



# Risk Factors for First Time and Recurrent Patella Dislocation with Focus on Familial Association

## - A Systematic Review and Best Knowledge Synthesis of Present Literature

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### Introduction

Patella dislocation (PD) is a common knee injury, which has a substantial impact on function and quality of life. The annual incidence rate of PD has been described from seven to 77 per 100,000 person-years, and patients with prior PD have a 22.7% - 30% risk of experiencing a recurrent dislocation.

The etiology of patella dislocation (PD) is complex and to large extent unknown. A range of biomechanical as well as epidemiological risk factors to PD have been identified. Also, familial association has been suggested a risk factor to PD, but the association is not well investigated.

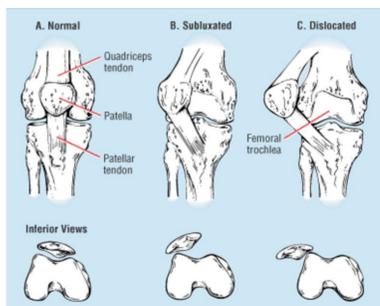


Figure 1. Normal location of patella vs subluxated and dislocated patella

### Aim

The aim of our study was to do a systematic review and best knowledge synthesis of the present literature with a special focus on familial association to identify risk factors for first time and recurrent PD.

### Methods

The study was performed as a systematic review following PRISMA guidelines. The systematic review was conducted from the Population Intervention Compared Outcome (PICO) question: *Are there certain factors associated with increased risk of first time as well as recurrent patellar dislocation and is familial association one of these?* PubMed and EMBASE were systematically searched. Studies investigating participants with risk factors for first time as well as recurrent PD were included. The records were screened, and data extracted independently by two researchers supervised by a third independent assessor. The study was registered in PROSPERO.

Methodological quality and risk of bias was assessed using the CASP checklists. In addition to emphasize high quality studies we added an additional column to the CASP checklist, rating the studies after a custom-made score high, moderate and low. Due to the various study designs included in this review we used three different CASP checklist. The CASP cohort study checklist was used for cohort studies, case reports, cross-sectional studies and incidence studies. The CASP case control study checklist was used for case control studies. The CASP diagnostic study checklist was used for diagnostic studies

### Results

A number of 5,870 records were identified and assessed as eligible studies for full text review were a total of 265 studies. Fourteen studies were included after the review of reference lists from the studies meeting the eligible criteria and the reviews previously excluded due to their study design. Eighty-seven studies were included in the review. Forty-one studies concerning genetic risk factors, 20 studies concerning epidemiological risk factors, 37 studies concerning bony risk factors and four studies concerning soft tissue risk factors.

### Genetic Risk Factors

#### Familial association

Seventeen studies describe familial association as a risk factor for PD.

Fithian et al. find that participants with a family history of PD have 3.7 higher odds of PD in the contralateral asymptomatic knee. Atkins et al. find familial association to PD in 9% of 74 participants [6]. Mäenpää et al. find that 11 participants out of 75 with familial association for PD. Also, three other studies find various numbers of participants with familial association to PD.

Thompson et al. suggest an inheritance of a recessive gene as a risk factor for PD, while others say that the cause for PD may be an autosomal dominant disorder. Eleven studies show familial association with PD in a few members across generations.

#### Syndromes

Twenty-one studies describe 13 different syndromes that may be associated for PD.

### Epidemiological Risk Factors

#### Age

Fourteen studies investigate age as a risk factor for first time and recurrent PD. The age limit varies in the studies, but in general age below 18-25 is considered a risk factor. Furthermore, the risk decreases with higher age.

#### Skeletal immaturity

Five studies investigate skeletal immaturity as a risk factor for recurrent PD, whereof four studies find an association to PD. The definition of skeletal immaturity was determined based on the status of distal femur and proximal tibia physis being open.

#### Gender

Ten studies investigate association between female gender and development of first time and recurrent PD, whereof four studies find an association between female gender and PD

#### BMI

The studies included do not specify the BMI definition well. Four studies investigate BMI being a risk factor to PD whereof two studies find BMI being a significant risk factor for PD

### Bony Risk Factors

#### Trochlear dysplasia

Measures that define trochlear dysplasia vary in the studies, e.g. Dejour classification, trochlear depth, sulcus angle, trochlear facet asymmetry and lateral trochlear inclination angle.

Ten studies find trochlear dysplasia being a risk factor for first time PD. Fourteen studies investigate trochlear dysplasia as a risk factor for recurrent PD, whereof 11 studies find trochlear dysplasia being a risk factor for PD.

#### TT-TG distance

Most studies included in this review use various threshold distances from > 14 to 20 mm to quantify increased TT-TG. Eleven studies find increased TT-TG distance as a risk factor for first time PD. Six studies find increased TT-TG distance as a risk factor for recurrent PD.

#### Patella Alta

Patella alta is most often measured using Insall-Salvati ratio (IS-ratio) and/or Caton-Deschamps index (CD-index).

Eight studies find patella alta being a risk factor for first time PD. Twelve studies investigate patella alta as a risk factor for recurrent PD, whereof eight studies find patella alta being a risk factor for recurrent PD.

#### Patellar Tilt

The threshold for patellar tilt varies between 11° and 20° in the studies included in this review. Five studies find patellar tilt as a risk factor for first time PD. The results for recurrent PD are non-significant.

#### Knee Rotational Malalignment

The definition of knee rotational malalignment varies in the studies, e.g. femoral anteversion, knee rotation, tibial torsion and genu valgum.

Two studies find that knee rotational malalignment is a significant risk factor for first time PD. Three studies find that participants with knee rotational malalignment have a higher risk of recurrent PD.

Genetic risk factors	For association <sup>1</sup>	Against association <sup>2</sup>	Incomplete analysis <sup>3</sup>	Evidence of association <sup>4</sup>
Family association	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Downs syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Rubinstein-Taybi syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Kabuki syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Prader-Willi syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Nail Patella syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Marfan syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Van Den Ende-Jong syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Obdo syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Di George syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Leri Weill syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Turner's syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Dysmorphic syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Newly recognized syndrome	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Homozygote truncating mutation	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Alpha-mannosidase deficiency	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Achondroplasia	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak

Epidemiological risk factors	For association <sup>1</sup>	Against association <sup>2</sup>	Incomplete analysis <sup>3</sup>	Evidence of association <sup>4</sup>
Age	High: 4 Moderate: 5 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Medium
Skeletal immaturity	High: 2 Moderate: 2 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Medium
Gender	High: 2 Moderate: 2 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
BMI	High: 2 Moderate: 2 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Race	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
History of PD	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Sports-related injury	High: 1 Moderate: 2 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak

Soft tissue risk factors	For association <sup>1</sup>	Against association <sup>2</sup>	Incomplete analysis <sup>3</sup>	Evidence of association <sup>4</sup>
MPFL abnormality	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Patellar tendon volume	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Type I muscle fibers	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Type 2C muscle fibers	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Joint laxity	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak

Bony risk factors	For association <sup>1</sup>	Against association <sup>2</sup>	Incomplete analysis <sup>3</sup>	Evidence of association <sup>4</sup>
Trochlear dysplasia	High: 8 Moderate: 9 Low: 1	High: 2 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Strong
TT-TG distance	High: 7 Moderate: 9 Low: 3	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Strong
Patella alta	High: 9 Moderate: 7 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Strong
Patellar tilt	High: 3 Moderate: 2 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Medium
Knee rotational malalignment	High: 2 Moderate: 3 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Medium
TT torsion	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Patella dysplasia	High: 2 Moderate: 2 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Lateral patella displacement	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Lateral patofemoral angle	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Lateral condyl index	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Patella trochlea index	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
The distance from vastus medialis	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Patellar volume	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Congruence angle	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
PT/P ratio	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Q-angle	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Spontaneous reduction of the patella	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Trochlear medialization	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak
Tuberosity lateralization	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	High: 1 Moderate: 1 Low: 1	Weak

### Summary Tables.

The four tables shows risk factors for patella dislocation listed in strongest consensus according to this review.

<sup>1</sup> For association: Number of studies, rated high, medium or low in methodological quality according to CASP, which found a significant association between risk factor and PD  
<sup>2</sup> Against association: Number of studies, rated high, medium or low in methodological quality according to CASP, which found a non-significant association between risk factor and PD  
<sup>3</sup> Incomplete analysis: Number of studies, rated high, medium or low in methodological quality according to CASP, which did not include any statistical analysis.  
<sup>4</sup> Custom-made score, rating the evidence of association strong, medium or weak. Rating was according to number of studies investigating the respective risk factor as well as numbers of studies for association given in percent. Also, it has been taken in account for, whether the studies rated high, medium, low in methodological quality according to the Critical Appraisal Skills Programme (CASP) checklists.

### Soft Tissue Risk Factors

Two studies investigate abnormalities in soft tissue stabilizers as risk factors for first time PD. One study find that a longer MPFL and a thinner ligament thickness at patellar insertion are significant risk factors for first time PD. Another study investigate the association between first time PD and patellar tendon volume and find no significant relation. Two studies investigate soft tissue stabilizers as risk factors for recurrent PD. One study investigate muscle fibers and find that an increased number of type 2c muscle fibers and decreased number of type 1 muscle fibers are associated with recurrent PD. Another study find joint laxity in relation to recurrent PD.

### Discussion

#### Genetic Risk Factors

Current studies investigating familial association as a risk factor for PD seem to agree that there is a familial accumulation of PD, but the studies only investigate small populations, and the associations are not further elaborated. Most studies regarding familial association are case reports presenting small populations of a few family members across generations. Due to the small populations, it is possible that the association is an incidental finding. Furthermore, the underlying genetics are not consistent.

Thirteen different syndromes are possibly associated to PD. Most studies do not investigate the syndrome as a risk factor for PD. Rather, they investigate a certain syndrome, and find that the participants, among many other malformations, suffer from PD.

#### Epidemiological Risk Factors

Most studies agree that there is an accumulation of PD in young participants and that skeletal immaturity is a risk factor for recurrent PD. Skeletal immaturity is a comparable factor for age, being a biological age of the participant. The evidence concerning female gender as a risk factor for PD is contradictive as some studies find an association and others do not.

#### Bony Risk Factors

Most studies agree that trochlear dysplasia is the main risk factor for PD. Despite varying parameters used to quantify trochlear dysplasia in the studies, there is a strong consensus that trochlear dysplasia is the main risk factor for PD. Also increased TT-TG distance, patella alta and patellar tilt are important and significant risk factor for PD.

### Soft Tissue Risk Factors

It appears that there is a connection between abnormalities in soft tissue stabilizers, especially MPFL and PD. Four studies investigate the association between abnormalities in soft tissue stabilizers as risk factor to PD. Most studies regarding abnormalities in soft tissue stabilizers are of moderate methodological quality

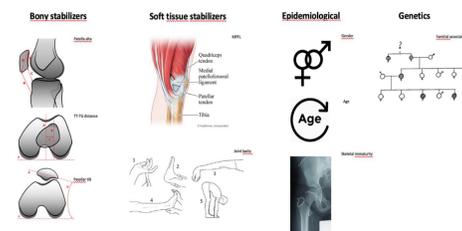


Figure 2. Some of the risk factors associated to PD.

### Conclusion

Current studies investigating familial association as a risk factor for PD agree that there is a familial accumulation of PD, but further studies are needed to investigation of the strength and the cause of the association. Also, a range of syndromes seem associated to PD. There is a consensus that young age and skeletal immaturity increases the risk of recurrent PD. The role of gender is contradictive. There is a strong consensus that abnormality of bony stabilizers are risk factors to PD. Trochlear dysplasia, increased TT-TG distance and patella alta are strongly associated with PD.