ADOLESCENT KNEE PAIN AND PATELLAR DISLOCATIONS ARE ASSOCIATED WITH PATELLO-FEMORAL OSTEOARTHRITIS IN ADULTHOOD: A CASE CONTROL STUDY

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1. Introduction

Patellofemoral Osteoarthritis (PFOA) is frequently identified as a disease of middle to old age, with an incidence of 79% found in cadavers aged ≥65 years [1], and radiological evidence of isolated PFOA in 14% of women, and 15% of men greater than 60 years of age [2]. Patella-related pain and instability are common problems in adolescence, reported in up to 30% of students aged 13-19 (n=446) [3]. It remains unknown whether patella-related problems at a young age are related to advanced patellofemoral disease later in life.

The term adolescent anterior knee pain syndrome represents a constellation of symptoms, and has traditionally been thought of as a benign condition. Anterior knee pain is common amongst adolescents, and traditional teaching based on studies from the 1980's and 1990's was that it was a self-limiting condition [4-6]. More recent reports have begun to show a link between the occurrence of adolescent anterior knee pain and subsequent PFOA [7]. However, a systematic review in 2010 concluded that currently 'there is a lack of sound evidence from epidemiological studies on the association between anterior knee pain in younger adults and subsequent PFOA' [8].

Furthermore, studies dating back to 1952 have remarked upon indirect associations between patella dislocation and subsequent PFOA [9]. This could be due to trauma to the joint surfaces, but could also be related to shared anatomical abnormalities pre-disposing to both conditions. However, other than this early report, there is little available data in the literature to

determine whether a history of patellar dislocation is a risk factor for the subsequent development of PFOA.

The aim of this study is to determine the relative prevalence of adolescent anterior knee pain and previous patellar dislocations in patients with severe, symptomatic isolated PFOA and in a control group of patients with severe medial compartment knee OA. These comparative relationships will then be analysed and evaluated using a multivariate model.

2. Methods

2.1 Study design

A case-control study was performed using our knee arthroplasty database to identify 190 patients who had undergone a patellofemoral arthroplasty (study group), and a control group of 445 patients who had undergone a medial unicompartmental knee arthroplasty, both surveyed between 4- and 8-years post-operatively.

The inclusion criteria for the patellofemoral arthroplasty group were the presence of severely symptomatic and radiologically confirmed PFOA, and the absence of radiological signs of OA in the medial or lateral tibiofemoral compartments. This group represent a clearly defined cohort of patients with severe symptomatic isolated PFOA requiring patellofemoral joint arthroplasty as determined by their treating surgeon. By the same measure, the criteria for the unicompartmental control group meant that the patients would have minimal, if any, PFOA at the time of the operation, with severely symptomatic and radiologically confirmed medial compartment tibiofemoral OA requiring arthroplasty. Any patient on the database who had recently taken part in another research study was excluded to prevent excessive participation burden. This left 635 cases and controls remaining for the study.

Once identified, each of these patients was sent a postal questionnaire enquiring about the symptoms and interventions they had received prior to arthroplasty surgery (see Appendix). A description of previous surgery was requested as a potential confounder in later statistical analysis, as many

studies have shown a potential link between types of surgery and development of PFOA [10-12].

Cases were 1:1 frequency-matched by gender; control cases were individually removed until the gender proportions of each group were equal. To maintain comparability, any discrepancies in mean age between groups were minimised. No patients in the case population were removed in order to perform the matching as any alterations in the case sample would consequently cause a misrepresentation of the diseased population, and would have affected the generalisability of the results of the study. Matching was performed in a blinded fashion with no access to the questionnaire data.

2.2 Statistical analysis

Descriptive demographic data are described as percentages. Incomplete or unclear answers from the questionnaires were treated as missing data points. Adolescent anterior knee pain (AKP) was defined as patient reported anterior knee pain present at age 18 years and under; this was analysed as a dichotomous variable. The presence of symptomatic patellar instability was defined as two or more positive answers to the questions regarding patellar instability whilst walking, using stairs and whilst playing sports. This dichotomization allowed for more effective comparison to the categorized dislocation variable, as well as better applicability to the multivariate statistical analysis being performed.

Initially, a multivariate correlation was performed including all data from the questionnaire. From this, particular relationships were confirmed for further analysis, and the extent of the effects of confounders could be evaluated.

Binary logistic regression was used to compare the disease state (PFOA or medial compartment OA - the dependent variables) with the set of independent variables under analysis (patient reported adolescent AKP, history of dislocation, instability and previous surgery) to produce adjusted odds ratio (OR) values (Table 1). The latter two independent variables were added to the model due to their higher levels of correlation with the disease state, to test the robustness of the data and account for confounding variables. 95% confidence intervals (CIs) and *p* values were calculated for this multivariate model. A *p* value of <0.05 was considered statistically significant.

Additionally, further comparative sub-analysis of the median age of 1st dislocation was performed, as well as an observation of differences between the ages of onset of PFOA between those with and without a history of patellar dislocation. The data was identified as non-parametric using a Shapiro-Wilk normality test, therefore the data is expressed as the median, interquartile ranges and ranges.

3. Results

Of the 190 PFOA cases, 111 (58%) were available to take part in the study (Fig. 1), with a mean age of 60 years (range 29-89). Of these, 77% were female, 23% were male, and 51% were left-sided.

In the control group, a response rate of 53% was recorded (n=234). After matching, the mean age of the controls was 68 years (range 52-94). 77% were female, 23% male, and 53% left-sided. Before matching, the mean age was 74 years (range 52-94).

The unadjusted OR analysis showed that patient reported previous dislocation was significantly associated with PFOA (OR, 8.8; 95% CIs 3.88-19.82) (Table 1). The presence of PFOA was also associated with patient reported adolescent AKP (OR, 20.2; 95% CIs 4.69-86.91).

The multivariate binary regression confirmed that statistically significant associations existed between patient reported adolescent AKP and PFOA (OR, 7.5; 95% CIs 1.51-36.94), as well as patient reported previous dislocation and PFOA (OR, 3.2; 95% CIs 1.25-8.18). A significant association was also seen for patient reported instability (OR, 3.5; 95% CIs 1.62-7.42) and patient reported previous surgery was confirmed as a noteworthy confounder, with an adjusted OR of 3.5 (95% CIs 1.75-7.14).

In those individuals who reported dislocations, the median age of 1st dislocation was 15 years (range 4-55) for the PFOA cases compared to a

median age of 59 (range 30 to 65) in the control cases in whom this had occurred (Fig. 2). It should be noted that the sample size in the control group was small in this analysis, due to the low rate of patella dislocation in this group (n=6 control cases c.f. n=42 cases in the PFOA group). In the patellar dislocation group, the median age of onset of severe PFOA (i.e. the age at the time of arthroplasty) was 58.2 years, compared to 60.3 years in those who hadn’t suffered dislocations.

4. Discussion

Based on our data, if an individual experiences AKP under the age of 18 years, they are approximately 7.5 times more likely to develop severe, symptomatic PFOA later in life. This adds significant weight and evidence to the theory that adolescent AKP is not solely a benign, self-limiting condition.

Whilst studies have shown some evidence of a link between anterior knee pain and development of PFOA, a clear causal relationship and the extent of this association has not been established. Reasons vary from small sample populations and follow-up rates [13] to an absence of control groups at the time of recruitment [5]. In the studies that have described this, it has been as a secondary outcome or association rather than as the primary outcome or association in the study design. Studies to date have also failed to define what they consider to be the diagnostic criteria of PFOA.

Utting et al. used a comparable method to ours to demonstrate evidence of a relationship between AKP and PFOA, with patients who underwent isolated patellofemoral replacement recalling knee pain lasting for an average of 6.4 years longer than those in the medial unicompartmental arthroplasty group [7]. Whilst similar data collection techniques to our study were employed, no matching was performed and basic comparison tests were used, without the use of a logistic regression to take into account the other variables and potential confounders in the study.

Nimon et al. followed up patients with AKP for 14-20 years [13]. They noted that only 22% were pain free at final follow up, and no patient went on to develop signs of structural disease. In contrast, a separate study by Hvid et al. observed approximately 68% of patients with chondromalacia patella had some element of structural abnormality [14]. However, the latter study's conclusions must be approached with caution; individuals were only included who had a 'significant clinical syndrome', a criticism that has been noted by other authors [8].

Despite the most rigorous search for a specific diagnosis, many adolescent patients are referred to as simply having idiopathic AKP or chondromalacia patella, with the two terms being used interchangeably [15]. Whilst it is often accepted that biomechanical factors play at least some role in the disease process and explain the pain experienced [16], further work is required to describe the underlying pathological mechanisms.

Anatomical variations such as patella alta and trochlear dysplasia have been implicated as potential causative factors in the development of PFOA [17]. It may be that our results can be explained by anatomical variations that result in pain and instability in youth, and osteoarthritis in later life. These abnormalities would not have been identified in this purely clinical study and further investigation of this is warranted.

Malalignment and joint laxity may also explain differences between the groups in our study. Although both have been shown to predate osteoarthritic

changes in the knee [18, 19], there is no evidence at present that either directly causes PFOA over other forms of arthritis, such as unicompartmental tibiofemoral OA.

Unicompartmental arthroplasty patients were chosen as the control group due to the presence of some osteoarthritis, compensating for recall bias based on pain and awareness of symptoms in the knee. A control group must represent the population in which the cases are taken from – this is fulfilled in this context, as the unicompartmental arthroplasty patients, with a mean age of 68, have had time for PFOA to develop, proven by the case mean age of 60, with PFOA being recorded as early as the age of 29 years in some. The inclusion of this control group has also minimised the effects of other osteoarthritic-causing, therefore confounding, factors, such as increased exercise and obesity.

Based on our adjusted OR calculations, a patient is approximately 3.2 times more likely to develop PFOA if they have had a patellar dislocation. Previous research has focused on the evaluation of surgical techniques with data being collected after operations that may influence the progression of the disease [9, 11, 20]. These studies concluded that the surgical intervention itself is the primary predisposing factor for PFOA. Our study has demonstrated that although previous surgery on the knee is significantly associated with the risk of developing PFOA (adjusted OR of 3.5), other factors such as patient reported previous dislocation (adjusted OR of 3.2), instability (adjusted OR of

3.5) or adolescent AKP (adjusted OR of 7.5) demonstrate similar or greater ORs.

In the case of patellar dislocation, the mechanism underlying this relationship may be due to the rapid movement of the patella out of the trochlear groove and over the edge of the lateral femoral condyle, then subsequent relocation. These movements lead to cartilage damage, and can initiate the pathological process that results in PFOA. Heywood noted this association, observing a 100% arthritis rate in those who had experienced dislocations for over 25 years [21]. Another potential explanation is that other anatomical variations, such as trochlea dysplasia and patella alta, may be associated with an increased risk of dislocation [22] and independent development of PFOA.

Additionally, it may be argued that activity level of participants acts as a confounding factor to patellar problems and dislocation, with one study recording 70% of first presentations occurring following sport [23]. This has not been investigated in this study, and neither was the occurrence of previous minor joint injury (i.e. not requiring surgery), which could also be related to the development of PFOA. However, the increased joint loading related to participation in sports or injuries may be expected to influence the development of tibiofemoral OA. Further larger studies should consider this as a potential factor in the future as we are unable to comment on an effect of sports participation or joint injury based on our data.

The considerable passage of time from adolescence to the onset of OA presents a challenge to the accuracy of data collected by recall. The study has been designed with a control group who have had similar knee arthritis and arthroplasty experience, as well as having a similar mean age. This was included with the objective of controlling for this factor, although the risk of recall bias remains. A longitudinal study would be the optimal design for answering this question, however the 50-year follow-up required would be prohibitive. Other limitations of this study design include its retrospective nature - it is impossible to determine how many individuals will go on to develop PFOA, and the end stage population in this report is far smaller than the population at-risk i.e. AKP is very common, and only a small proportion will actually go on to develop PFOA.

Only severe cases of arthritis were included in the analysis and so this conclusion cannot be fully generalised to consider milder forms of the disease. This does not imply that less severe disease is not associated with adolescent AKP or patellar dislocation, as it is almost certain that these patients moved gradually through the disease spectrum over their lives. The inclusion criteria that was used was easily and clearly definable, allowing for a high level of specificity with no overlap in the pathologies, which we believe is a strength of the study.

A high loss to follow up ratio is also present in this cohort. Due to these factors, as well as the potentially imprecise appreciation of a small number of

anatomical differences, larger prospective studies are required to further describe the relationships highlighted here

5. Conclusions

Based on the data presented, an association has been demonstrated between adolescent anterior knee pain, a history of patella dislocation and the development of severe patellofemoral osteoarthritis. Further work is required in the area to confirm this in larger cohorts, with a broader spectrum of disease severity and a more detailed assessment of possible confounding and aetiological factors. However, these results should bring into question the traditional belief that adolescent anterior knee pain is a benign pathology. These patients merit investigation, and we encourage clinical acknowledgement of the potential for the later development of osteoarthritis when encountering patients suffering from both adolescent AKP and patellar dislocation.

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Table 1 – Multivariate binary logistic regression – Adjusted ORs

Risk Factor	Unadjusted odds ratio (95% CIs)	Adjusted odds ratio (95% CIs)	*p* value
Previous Dislocation	8.8 (3.88-19.82)	3.2 (1.25-8.18)	0.016
Adolescent AKP	20.2 (4.69-86.91)	7.5 (1.51-36.94)	0.014
Previous Surgery	6.2 (3.34-11.67)	3.5 (1.75-7.14)	<0.001
Patient-reported instability	5.83 (3.00-11.28)	3.5 (1.62-7.42)	0.001

Fig. 1 Flow diagrams summarizing the process for selection of participants in the study group (a) and the control group (b)

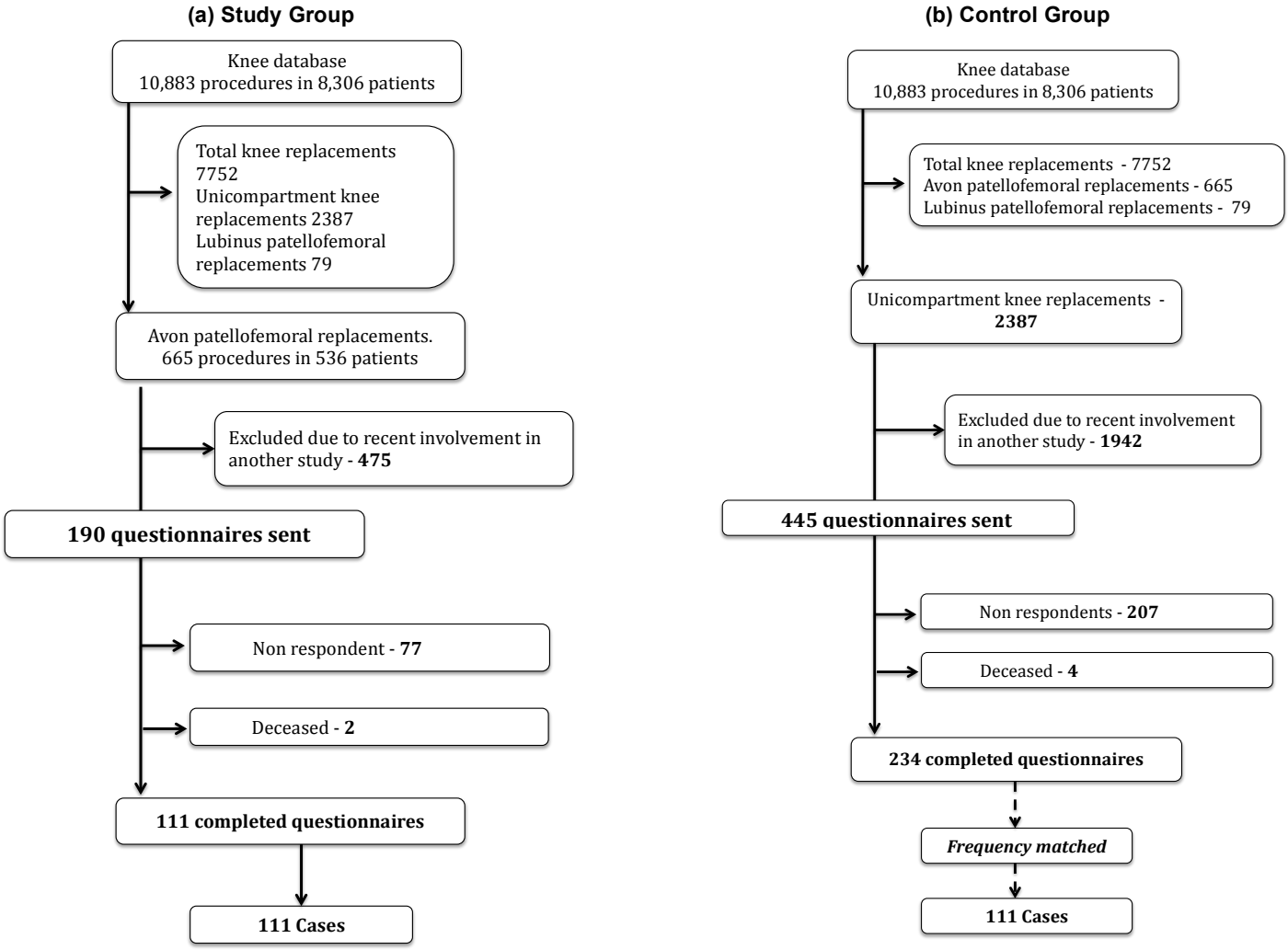
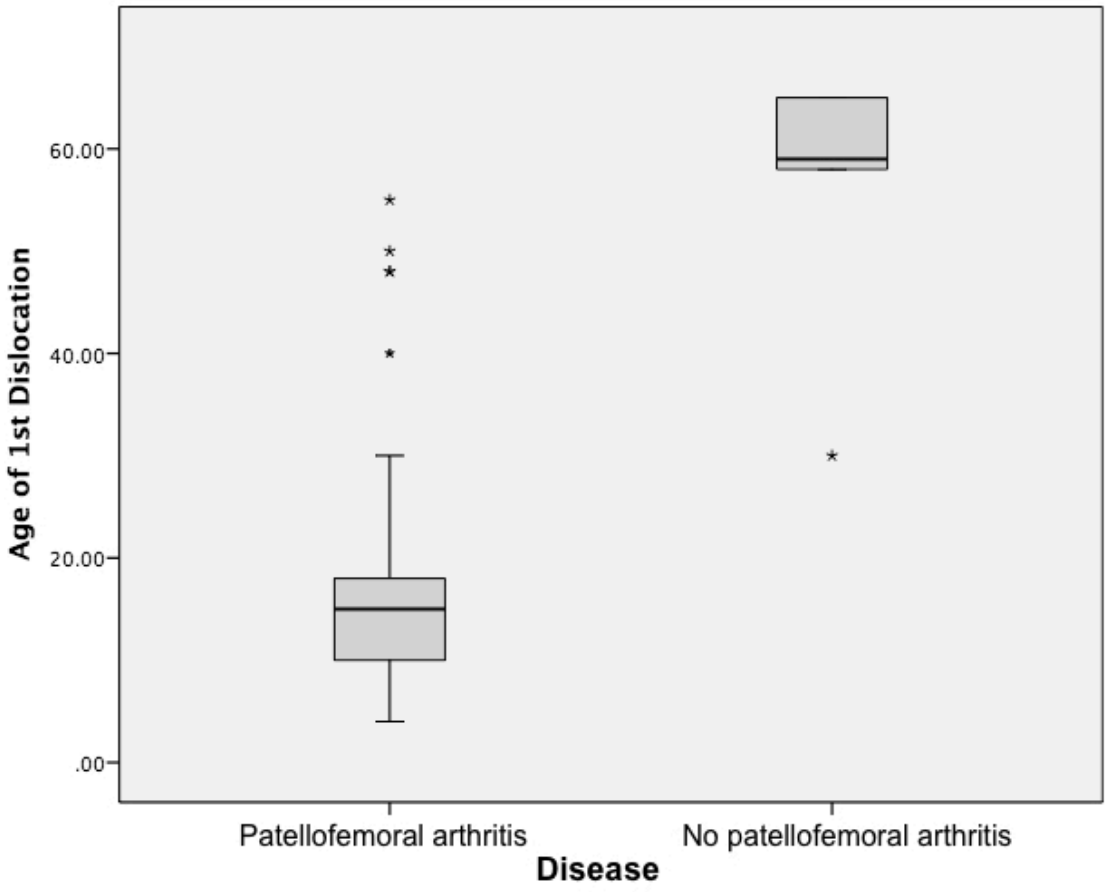


Fig. 2 Differences in age of 1st dislocation between PFOA cases and unicompartmental arthritis controls (labelled as 'No Patellofemoral Arthritis'). The box length represents the 25th to 75th percentiles, with the median denoted by the line in the box. The whiskers represent the range, and outliers are marked with an asterisk.



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