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Current Concepts Review

Specific considerations in female patients with patellar instability: current concepts



Francisco Figueroa^{a,b,*}, Rodrigo Guiloff^{a,b}, Sarah Bolton^{c,d}, David Figueroa^a, Sachin Tapasvi^e, Esteban Stocker^a

^a Clinica Alemana-Universidad del Desarrollo, 7650568, Chile

^b Hospital Sotero del Río, 8207257, Chile

^c Fortius Clinic, WIH 6EQ, UK

^d Chelsea & Westminster Hospital, SW10 9NH, UK

^e The Orthopaedic Specialty Clinic, Pune, 411004, India

ABSTRACT

Prior literature suggests that patellofemoral instability (PFI) is significantly more prevalent in women than in men. This higher prevalence is commonly attributed to anatomical differences between sexes, particularly with patellofemoral alignment. These differences encompass a higher rate of trochlear dysplasia (TD), patella alta, an increased Q angle, and soft tissue imbalances. In recent years, worse outcomes have been reported in female patients after patellofemoral stabilization surgery using medial patellofemoral ligament reconstruction (MPFLr) alone or in combination with a tibial tubercle osteotomy (TTO), for this reason an “à la carte” plan (addressing the individuals anatomical risk factors) could be more appropriate for female patients.

Current Concepts

- The high prevalence of patellofemoral instability in women is commonly attributed to anatomical differences between sexes, particularly with patellofemoral alignment. These differences include higher incidence of trochlear dysplasia, patella alta, an increased Q angle, and soft tissue imbalances.
- Ligamentous laxity is often considered a nonmodifiable anatomical risk factor; however, it has been demonstrated that having less lean muscle mass throughout the lower body is associated with greater laxity. This finding suggests that strength training may have the ability to aid in controlling laxity, which can contribute to dynamic joint stability during physical activity.
- Previous studies have demonstrated that female patients have a greater risk of any postoperative complications, higher risk of recurrent dislocation or instability; and worse postoperative outcome scores after a medial patellofemoral ligament reconstruction.
- Isolated medial patellofemoral ligament reconstruction or, in combination with a tibial tubercle osteotomy, may be appropriate in most patients with patellofemoral instability. However, more reconstruction procedures (coronal or rotational osteotomies, and trochleoplasty) may be indicated in patients with additional risk factors. This individualized approach may improve clinical results in female patients.

* Corresponding author. Vitacura 5951, Santiago, 7650568, Chile.

E-mail addresses: franciscofigueroab@gmail.com (F. Figueroa), rguiloff@gmail.com (R. Guiloff), sarah.bolton@doctors.org.uk (S. Bolton), dfigueroa@gmail.com (D. Figueroa), stapasvi@gmail.com (S. Tapasvi), estebanstocker9@gmail.com (E. Stocker).

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Future Perspectives

Several authors have proposed that the reason for the gender disparity between results in patellofemoral stabilization surgery is the presence of greater anatomical risk factors in female patients, and therefore surgery to only address one anatomical variant would be less effective. For this reason, it could be theorized the threshold for performing surgery that adequately corrects the majority of the anatomical risk factors for recurrent patellar dislocations may be lower in female than in male patients. This must be adequately proven in the literature with studies assessing gender disaggregated data and comparing the results of standardized surgeries with “à la carte” bespoke surgery, taking into consideration the individual's risk factors.

INTRODUCTION

Patellofemoral instability (PFI) is a common injury of the knee, with lateral patellar dislocations accounting for 2%–3% of all knee injuries [1]. Affected patients may sustain patellar subluxations, dislocations, subjective feelings of patellar instability, or some combination thereof. The population predominantly affected is young patients, with the vast majority of PFI events occurring during the second decade of life [2–4]. PFI is associated with persistent pain and disability, chondral and osteochondral shear injuries, and long-term degenerative joint disease [5].

Prior literature suggests that PFI is significantly more prevalent in women than in men [3,5] with the highest risk population being females between the ages of 10–17 years old [3]. An analysis of active-duty military personnel by Hsiao et al. [6] revealed higher rates of patellar dislocation in female service members. Similarly, Mitchell et al. [7] found that in sex-comparable sports, women were at higher risk of PFI. In a descriptive study of a surgical PFI population of 492 patients [5], 70.5% of them were female patients.

Contrarily, when the first episode of patellar dislocation occurred, Ling et al. [8] showed that female sex is not a factor for further dislocations. However, besides this, the rate of surgical management for patellar instability is higher in female patients [9].

To better understand outcomes following treatment of PFI, there has been a continued interest in the differences between male patients and female patients. However, there is a paucity of information on the impact of patient sex on outcomes after treatment for PFI.

The objective of this narrative review is to summarize the published literature regarding sex differences in the treatment process of PFI and to establish one author's recommendation on specific considerations when treating female patients with PFI.

ANATOMY

The high prevalence of PFI in women is commonly attributed to anatomical differences between sexes, particularly in patellofemoral alignment. These differences encompass a trochlear dysplasia (TD), patella alta, an increased Q angle, and soft tissue imbalances. Nevertheless, there is a lack of comprehensive literature on precise anatomical gender comparisons, and thus, sex-related differences remain poorly understood [10].

Trochlear dysplasia

TD is acknowledged as the major anatomical factor contributing to patellar dislocation [11,12]. Dejour et al. found TD to be present in 96% of patients with true patellar dislocations [13]. Even though their study predominantly comprised female patients (75%), gender disaggregated data were not provided. TD is primarily diagnosed based on radiological findings, which indicate a smaller and shallower trochlea, increasing the predisposition to patellar dislocation. Notably, in patients with a history of previous dislocation, a higher prevalence of TD has been observed in females compared to males [14].

Nevertheless, in the normal population (individuals without prior dislocations), the female trochlea has been found to be significantly

smaller than males [15,16] and wider (approximately 8%), even after adjusting for measurement ratios [16]. Gender differences are also apparent in trochlear depth, assessed by the sulcus angle, with females having a significantly shallower trochlea [16,17]. These gender differences may be crucial when considering sex-specific parameters for establishing normal values when assessing risk factors for PFI and determining intraoperative parameters.

In this context, Tanaka et al. recently endeavored to establish optimal cutoff values for each measurement associated with TD using magnetic resonance imaging (MRI), by comparing asymptomatic and symptomatic patients for PFI (those with more than one documented episode of a patellar dislocation) [14]. They found gender-related differences in all trochlear measurements and cutoff values, except for cartilaginous trochlear depth. In a recent study, a new parameter for TD, named “trochlear extension length”, has been introduced, which also displayed gender-related differences, measuring 10.6 mm and 12.6 mm for females and males, respectively [18].

Patella alta

A more proximally based position of the patella relative to the femur results in a delay in patellar engagement within the trochlear groove during the initial flexion phase. Consequently, this increases the range of motion the patella during which the patella tracks without bony restraints. This scenario can result in lateral dislocation due to the prevailing dominance of lateral musculature forces over medial ones [11]. Dejour et al. have identified patella alta as the second major independent risk factor for PFI, with a presence in 24% of patients with a confirmed patellar dislocation [13]. Other authors have corroborated these findings [11,12,18]. However, once again, gender disaggregated data were not provided.

There is a scarce and conflicting body of literature concerning gender-related differences in patellar height. Cadaveric morphometric analyses have revealed a higher tendon length-to-patellar length ratio in females compared to males [19–21]. However, in a study involving 1423 patients (1071 females and 352 males) using MRI comparison, Hong et al. found that although the Insall-Salvati (IS) ratio was significantly higher in females than in males, no difference in patellar alta and baja was observed between genders based on two standard deviations and extreme 2.5% value methods [22]. Furthermore, in a recent three-dimensional assessment of patellofemoral anatomy, women were found to have an even lower IS ratio than men [23]. The same lack of agreement is found when different measurements, such as the Caton-Deschamps, Blumensaat's line, and Blackburn Peel, are employed [24–27].

These common radiological indexes have been questioned as they are indirect methods for assessing patellar height (relating the patella to the tibia) [12], and variations in knee positioning, quadriceps contraction, and imaging modality can influence their measurements [11]. Direct measurements have emerged to assess functional patello-trochlear engagement [28,29]. Within the limited available evidence, regarding gender differences, Grim et al. compared the MRIs from 23 males and 12 females, all first-time patellar dislocators, and found no statistical differences based on sex [27].

The literature predominantly does not show gender-related differences in patellar height. However, consensus is lacking, as evidence is limited, and patellar height appears to depend on the assessment measurement and modality.

Increased Q angle

An elevated quadriceps, or Q angle (the lateral vector of the extensor mechanism acting on the patella), is another extensively studied anatomical risk factor for PFI [11]. The Q angle exhibits a wide range of values, typically varying from 8 to 20° [30]. Nonetheless, research consistently agrees that females have a greater Q angle than males [30–35], which is even higher in symptomatic PFI patients [36]. Although gender differences in Q angle values are well-established, the causes of these are less understood [34,37]. Some authors have proposed that women's wider pelvis provides a more laterally positioned proximal reference point than men's [38–41]. However, this hypothesis has been challenged as anatomical and trigonometric studies have shown that mediolateral translations of the anterior superior iliac spine has a minimal effect on the Q angle [31,42,43]. Therefore, these gender disparities most likely arise from more distal anatomical structures, such as the center of the patella and the tibial tuberosity (TT).

These distal anatomical structures represent the Q angle primarily as the tibial tuberosity-trochlear groove (TT-TG) distance [11–13]. In fact, radiological studies have found that women possess a higher TT-TG [23] and a more laterally situated TT compared to men [37,44], which helps explain the gender disparity in this predisposing factor for PFI. This lateral placement of the TT may be related to other established modifiers of the Q angle (by altering the TT-TG), such as tibial rotation and valgus knee coronal alignment [11,37,45]. Additionally, femoral rotation can also predispose to an increased Q angle; greater femoral anteversion results in internal rotation of the distal femoral epiphyses, increasing the lateral vector and thus elevating the risk of patellar dislocation [11]. Females have been found to exhibit greater valgus alignment and femoral anteversion compared to men [46–50], although not necessarily higher external tibial torsion [49,50].

Considering that asymptomatic and symptomatic females possess proven anatomical differences, predisposing them to a higher TT-TG, one might expect a sex-related threshold for this parameter to exist. Nonetheless, there is controversy regarding this specific difference in TT-TG, as some studies have not found statistical differences between genders [51,52]. Therefore, it is advisable to conduct a more comprehensive analysis of individual factors influencing the Q angle (such as tibial/femoral torsion and valgus alignment) rather than relying solely on the TT-TG when making surgical decisions.

Soft tissue laxity and muscle imbalance

Hyperlaxity is commonly considered a risk factor for recurrent lateral patellar dislocation [12]. Generalized joint laxity has been found to occur in two-thirds of individuals with true patellar dislocations [53], and women tend to exhibit greater joint laxity than men [54]. In a recent systematic review, increased joint laxity was found to be statistically significantly associated with patellar dislocation [55]. Even though knee laxity is often considered a nonmodifiable anatomical risk factor, Shultz et al. has demonstrated that having lower muscle mass in the lower extremity is associated with greater laxity and less stiffness in the frontal and transverse planes of the lower extremity. This finding suggests that strength training interventions may modify laxity and stiffness, which can contribute to dynamic joint stability during physical activity [54]. However, this statement should be taken with caution since in patients with extreme ligament laxity (for example Ehlers-Danlos syndrome) this principle (greater muscle mass produces less laxity) may not necessarily be applicable, and the muscle deficiency could be due to the laxity itself.

One of the key dynamic stabilizers of the patella is the vastus medialis obliquus (VMO) [11], which has been found to be insufficient, being

hypoplastic or even missing its oblique portion in patients with PFI [56, 57]. Neuromuscular imbalance of the VMO in relation to the vastus lateralis (VL) muscle has also been found to contribute to PFI, leading to patellar maltracking within the femoral trochlea [58]. Consequently, gender differences in VMO and VL activity have been considered a potential factor contributing to the higher prevalence of PFI in females [59]. Nevertheless, no consensus exists regarding sex-related differences in VMO and VL activation. Some studies have found a higher VMO/VL ratio in males compared to females in both isometric and weight-bearing exercises [60,61], while others have found no statistically significant gender-based differences in the activation of the VMO/VL ratio during both weight-bearing and non-weight-bearing activities [59,62,63]. These conflicting findings have been attributed to limitations in sample size and subject profile (including morbidity and activity levels), and variations in the exercises used for assessment [59].

SURGICAL TREATMENTS

Medial patellofemoral ligament reconstruction (Table 1)

Since its introduction, medial patellofemoral ligament (MPFL) reconstruction (MPFLr) has become one of the most common treatments of patellar instability. One study [64] found that MPFLr constituted 75% of all patella-stabilizing surgical procedures within the Danish health care system in 2014. Previous studies [64–66] have demonstrated that female patients have a greater risk of any postoperative complications (5.45 times higher than male patients); female patients also have higher 1-, 5-, and 8-year risk of recurrent dislocation or instability and worse postoperative outcome scores after a MPFLr.

To date, most of the recent literature focusing on sex-specific outcomes after MPFLr [67–71] for patellar instability has found no statistically significant differences when comparing postoperative functional outcome scores between male and female patients. However, Howells et al. [66] found statistically significant differences between males and females when an atraumatic patellar instability event was present. It is highly probable that for patients in this atraumatic injury group, anatomy was the primary cause of their instability. This would then support the idea that anatomic differences, and thus patient sex, plays an important role in the patients' response to MPFLr and ultimately the functional outcome scores used to measure that response. This contrasts with the traumatic group, in which it is less likely that anatomic differences contributed to the initial injury and patient response to MPFLr. Hiemstra et al. [72], in a study evaluating the effect of trochlear dysplasia on outcomes after isolated soft tissue stabilization for PFI, noted a higher proportion of females in the weak, atraumatic, risk anatomy, pain, and subluxation (WARPS) instability subtype, which carries more risk, including ligamentous laxity and rotational abnormalities that are less amenable of resolving with an isolated MPFLr.

During the last year, new studies are starting to highlight the differences in outcomes between males and females after a MPFLr. A 10-year follow-up cohort study by Shatrov et al. [73] showed that after isolated MPFLr only female patients experienced recurrent dislocations. Furthermore, patients with an unsatisfactory outcome were more likely to be female; however, this was not statistically significant. Ryan et al. [74] showed that male patients exhibited significantly lower rates of revision surgery for knee stiffness within 1 and 2 years after the index operation when compared with female patients.

Abed et al. [75] in a study evaluating prolonged opioid use after MPFLr found that female sex had a statistically significant association with prolonged opioid use following MPFLr regardless of opioid familiarity (being familiar to opioids before the surgery). Most importantly, in a previous study, Khazi et al. [76] demonstrated that opioid use at 6 weeks after patellofemoral stabilization surgery was associated with worse Knee Injury and Osteoarthritis Outcome Score (KOOS) at 6 months and 2 years postoperatively.

Table 1
Studies evaluating outcomes after medial patellofemoral reconstruction.

Lead author (Year)	Level of evidence	Population (number of female patients)	Outcome summary
Howells (2012)	IV (Prospective analysis)	193 Total 109 Females (56.4%)	<ul style="list-style-type: none"> - Women had significantly worse clinical outcomes scores than men. - Women reported significantly worse subjective responses regarding rates of improvement, willingness to repeat if the situation arose, likelihood of recommending the procedure to friends, rates of recurrent symptoms, presence of residual symptoms and decreased rates of sports resumption. - Female patients with atraumatic recurrent dislocation had worse outcomes.
Hopper (2014)	IV (Case series)	68 Total 50 Female (73.5%)	<ul style="list-style-type: none"> - No significant differences were found between male and female patients.
Hiemstra (2019)	III (Cohort study)	298 Total 225 Females (75.5%)	<ul style="list-style-type: none"> - There were 11 redislocations in the cohort, all in female patients. - Women were more frequently in the WARPS (weak, atraumatic, risky anatomy, pain, and subluxation) group. - The WARPS group was associated to worse postoperative outcomes.
Neri (2019)	IV (Case series)	112 Total 59 Females (52.6%)	<ul style="list-style-type: none"> - Sex did not significantly influence the evolution of functional scores (Kujala, IKDC).
Bouras (2019)	II (Cohort study)	56 Total 35 Female (62.5%)	<ul style="list-style-type: none"> - Female patients had lower scores at baseline and follow-up, but gender did not impact the total improvement from baseline.
Ryan (2023)	III (Retrospective, comparative prognostic trial)	4095 Total 2798 Females (68.3%)	<ul style="list-style-type: none"> - Male patients were significantly less likely to require procedures to correct knee stiffness at both 1 year and 2 years postoperatively.
Abed (2023)	III (Retrospective cohort study)	23,249 Total 15,763 Females (67.8%)	<ul style="list-style-type: none"> - Female sex was found to have statistically significant association with prolonged opioid use following MPFLr.
Shatrov (2023)	IV (Case series)	54 Total 37 Female (68.5%)	<ul style="list-style-type: none"> - All patients experiencing recurrence were female patients. - Patients with an unsatisfactory outcome were more likely to be female (statistically not significant).

IKDC: International Knee Documentation Committee; MPFLr: Medial Patellofemoral Ligament Reconstruction.

Tibial tubercle osteotomy (Table 2)

Tibial tubercle osteotomy (TTO) is a well-described technique to treat a range of patellofemoral disorders, including patellofemoral instability. In general, a TTO is considered in patients with an excessive lateral position of the tibial tubercle (measured by TT-TG >20 mm) or patellar height abnormality (Caton-Deschamps index >1.2) [77]. Evidence regarding TTO in female patients is scarce and controversial.

Bloom et al. [78] in a study evaluating sex-based differences in outcomes of tibial tubercle anteromedialization (AMZ), where 60% of the surgeries were performed to treat PFI showed that female patients undergoing an AMZ TTO not only had good patient reported outcomes, but more importantly, their patient-reported outcomes and postoperative reduction in activity levels were not significantly different from that of males despite the physiologic differences that are believed to exacerbate patellofemoral pathologies among females.

Contrarily, in a cohort of 116 patients, where more than 65% had a TTO as part of a PFI treatment, Žlak et al. [79] found that the postoperative Tegner Activity Scale was inferior in female patients. The same finding was supported by Allen et al. [80] who found that female was associated with worse International Knee Documentation Committee (IKDC) and Kujala scores in a cohort of patients that received MPFLr and a TTO for recurrent lateral patellar instability. They theorized that this result could be caused by the presence of more patients with high-grade dysplasia in the female group. Similarly, Su et al. [81] in a study of MPFLr combined with lateral release and TTO showed that female gender was a risk factor for lower IKDC, Tegner, and Kujala scores.

Other treatments

Whereas isolated MPFLr or MPFLr combined with a TTO may be appropriate in most patients with PFI, more complex reconstruction procedures may be indicated in patients with additional risk factors. In a study evaluating combined MPFLr and bony corrections such as coronal realignment (distal femoral and high tibial) osteotomies and trochleoplasty for complex PFI cases, Lutz et al. [82] showed that one third of the female patients experienced restrictions on sexual activities due to problems associated with chronic PFI preoperatively. However, improved sexual activity was observed in 60% of the patients postoperatively after undergoing these combined invasive procedures.

Similarly, Mengis et al. [83] in a study evaluating deepening trochleoplasty with concomitant patellar-stabilizing procedures found that patients undergoing these procedures can expect good clinical results and a high rate of return to sports participation, with two-thirds of the patients returning to their preoperative Tegner-level of activity or higher and most importantly, without gender differences.

AUTHOR’S APPROACH

In recent years, there has been more literature highlighting worse outcomes in female patients after patellofemoral stabilization surgery using MPFLr alone or in combination with a TTO. Although the evidence is scarce, several authors theorize that the reason for these worse results is the presence of greater anatomical risk factors in female patients [66, 74,80], and therefore simpler surgeries would be subject to greater stress.

Table 2
Studies evaluating outcomes after tibial tubercle osteotomy.

Lead author (Year)	Level of Evidence	Population (number of female patients)	Outcome summary
Allen (2018)	IV (Therapeutic case series)	28 Total 14 Females (50%)	- Female gender was associated with worse outcomes (IKDC, Kujala, Tegner).
Zlak (2021)	III (Retrospective cohort study)	138 Total 97 Females (70.2%)	- Female gender is specifically associated with a lower postoperatively Tegner activity scale.
Su (2021)	IV (Case series)	108 Total 78 Females (72%)	- Female gender as risk factor had a negative impact for IKDC, Tegner and Kujala scores.
Bloom (2022)	III (Retrospective cohort study)	109 Total 79 Females (72.5%)	- No statistically significant differences between sexes in concomitant procedures, pain scores, or patient-reported outcome scores. - No significant difference in outcomes between sexes for TT AMZ overall.

AMZ: Anteromedialization; IKDC: International Knee Documentation Committee; TT: Tibial Tubercle.

This is why in our practice we recommend, when treating any patient with PFI a thorough examination be performed including: limb torsion, coronal axis, measurement of lateralization of the TT and patellar height, and trochlear dysplasia evaluation, in order to offer to these patients the most appropriate surgery, the so-called “à la carte” surgery [11,13].

Ensuring optimization of muscular conditioning is essential prior to surgery, especially for female patients who are more likely to have less muscle mass. Once optimized, we believe that in female patients, the threshold for performing surgery that aims to adequately correct the risk factors for recurrent patellar dislocations should be lower than in their male counterparts. This is in order to avoid poor results that have been seen in some recent series using more minimal surgeries and overlooking anatomical factors that seem to be more frequent in women.

Contrarily, in cases of a first episode of patellar dislocation, as evidence suggests that female sex is not a factor for recurrent dislocation [8], we advocate for a conservative treatment (except in cases where an osteochondral lesion that needs fixation or removal is present) focused on lower body strength and conditioning to improve lower body muscle mass as female patients are more likely to have more generalized joint laxity. However, there are authors [84] that recommend stratifying patients after a first episode of patellar dislocation and those who have a higher risk of recurrent dislocation (contact sports, very young, large anatomical abnormalities) to undergo surgical management.

Lastly, but not less important, currently, gender disaggregated data is not readily available, and there is no clear evidence as to why female patients have recurrent dislocations or symptoms of PFI after MPFLr or why they are less likely to be satisfied after surgery. It makes logical sense that the anatomy is where the answer lies and therefore it is essential to understand and be aware of variants in anatomy especially for female patients who are more likely to have variants outside of normal values. Satisfaction postsurgery is a complex and multifactorial issue; we have tried to address variants in anatomy, but gender-related literature on psychology, prehabilitation, and rehabilitation postoperatively is still scarce or nonexistent, and further review of these areas could give us a better explanation of the different outcomes in female patients after PFI surgery.

CONCLUSION

PFI is significantly more prevalent in women than in men. There are anatomical differences between males and females that must be considered both when treating conservatively and surgically. In recent years there has been more published data reporting worse outcomes in female patients after patellofemoral stabilization surgery using MPFLr alone or in combination with a TTO.

Assessing the individual’s anatomical risk factors and a treatment-based “à la carte” system that addresses all anatomical risk factors seems logical however, we need more long-term studies with gender disaggregated data to truly understand why females have a worse outcome after surgery.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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