outcome systems are displayed at different follow-up intervals

<sup>a</sup> KSS total represents the sum of KSS and Knee Function Score and was in some cases reported as single score and in some cases calculated McMaster Universities Arthritis Index

Knee Surg Sports Traumatol Arthrosc



Fig. 4 All studies reporting patellofemoral arthroplasty (PFA) functional outcomes with all scores standardized to the maximum score of 100 %

Patella-specific scores (i.e. Melbourne Score and Hungerford and Kenna Score) were 85.6 and 83.3 %, respectively. Pain scores (Knee Pain Score and Bristol Pain Score) were 84.8 and 85.8 %, respectively (Table 2; Fig. 4).

## Discussion

The most important finding of this systematic review was that survivorship of PFA at 5-, 10-, 15- and 20-year followup was 91.7, 83.3, 74.9 and 66.6 %, respectively. Cohort studies revealed an annual revision rate of 2.14, while registries yielded an annual revision rate of 2.19. Older studies (i.e. published before 2010) reported a higher annual revision rate when compared to more recently published studies (2.33 vs. 1.93). Finally, a mean functional outcome score of 82.2 % of the maximum scores was reported following PFA.

At short-term follow-up of 5–6 years, fairly good results were reported. PFA survivorship at 5-year follow-up was 91.7 %, while the percentage of patients reporting good or excellent knee function varied between 86.8 and 92.5 %. Furthermore, some small studies reported excellent 5-year PFA survivorship (96.2–100 %) [2, 75], which indicates that good results can be achieved at short-term follow-up. At midterm follow-up, the 10-year survivorship was 83.3 %, while the percentage of patients reporting good or excellent knee function varied between 76.2 and 82.4 %. Similarly, individual studies have shown that PFA is durable at 10-year follow-up with survivorship between

88 and 89 % [2, 50]. These results at 5- and 10-year followup show fairly good results following PFA, especially when taking into account the fact that different PFA designs were included from 1995 to 2015.

At long-term follow-up of 15 and 20 years, the survivorships of PFA were 74.0 and 66.6 %, respectively, while 79.5-82.3 % of the patients reported good or excellent function at long-term follow-up. To our knowledge, only three studies have reported PFA survivorship at 15 years or later [6, 50, 96]. These studies reported 15- and 16-year survivorships of 58-79 %, while two of these studies reported 20-year survivorship of 59–69 % [50, 96]. Interestingly, the cohorts of these studies started between 1972 and 1977. It has been shown that these first-generation prostheses have higher revision and reoperation rates when compared to second-generation prostheses [14, 27, 79]. These numbers are therefore not representative of the long-term survivorship potential of the current available prostheses, and caution is advised with drawing conclusions about long-term PFA survivorship on the basis of such series.

Similarly, when comparing more recent studies with studies published before 2010, it was noted that the more recent cohort studies reported a lower annual revision rate (1.93 vs. 2.33, Table 1). Several factors may explain these differences including the aforementioned differences in revision and reoperation rate between first- and second-generation prostheses. There are more improved and second-generation prostheses in the group of more recently published studies, which may contribute to the lower failure rate. Similarly to the findings of Dy et al.

[27], the results of the present study suggest that better long-term results may be expected with second-generation or improved prostheses, but longer follow-up of these prostheses is not available yet. Secondly, differences in annual revision rate between both study groups can possibly be explained by improved patient selection criteria. Progression of OA in the tibiofemoral components is one of the major failure modes in PFA [1, 73, 96], and OA in the tibiofemoral compartment is therefore considered a contraindication. However, this was not uniformly applied in all studies and may have influenced the results [55]. Thirdly, some prosthesis designs have been consistently associated with unfavourable outcomes. The Lubinus prosthesis (Waldemar Link, Hamburg, Germany) has been used in several studies that were published before 2010 with poor results [13, 89, 92]. This is corroborated by the fact that the highest revision rates in the Australia registry were associated with the Lubinus prosthesis and this prosthesis is consequently no longer seen in studies that are published after 2010.

In general, treatment of isolated patellofemoral OA is difficult in younger patients (i.e. <55 years). Due to the historically poor results of PFA, several surgeons have advocated to TKA over PFA in the setting of isolated patellofemoral OA [21, 43, 63, 69, 80]. However, TKA in this setting entails the replacement of two healthy tibiofemoral compartments, which is considered to be invasive [56, 58, 87] and is particularly problematic in the young population where TKA revision rates are higher when compared to older patients [28, 35, 62]. This bears consideration given that the number of primary and revision TKA is projected to increase between 2005 and 2030 in the USA by 673 and 601 %, respectively [52]. When taking these findings into account along with the fact that younger patients have more years to live, these patients are at higher risk of multiple revision surgeries with subsequent rehabilitations and risk of infections [83]. Therefore, replacing only the patellofemoral compartment could delay the replacement of all compartments or even make this procedure redundant. The findings in this study showed that at 10-year follow-up, 83.3 % of the patients retain their PFA and that on average 82.7 % of these patients report good or excellent knee function. This suggests that 69 % of patients undergoing PFA have good or excellent function and could theoretically postpone the need for TKA by 10 years. Furthermore, PFA survivorship is likely to be higher due to second-generation prostheses and improved patient selection. Inevitable OA progression in the tibiofemoral components may occur in some patients, requiring revision to TKA, but in other patients, the need for TKA can be postponed by several years. PFA may even serve as a permanent solution in the absence of OA progression. Furthermore, several studies have shown that good results can be achieved with PFA to PFA revision [36, 49] and PFA to TKA revision,

if necessary [59, 97]. We agree therefore with several authors that state PFA can be a useful technique for treating isolated patellofemoral OA in younger patients or can be utilized as a bridging technique for future TKA if OA progression occurs [29, 55, 57]. However, future comparative clinical studies are necessary to assess the exact role of PFA in the setting of isolated patellofemoral OA, especially in the young patient [76].

Several limitations are present in this study. Firstly, longterm survivorship in this study is probably underestimated as a consequence of including data from both first- and second-generation prostheses [14, 27]. However, long-term survivorship was only available from first-generation prostheses. It was aimed to counter this phenomenon by reporting the annual revision rate in studies published before and since 2010 because this corrects for follow-up length. Secondly, heterogeneity in surgical technique could influence the results. Thirdly, a possible publication bias exists in this study. Non-English articles were included to minimize publication bias, but this possibility cannot be excluded.

This study provides an overview of the functional outcomes and survivorship of PFA in the setting of isolated patellofemoral OA. The data suggest that PFA could be a fairly good treatment option for patients with isolated patellofemoral OA. Therefore, a surgeon might consider PFA as a treatment over TKA in young patients with isolated patellofemoral OA.

# Conclusion

This systematic review showed that outcomes of PFA for isolated patellofemoral OA were fairly good with 5-, 10-, 15- and 20-year survivorships of 91.7, 83.3, 74.9 and 66.6 %, respectively, and overall functional outcomes of 82 %. Furthermore, it was shown that the more recently published studies reported lower revision rates when compared to prior studies.

#### Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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