

# Characteristics of Patients With Primary Acute Lateral Patellar Dislocation and Their Recovery Within the First 6 Months of Injury

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## ABSTRACT

We prospectively studied the characteristics and early recovery of an unselected population of patients who had acute first-time lateral patellar dislocation. The recovery program used standardized rehabilitation, emphasizing range of motion, muscle strength, and return of function. Patients returned to stressful activities including sports as tolerated when they regained full passive range of motion, had no effusion, and when quadriceps muscle strength was at least 80% compared with the noninjured limb. Seventy-four patients met the enrollment criteria; 37 men and 37 women. The average age was 19.9 years, and preinjury sports participation was similar to that of ligament-injury patients. Four percent of patients ( $N = 3$ ) had a history of birth complications, 3% ( $N = 2$ ) had a history of lower extremity problems as an infant or child, and 9% ( $N = 7$ ) had a family history of patellar dislocation. Radiographs revealed a 50% incidence ( $N = 37$ ) of patella alta; all patients demonstrated lateral patellar overhang. Patients regained range of motion (mean,  $0^\circ$  to  $132^\circ$ ) by 6 weeks. Sports participation remained significantly reduced throughout the first 6 months after injury, with the greatest limitations in kneeling and squatting. At 6 months, 58% of patients ( $N = 43$ ) noted limitation in strenuous activities. The patients who had acute primary patellar dislocation were young and active. Most injuries occurred during

sports, and few patients had abnormal physical features, contradicting any stereotype of an overweight, sedentary, adolescent girl whose patella dislocates with little or no trauma.

Recurrent anterior knee pain and giving way can result in significant disability in patients who have suffered a patellar dislocation. Hawkins et al.,<sup>11</sup> Cofield and Bryan<sup>5</sup> and others<sup>16</sup> have reported that sequelae of patellar dislocation affect up to one-half of patients after injury. Cofield and Bryan reported a high degree of functional impairment even among patients who reported no recurrent instability and noted that results were less satisfactory if they took into account reductions in activity level. Cash and Hughston<sup>4</sup> reported that evidence of dysplasia in the contralateral knee increased the likelihood of recurrent problems after the initial dislocation, whereas Larsen and Lauridsen<sup>16</sup> did not find dysplastic factors to be prognostic of recurrence and concluded that dysplastic factors could not be used to predict who would develop late patellar instability symptoms.

Because of design limitations in these studies it is difficult to reconcile the different and often conflicting findings so that clear recommendations can be made for the physician evaluating and counseling the patient with a first-time patellar dislocation. Despite troubling evidence that many of these patients are prone to reinjury and late disability, the population at risk for poor outcomes is not yet clearly defined, nor is it apparent that surgical procedures to improve alignment or restore stability can reliably improve patients' outcomes.<sup>1,6</sup> As a matter of general practice, most orthopaedic surgeons treat the first injury conservatively unless there is an obvious osteochondral fracture with a loose intraarticular fragment.

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A definitive study of the epidemiologic factors and natural history of patellar dislocation would require prospective patient entry; identification of associated injuries, pertinent historical data, and physical features that may affect predisposition for the injury or risk of poor outcome; and follow-up of patients for at least 5 years after injury. Such a study has not been done. Most of the literature on patellar dislocation is retrospective, and patients with prior dislocation or subluxation are frequently not excluded from the study samples. If it is true that up to half of patients who have had at least one patellar dislocation experience impairment as a result of the injury,<sup>5</sup> then patients who experience a second dislocation are not likely to have been as active before their second dislocation as they were at the time of their initial injury. Furthermore, one would expect that the injury activity would be less likely to be a sporting event than if the patient had no history of patellar dislocation. If partial disability or impairment before the original injury is not taken into account, the second injury may appear less disabling than is actually the case because the "preinjury" activity is artificially low. Finally, if certain subgroups of patients, such as teenage girls, are more likely to redislocate their patellas, failure to exclude patients with prior dislocations will result in overrepresentation of these subgroups within the sample being studied, leading to incorrect conclusions about the nature of the population at risk, mechanisms of injury, and outcomes.

We undertook a study to determine the characteristics of patients at risk for primary patellar dislocation, the course of early recovery, and the risk of late disability and recurrence. Of primary interest to us was the effect of the injury itself: How does patellar dislocation in a previously asymptomatic individual affect his or her subsequent function? We asked the following questions: 1) Who is at risk for primary patellar dislocation? 2) What are the mechanisms of injury and what are the injury activities? 3) How soon do patients recover function and to what degree? 4) What factors affect early recovery after the initial injury? This paper presents the initial findings of an ongoing prospective study that was designed to assess the factors associated with first-time unilateral patellar dislocation in previously asymptomatic persons in an unselected population. Data on early recovery of strength, range of motion, and function are presented.

## MATERIALS AND METHODS

The Kaiser Permanente health care facilities in San Diego, California, serve the Kaiser Foundation Health Plan members in the greater San Diego area. This population represents a segment of the local population that is selected by choice of health plan only. Because of the nature of the health plan, members receive virtually all their care at San Diego Kaiser facilities. During the study period of January 1992 through December 1994, the Kaiser Health Plan enrollment averaged 367,335 members each year. Data were available for patient age and sex. Patients who came to Kaiser Permanente emergency rooms and primary care offices with a knee injury were referred to the

Knee Injury Clinic of the Department of Orthopedics if they had at least one of the following: 1) effusion, 2) pathologic joint motion, or 3) clinically significant disability. Approximately 1000 patients were evaluated each year in the Knee Injury Clinic. A preliminary review performed in 1990 showed that an average of 44 patients per year were diagnosed with patellar dislocation, including both first-time (primary) and recurrent dislocations. Primary dislocations represented one-half of all dislocations seen at the clinic, averaging about 22 patients per year.

In January 1992 we began prospectively monitoring patients after acute primary patellar dislocation. The diagnosis required either a dislocated patella requiring reduction in the emergency department (2 patients) or a convincing history of dislocation associated with full giving way and all of the following physical findings: 1) hemiarthrosis or effusion, 2) tenderness along the medial retinaculum, and 3) apprehension with lateral patellar displacement. Patients were included in the study only if there was no history of patellar subluxation or dislocation and if they were seen within 4 weeks of the initial injury. We also excluded patients who had a history of knee symptoms resulting in greater than 8 weeks of functional impairment or a history of knee fracture, knee surgery, or ligament instability. Seventy-four patients who satisfied these criteria were evaluated and followed up at 6, 12, and 24 weeks.

We attempted to define the relationship between acute patellar dislocation and other abnormalities of the lower extremity that are associated with familial or dysplastic risk factors. All patients completed an initial questionnaire on which they were to list siblings and their ages and describe any family history of knee problems, with age of onset. Also to be listed on the questionnaire were the patient's history of birth complications related to the lower extremity, such as breech presentation, and history of knee, leg, or hip problems as an infant or child. The forms noted the date and mechanism of injury. Patients were asked to describe their preinjury level of sports participation, noting individual sports and the actual time spent participating in each sport on a weekly basis during the year before injury.

The data sheet for recording physical findings is shown in Appendix 1. Initial physical measurements are shown in standard text and were recorded only once during the study. These parameters included limb alignment, measured from behind the standing patient, quadriceps angle at 30° of knee flexion with the patient supine and the patella centered in the femoral trochlea,<sup>8</sup> hip rotation measurements and foot-thigh angle, measured by the method of Staheli et al.<sup>23</sup> Generalized ligament laxity was assessed as passive thumb-to-forearm distance.<sup>17</sup> Items in the appendix that are displayed in capitalized, bold text were repeated at each visit. Active patellar tracking was graded as follows: 0, smooth entry into the groove; 1, slight comma sign; 2, a marked but smooth comma sign; 3, abrupt dislocation/relocation of the patella in beginning flexion.

Data were collected at 6, 12, and 24 weeks to assess early functional recovery after patellar dislocation. Pa-

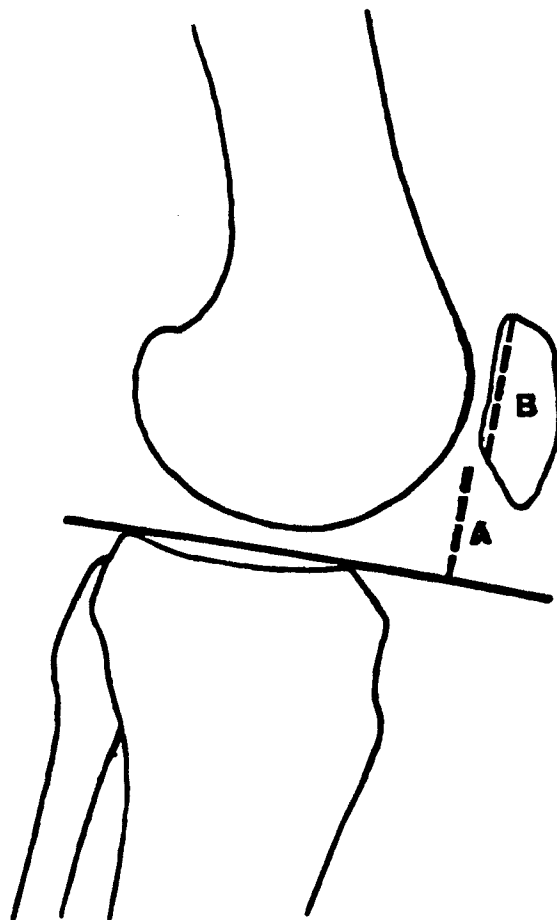
tients were asked to rate their level of difficulty in walking, climbing stairs, kneeling, lateral motion, jumping, and cutting. Patients further rated their functional limitations and pain and swelling with various levels of activity. They also noted their postinjury sports participation and use of a brace. Physical examination included grading of crepitus, effusion, compression, facet or retinacular tenderness, apprehension, and patellar tracking (Appendix 1). Strength and function testing (single-legged hop-for-distance and Cybex isokinetic quadriceps and hamstring testing [Cybex II dynamometer, Lumex Inc., Ronkonkoma, New York]) were performed at 12 and 24 weeks.

Radiographs were performed at the initial visit and included weightbearing AP, Merchant, and lateral views. All films were read one of two authors (DMA or KSM), who were blinded as to the diagnosis and side of injury. Measurements of patella alta,<sup>2,15</sup> congruence angle,<sup>20</sup> sulcus angle,<sup>3,20</sup> Laurin angle,<sup>17</sup> and lateral patellar overhang<sup>3</sup> were performed on radiographs of the injured and noninjured knee using the techniques and landmarks as described by the authors who originally described the measurements. The measurements were compared with published normal and abnormal values (see Tables 2 and 3).

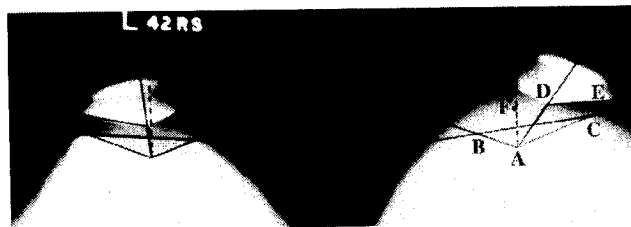
Patella alta was measured by the method of Blackburne and Peel<sup>2</sup> (Fig. 1). A lateral radiograph was taken of the knee in at least 30° of flexion. A line was projected forward along the tibial plateau and two measurements were taken. Line A was the perpendicular height of the lower end of the articular surface of the patella from the tibial plateau line, and line B was the length of the articular surface of the patella. The ratio A/B provided a measure of patellar level. Blackburne and Peel defined the normal ratio as 0.8, and patella alta as greater than 1.0. Sulcus angle, as described by Brattström,<sup>3</sup> was defined as the angle formed by the highest points on the medial and lateral femoral condyles and the lowest point of the intercondylar sulcus (Fig. 2). Congruence angle, as described by Merchant et al.<sup>19</sup> measures the relationship of the patellar articular ridge to the intercondylar sulcus. To make this measurement, the sulcus angle is bisected to establish a zero reference line. A second line is then projected from the apex of the sulcus angle through the lowest point on the articular ridge and the angle between these two lines is measured. If the apex of the patellar articular ridge is lateral to the zero line, the congruence angle is designated positive.

The Laurin angle<sup>17</sup> is defined by the intersection of the line between the femoral condyles and a line between the margins of the lateral facet of the patella (Fig. 2). An angle of 0° or opening medially (<0°) is considered abnormal. Patellar overhang was defined by a perpendicular line from the lateral border of the patella to the femoral condyles; any portion of the patella lateral to the femoral condyle was defined as patellar overhang and was measured in millimeters.

The reader of the radiographs also noted the presence of fractures and whether the physis was open or closed. Partial physeal closure was considered "closed" for the purposes of this study. Magnetic resonance imaging was offered to all patients included in the study to assess the



**Figure 1.** The Blackburne and Peel<sup>2</sup> measurement for patella alta uses the ratio between the perpendicular distance from the lower articular margin of the patella to the tibial plateau (A) and the length of the articular surface of the patella (P).



**Figure 2.** Merchant views of the knee marked for measurement of sulcus angle (subtended by lines AB and AC), congruence angle (subtended by lines AF and AD), and Laurin angle (subtended by lines BC and DE).

degree of retinacular injury and identify associated injuries that might have a bearing on outcome. Fifty-six patients underwent MR imaging.

Patients were initially placed in knee immobilizers for comfort and allowed weightbearing as tolerated with crutches. Patella-stabilizing braces were issued for use as soon as comfort permitted. Patients were encouraged to

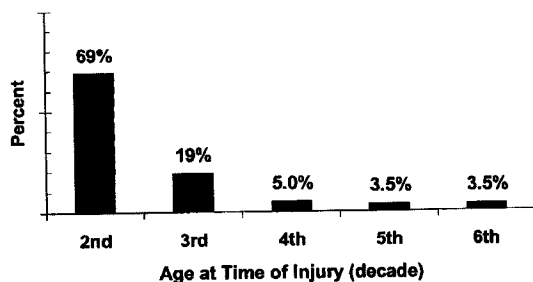
begin resisted closed-chain exercises and passive range of motion in the brace as tolerated. The patients were allowed to return to stressful activities including sports as tolerated when they had regained full passive range of motion and had no effusion and when quadriceps muscle strength was at least 80% compared with the noninjured limb. They were encouraged to wear patella-stabilizing braces for pivoting activities and sports.

**Statistical Analysis**

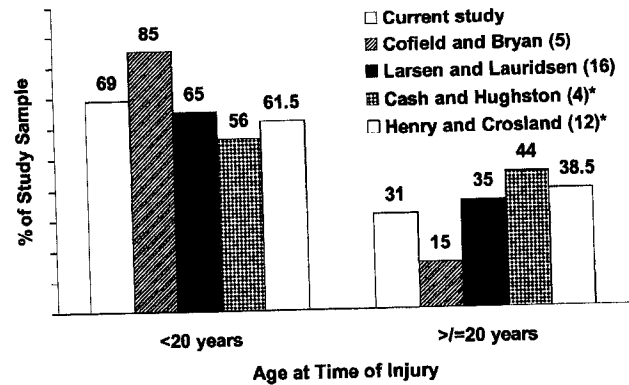
Mean annual risk (incidence rates) was expressed as mean  $\pm$  95% confidence intervals. Paired *t*-tests were used to compare radiographic parameters in injured and non-injured limbs. Single-factor analysis of variance was used to assess recovery of muscle strength and sports participation at 6, 12, and 24 weeks' follow-up, as compared with the preinjury state. The threshold for statistical significance was set at *P* = 0.05. The Pearson product moment correlation coefficient was used to determine relationships between continuous variables.

**RESULTS**

Seventy-four primary patellar dislocations in 74 patients were evaluated during the 3 years of the study. The age distribution is shown in Figure 3, and a comparison to previous published studies is given in Figure 4. There were 37 men and 37 women. The average age was 19.9 years (range, 11 to 56). The average annual risk for this injury in the Kaiser Health Plan population is therefore 25 in 367,335, or 7 per 100,000 members per year. Fifty-one patients (69%) were between 10 and 19 years of age. The average membership in this age range was 55,241; the average annual risk was therefore 31 per 100,000 per year for members in their 2nd decade. Analyzing the incidence of injury by sex, average annual risk among members in their 2nd decade was  $33 \pm 4$  (95% confidence interval) per 100,000 for girls and  $30 \pm 17$  per 100,000 for boys. Fourteen patients (19%) were age 20 to 29 years (average annual risk, 11 per 100,000). Average annual risk for women in the 3rd decade was  $9 \pm 5$  per 100,000, and for men it was  $14 \pm 9$  per 100,000. Nine patients were between the ages of 30 and 59 years. For patients between 30 and 59 years of age, average annual risk was 1.5 to 2 per 100,000.



**Figure 3.** The age distribution of patients in this study who had patellar dislocation.

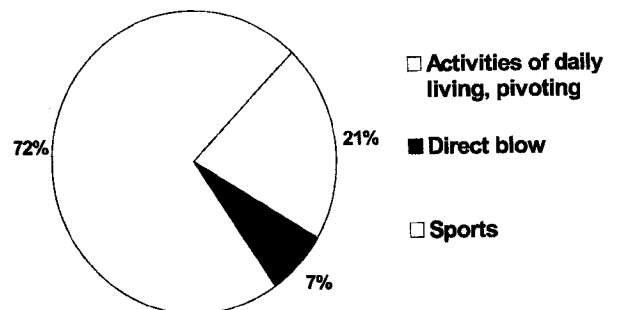


**Figure 4.** The age at injury for patients with acute primary dislocations in the present study and in a summary of the literature. Asterisks indicate that the lower age group includes age 20 for these studies.

Preinjury sports participation, expressed as total hours per week, was related to the patients' age when they sought medical help for their injuries (*P* = 0.018). Patients under 20 years of age composed a very active population with an average of 6.9 hours per week of sports participation. This corresponds to a yearly average of 359 hours of sports participation. Patients 20 years of age and over reported an average of 2.8 sports hours per week, or 146 hours per year. Correlation between age and hours of sports activity was poor, reflecting variability of lifestyles. Fifty-three patients (72%) were injured during sports activities and two-thirds of these injuries (35 injuries) occurred during level 1 cutting or pivoting sports (Fig. 5).

Nine percent of patients (7 patients) reported a family history of patellar dislocation. Four percent (3 patients) reported a history of birth complications such as breech presentation or Caesarean section. Three percent (2 patients) of patients reported a history of lower extremity problems as an infant or a child requiring bracing or harnessing of the lower extremity.

Average standing limb alignment, quadriceps angle,<sup>9</sup> and rotation measurements<sup>23</sup> were all within published normal limits and did not differ significantly between the injured and noninjured limbs (Table 1). However, the range of the individual variation was substantial. Seventeen percent of female patients (6 of 36 [data were missing



**Figure 5.** Breakdown of the mechanism of injury in this study.

TABLE 1  
Physical Parameters of Patients Who Had Primary  
Patellar Dislocation

| Parameter             | Mean           | Range      |
|-----------------------|----------------|------------|
| Limb alignment        | +2.7° (valgus) | -5° to 7°  |
| Quadriceps angle      | 16.8°          | 8° to 45°  |
| Hip internal rotation | 44.3°          | 20° to 80° |
| Hip external rotation | 35.8°          | 10° to 70° |

for 1 patient in some cases) and 16% of male patients (6 of 37) had a quadriceps angle greater than 20°. Hip internal rotation was greater than published normal limits in one patient and less than normal in three patients. Hip external rotation was greater than published limits in three patients and less than normal in three patients. Measured foot-thigh angle was below published limits in three patients.

#### Radiographic Parameters

Radiographic measurements are listed in Tables 2 and 3. In the injured knee, 50% of patients (37 patients) exhibited patella alta. We observed an average sulcus angle of 144°, and 29% of patients (21 of 73) had a sulcus angle of 148° or more. The average congruence angle in the injured knee was 9.6°. The mean Laurin angle was positive (opening laterally), but a large number of knees exhibited a negative angle. Lateral patellar overhang was positive in all injured knees, indicating that the extreme lateral border of the patella lay lateral to the lateral femoral condyle in all knees. The presence of effusion on MRI examination was associated with measurable increases in congruence angle, Laurin angle, and lateral overhang ( $P = 0.001$ ,  $P = 0.017$ , and  $P = 0.065$ , respectively). Three osteochondral fractures (4%) were noted on plain radiographs, two on the medial surface of the patella and one on the lateral femoral condyle.

In the noninjured knee, we observed an average sulcus angle of 143°, and 26% of patients (19 patients) had a sulcus angle of more than 148°. The average congruence angle in the noninjured knee was 9.1° and the mean Laurin angle was positive. Lateral patellar overhang was positive in 97% of patients (72). Sixty-five percent of patients (48 patients) were noted to have closed physes on radiographs. Mean lateral patellar overhang was significantly less in the noninjured knees than in the injured knees ( $P = 0.004$ ).

Of the 56 patients who underwent MRI, 71% (40 pa-

TABLE 2  
Radiographic Parameters of the Injured Knees

| Parameter        | Mean   | Range        | Percent abnormal (A/B ratio <sup>a</sup> ) |
|------------------|--------|--------------|--|
| Patella alta     | 1.04   | 0.56 to 1.59 | 50% > 1.0                                  |
| Sulcus angle     | 144°   | 124° to 174° | 29% ≥ 150°                                 |
| Congruence angle | 9.6°   | -18° to 44°  | 69% > 0°                                   |
| Laurin angle     | 2.5°   | -16° to 18°  | 44% ≤ 0°                                   |
| Lateral overhang | 9.0 mm | 1.0 to 27 mm | 100% > 0 mm                                |

<sup>a</sup> See text for method of determining patella alta.

TABLE 3  
Radiographic Parameters of the Noninjured Knees

| Parameter        | Mean   | Range         | Percent abnormal |
|------------------|--------|---------------|------------------|
| Sulcus angle     | 143.0° | 130° to 160°  | 26% ≥ 150°       |
| Congruence angle | 9.14°  | -22° to 58°   | 72% > 0°         |
| Laurin angle     | 4.09°  | -13° to 20°   | 28% ≤ 0°         |
| Lateral overhang | 6.3 mm | -2.0 to 14 mm | 97% > 0 mm       |

tients) had effusion or hemarthrosis. Evidence of medial retinacular injury was demonstrated in 63% (35 patients). Thirty-two knees (57%) demonstrated evidence of contusion at the lateral femoral condyle or medial patellar facet. Magnetic resonance imaging revealed 12 osteochondral fractures of the patella and 2 osteochondral fractures of the lateral femoral condyle. Three intraarticular free bodies that were not apparent on plain radiographs were identified by MRI. There were five associated injuries diagnosed by MRI. These included four ligament injuries: one ACL, two PCL, and one MCL (medial collateral ligament). These injuries most likely represented incomplete tears, as physical examination and arthrometer (KT-1000, MEDmetric, San Diego, California) testing did not reveal pathologic laxity. In addition, there was a posterior horn lateral meniscus injury that did not require surgical intervention.

#### Functional Parameters

During the early recovery phase after injury, the most frequently reported difficulties were noted in kneeling and squatting. Sixty-nine percent of patients (51 patients) noted difficulty in kneeling at 6 weeks, and 53% (39 patients) at 24 weeks. The number of patients who had difficulty in squatting decreased from 84% at 6 weeks to 58% at 24 weeks.

At 24 weeks, with strenuous activities such as jumping and cutting, 58% of patients (43 patients) noted impairment of function, 56% (41 of 73) noted pain, and 18% (13 of 74) noted swelling. Similar responses were noted for moderate activities such as hard manual labor or lateral motion. For lesser activities such as running or jogging, 42% (31 patients) noted limitation of function, 39% (29 patients) noted pain, and 11% (8 patients) noted swelling. Sedentary activity produced minimal limitation in function, minimal pain, and no swelling. Thirty-five percent of patients (26 patients) reported use of a brace at 6 weeks, 48% (35 of 73) at 12 weeks, and 53% (39 patients) at 24 weeks.

Range of motion returned to mean values of 0° of extension (range, -5° to 5°) and 132° of flexion (range, 75° to 155°) by 6 weeks. Results of strength testing are listed in Table 4. Effusion was noted in 31% of patients (23 patients) at 6 weeks and in 5% (4 patients) at 12 weeks. Lateral tracking of the patella was noted in 32% of patients (24 patients) at 6 weeks and in 16% (12 patients) at 12 weeks.

At 6 weeks, only 16% of patients (12 patients) had returned to sports. At 12 weeks, 45% (33 patients) had returned to sports, and by 24 weeks, 69% (51 patients) had

TABLE 4  
Return of Muscle Function as Percentage of Noninjured Limb

| Index                | Mean | Range     | Percentage <80% |
|----------------------|------|-----------|-----------------|
| Quadriceps, 12 weeks | 79   | 20 to 108 | 46              |
| Quadriceps, 24 weeks | 92   | 39 to 118 | 19              |
| Hop, 12 weeks        | 88   | 54 to 118 | 35              |
| Hop, 24 weeks        | 97   | 34 to 118 | 5               |
| Hamstring, 12 weeks  | 85   | 4 to 111  | 33              |
| Hamstring, 24 weeks  | 95   | 55 to 135 | 18              |

returned to sports. Sports participation among patients less than 20 years old decreased from 6.9 hours/week 1 week before injury to 2.6 hours/week at 3 months. In patients 20 years and older, participation decreased from 2.8 hours/week before injury to 0.6 hours/week at 3 months. Patients demonstrated a significant decline in overall sports activity in the first 6 months after injury ( $P = 0.015$ ). Thirty-five percent of the patients (26 of 74) reported the use of a brace at 6 weeks, 48% (35 of 73) at 12 weeks, and 53% (39 of 74) at 24 weeks. This probably reflected gradual return to activity.

## DISCUSSION

We undertook a study to define the characteristics of patients with acute first-time patellar dislocation and their early recovery in the first 6 months after injury. It was our aim to address several points regarding this injury.

### Patients at Risk for Primary Patellar Dislocation

Previous studies have reported varying demographics of age and sex among patients with patellar dislocation.<sup>4,5,11,12,16,18</sup> Because the demographics of the underlying population at risk were not presented in these studies, the data represent the prevalence of the injury in each individual practice, and not the actual incidence rate, or risk. Most likely, therefore, apparent variability in demographics (Fig. 4) reflects differences in entry criteria or investigator's practices, rather than differences in injury rates among the populations studied. For example, the high prevalence of men and an older age group in the study by Cash and Hughston<sup>4</sup> probably represented a specialized sports practice at a time when there were few highly competitive female athletes, rather than a higher incidence rate among males. Similarly, a higher prevalence of young patients probably reflects a primarily pediatric practice.

In the present study, all patients in the Kaiser Health Plan who had acute patellar dislocation were evaluated in the Knee Injury Clinic. The population at risk was determined by membership records maintained at the Health Plan offices. Within the Health Plan itself, variation in membership causes periodic changes in the proportion of juvenile and adolescent patients. During the period of study, we observed that the prevalence of patellar dislocations in men and women, and in younger and older patients, did not necessarily represent an accurate picture

of the true incidence rate, or risk, of primary patellar dislocation. By calculating risk based on the actual number of patients within each demographic category, we have corrected for apparent differences that occur when certain segments of the population are over- or underrepresented. Patients under 20 years of age (51 patients) composed 69% of the study group (see Fig. 3). There were equal numbers of men and women, in contrast to most previous reports, which have included more women than men.<sup>5,6,16,25</sup> The actual risk of sustaining this injury was slightly higher among girls in the 2nd decade, but the opposite was true in the 3rd decade. Because this study represents preliminary results and includes only 3 years of patient enrollment, 95% confidence intervals for incidence rates are relatively wide. We are continuing patient enrollment and will be able, at the final analysis, to provide epidemiologic data collected over 5.5 years, which should improve the precision of these statistics.

The association of developmental abnormalities with patellofemoral pain and instability has been well documented.<sup>13,16,22</sup> Crosby and Insall<sup>6</sup> noted a family history of patellar instability in 15% of the patients surveyed. Reider et al.<sup>21</sup> noted a family history of knee disorders in half of their patients, compared with 9% (7 patients) in our study. However, the population in the Reider et al. study included patients with chronic knee pain, whereas we excluded patients with recurrent knee problems. If a positive family history increases the risk of recurrence, one would expect a higher representation of such patients in a study that is not limited to patients with primary dislocations.

Clinical factors associated with patellar dislocation have been studied by many authors.<sup>4,8,11-13,16,20,21</sup> Insall et al.<sup>14</sup> defined a quadriceps angle of greater than 20° as abnormal when measured in extension. Larsen and Lauridsen<sup>16</sup> noted a 37% incidence of abnormal quadriceps angle, with 52% recurrence in these patients. Fithian et al.<sup>8</sup> measured the quadriceps angle at 30° of knee flexion to allow the patella to seat in the trochlea groove. In a sample of 22 patients, the authors noted significantly higher quadriceps angles among injured knees than in a sample of 94 control subjects, with no apparent variation from the patients' contralateral limbs. In the current study, we measured the quadriceps angle at 30° of flexion and once again were unable to demonstrate significant variation from the contralateral limb. Seventeen percent of female patients and 16% of male patients demonstrated a quadriceps angle greater than 20°.

Reider et al.<sup>21</sup> noted significant increases in patellar mobility, generalized ligament laxity, vastus medialis muscle deficiency, and patellar fat pad enlargement. Evaluation of the physical characteristics in our study including hyperlaxity, limb alignment, and hip rotation did not reveal any significant difference when the measurements for these characteristics were compared with those for the contralateral limb or normal published values. Furthermore, evaluation of these characteristics in our study revealed significant abnormality in only a small number of patients.

Radiographic parameters in the current study were

comparable with those in previous studies.<sup>10</sup> Patella alta, as measured by the method of Blackburne and Peel,<sup>2</sup> was present in 50% of patients (37 patients). Twenty-nine percent of patients demonstrated an abnormal sulcus angle, and a positive Laurin angle was noted in 28% of the noninjured knees (21 knees) and 44% of the injured knees (32 knees), possibly due to effusion or retinacular tearing. Lateral patellar overhang was significantly greater in the injured knees. This could be attributed to the effects of a retinacular injury or effusion, allowing greater lateral displacement. In the injured knees, congruence angle, Laurin angle, and lateral patellar overhang were all significantly higher in the presence of knee effusion, which was common in our sample. Further follow-up is needed in the present study to evaluate prospectively the role of these various radiographic factors in patellar dislocation.

### Mechanisms of Injury

The mechanism of injury involved vigorous sporting activity in the majority of cases, and the majority of patients were young and active. These patients' preinjury sports activity level was similar to that of patients with primary ACL injury.<sup>7</sup> These observations contradict any stereotype of an overweight, sedentary adolescent girl whose patella dislocates with little or no trauma. On the contrary, the association with sports and highly active people is disturbing in light of a previous study suggesting greater impairment after patellar dislocation in these patients.<sup>5</sup>

### Time Until Functional Recovery and Degree of Function Regained

Early-recovery data revealed that patients regained nearly complete motion by 6 weeks. Quadriceps muscle strength was greater than 80% in 54% of patients (40 patients) by 12 weeks and in 81% of patients (60 patients) by 24 weeks. The hamstring and single-legged indices demonstrated a quicker return. Subjectively, patients noted the greatest difficulties in kneeling and squatting at 6, 12, and 24 weeks. Preinjury sports participation in our patients was associated with age and was noted to be markedly higher in patients under 20 years old ( $P = 0.018$ ). All patients showed a marked decrease in sports hours per week at 3 and 6 months; compared with preinjury activity.

### Factors That Affect Early Recovery After the Initial Injury

Recurrent symptoms after patellar dislocation may be due to a variety of abnormalities, including articular damage or posttraumatic arthritis resulting from the initial injury,<sup>24,25</sup> recurrent instability including subluxation or frank dislocation,<sup>5,11</sup> or developmental abnormalities such as patellofemoral dysplasia or malalignment.<sup>4,11</sup> The severity of symptoms, and the likelihood of recurrent instability, may depend on the level of activity,<sup>11</sup> predisposing factors,<sup>4,5</sup> age at the time of initial dislocation,<sup>16</sup> and the degree of ligament injury resulting from the initial

dislocation.<sup>8</sup> Our study did not demonstrate any significant correlation between signs of dislocation, such as effusion or lateral tracking, and return of strength or motion; however, a larger study population may show a correlation.

Our study criteria excluded patients with previous knee impairment so that we could exclude recurrent dislocations and accurately define the characteristics of primary dislocation and factors in early recovery.

Patients with primary acute lateral patellar dislocation were initially placed in knee immobilizers for comfort and allowed weightbearing as tolerated with crutches. Patella-stabilizing braces were issued for use as soon as comfort permitted. Patients were encouraged to begin resisted closed-chain exercises and passive range of motion in the brace as tolerated. The patients were allowed to return to stressful activities including sports as tolerated when they had regained full passive range of motion and had no effusion and when quadriceps muscle strength was at least 80% compared with the noninjured limb. They were encouraged to wear patella-stabilizing braces for pivoting activities and sports. Using this protocol, early range of motion and function were achieved, and at 6 months there were no recurrences.

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### REFERENCES

1. Arnbjörnsson A, Egund N, Rydning O, et al: The natural history of recurrent dislocation of the patella: Long-term results of conservative and operative treatment. *J Bone Joint Surg* 74B: 140-142, 1992
2. Blackburne JS, Peel TE: A new method of measuring patellar height. *J Bone Joint Surg* 59B: 241-242, 1977
3. Brattström H: Shape of the intercondylar groove normally and in recurrent dislocation of the patella: A clinical and x-ray anatomical investigation. *Acta Orthop Scand (Suppl)* 68: 134, 1964
4. Cash JD, Hughston JC: Treatment of acute patellar dislocation. *Am J Sports Med* 16: 244-249, 1988
5. Cofield RH, Bryan RS: Acute dislocation of the patella: Results of conservative treatment. *J Trauma* 17: 526-531, 1977
6. Crosby EB, Insall J: Recurrent dislocation of the patella: Relation of treatment to osteoarthritis. *J Bone Joint Surg* 58A: 9-13, 1976
7. Daniel DM, Stone ML, Dobson BE, et al: Fate of the ACL-injured patient. A prospective outcome study. *Am J Sports Med* 22: 632-644, 1994
8. Fithian DC, Mishra DK, Balen PF, et al: Instrumented measurement of patellar mobility. *Am J Sports Med* 23: 607-615, 1995
9. Freeman BL III: Recurrent dislocations, in Crenshaw AH (ed): *Campbell's Operative Orthopaedics*. Eighth edition. St. Louis, Mosby Year Book, 1992, pp 1391-1461
10. Grelsamer RP, Newton PM: Patellofemoral imaging. *Sports Med Arthrosc Rev* 2: 226-236, 1994
11. Hawkins RJ, Bell RH, Anisette G: Acute patellar dislocations: The natural history. *Am J Sports Med* 14: 117-120, 1986
12. Henry JH, Crossland JW: Conservative treatment of patellofemoral subluxation. *Am J Sports Med* 7: 12-14, 1979
13. Hughston JC: Subluxation of the patella. *J Bone Joint Surg* 50A: 1003-1026, 1968

14. Insall J, Falvo KA, Wise DW: Chondromalacia patellae. A prospective study. *J Bone Joint Surg* 58A: 1-8, 1976
15. Insall J, Salvati E: Patella position in the normal knee joint. *Radiology* 101: 101-104, 1971
16. Larsen E, Lauridsen F: Conservative treatment of patellar dislocations: Influence of evident factors on the tendency to redislocation and the therapeutic result. *Clin Orthop* 171: 131-136, 1982
17. Laurin CA, Dussault R, Levesque HP: The tangential x-ray investigation of the patellofemoral joint: X-ray technique, diagnostic criteria and their interpretation. *Clin Orthop* 144: 16-25, 1979
18. McNab I: Recurrent dislocation of the patella. *J Bone Joint Surg* 34A: 957-967, 1952
19. Merchant AC, Mercer RL, Jacobsen RH, et al: Roentgenographic analysis of patellofemoral congruence. *J Bone Joint Surg* 56A: 1391-1396, 1974
20. Quinn SF, Brown TR, Demlow TA: MR imaging of patellar reticular ligament injuries. *J Magn Reson Imaging* 3: 843-847, 1993
21. Reider B, Marshall JL, Warren RF: Clinical characteristics of patellar disorders in young athletes. *Am J Sports Med* 9: 270-274, 1981
22. Sallay PI, Poggi J, Speer KP, et al: Acute dislocation of the patella: A correlative pathoanatomic study. *Am J Sports Med* 24: 52-60, 1996
23. Staheli LT, Corbett M, Wyss C, et al: Lower-extremity rotational problems in children. Normal values to guide management. *J Bone Joint Surg* 67A: 39-47, 1985
24. Vainionpää S, Laasonen E, Silvennoinen T, et al: Acute dislocation of the patella: A prospective review of operative treatment. *J Bone Joint Surg* 72B: 366-369, 1990
25. Virolainen H, Visuri T, Kuusela T: Acute dislocation of the patella: MR findings. *Radiology* 189: 243-246, 1993

**APPENDIX 1. PHYSICAL EXAMINATION - PATELLAR DISLOCATION**

|  | Nonindex | Index |
|--|----------|-------|
| Right/Left Index Knee?                                     |          |       |
| Standing alignment (valgus= +degrees)                      |          |       |
| Thumb to forearm (cm)                                      |          |       |
| Elbow hyperextension (deg)                                 |          |       |
| Supine Q angle (30° in patellar pusher)<br>At Rest Reduced |          |       |
| <b>KNEE FLEXION ARC - EXTENSION</b>                        |          |       |
| <b>KNEE FLEXION ARC - FLEXION</b>                          |          |       |
| Foot-Thigh Angle   |          |       |
| Hip Axial Rotation (Prone) IR                              |          |       |
| Hip Axial Rotation (Prone) ER                              |          |       |
| "J" Sign      Yes/No                                       |          |       |

|                                 | N | I | I - N |
|---------------------------------|---|---|-------|
| <b>CALF CIRCUMFERENCE (CM)</b>  |   |   |       |
| <b>KNEE CIRCUMFERENCE (CM)</b>  |   |   |       |
| <b>THIGH CIRCUMFERENCE (CM)</b> |   |   |       |
| <b>PASSIVE PATELLAR TILT</b>    |   |   |       |

|  | N | I | I - N |
|--|---|---|-------|
| Grade tenderness 0-3; 0=none; 1=mild; 2=moderate; 3=severe |   |   |       |
| <b>CREPITUS</b>  |   |   |       |
| <b>EFFUSION</b>  |   |   |       |
| <b>BURSAL</b>  |   |   |       |
| <b>COMPRESSION TEST</b>                                    |   |   |       |
| <b>MEDIAL FACET</b>  |   |   |       |
| <b>MEDIAL RETINACULUM</b>                                  |   |   |       |
| <b>LATERAL FACET</b>                                       |   |   |       |
| <b>LATERAL RETINACULUM</b>                                 |   |   |       |
| <b>PATELLAR TENDON</b>                                     |   |   |       |
| <b>APPREHENSION</b>  |   |   |       |
| <b>PATELLAR LATERAL TRACKING</b>                           |   |   |       |