Proximo-distal patellar position in three small dog breeds with medial patellar luxation

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Keywords
Medial patellar luxation, proximo-distal patellar position, small dog breeds, patella alta

Summary
Introduction: Medial patellar luxation is thought to be associated with a high proximal position of the patella in the trochlear groove. Objective: To determine whether the ratio of patellar ligament length and patellar length (L:P) is influenced by the stifle angle (75°, 96°, 113°, 130°, and 148°) in small dog breeds and to compare the L:P ratio in dogs of three small dog breeds with and without medial patellar luxation. Methods: A mediolateral radiograph of the stifle joint was used to measure the L:P ratio in the stifle joints of dogs of three small breeds with and without medial patellar luxation. The L:P ratio was evaluated at five stifle angles (75°, 96°, 113°, 130°, and 148°) in 14 cadavers (26 stifle joints) of small dog breeds in order to identify the best stifle angle to measure the L:P ratio. Then the mean ± SD L:P ratio was calculated for normal stifles and stifles with medial patellar luxation grades 1, 2, and 3 in 194 Pomeranians, 74 Chihuahuas, and 41 Toy or Standard Poodles. Results: The L:P ratio was the same for all five stifle angles in the cadavers (p = 0.195). It was also not significantly different in the three breeds (p = 0.135), in normal and medial patellar luxation-affected stifles overall (p = 0.354), and in normal and medial patellar luxation-affected joints within each breed (p = 0.19). Clinical significance: We conclude that a proximo-distal patellar position is not associated with medial patellar luxation in Pomeranians, Chihuahuas, and Toy or Standard Poodles. Thus a longer patellar ligament length does not play a role in the pathophysiology of medial patellar luxation in these small dog breeds.

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Introduction
Patella alta, defined as proximal displacement of the patella within the femoral trochlear groove, is associated with recurrent patellar dislocation, subluxation, chondromalacia, and pain in the anterior aspect of the knee in humans (1–4). It is also associated with medial patellar luxation in large-breed dogs (5–7). The extent of patellar displacement can be estimated by calculating the ratio of patellar ligament length (L) to patellar length (P), using mediolateral radiographs of the stifle joint. “L” is the measured distance along the caudal aspect of the patellar ligament from its origin on the apex of the patella to its insertion on the tibial tuberosity, and “P” is the longest longitudinal length of the patella (5). In large dog breeds, the L:P ratio is not affected by the angle of flexion of the stifle joint (5). In another study of the L:P ratio in normal and medial patellar luxation-affected stifles in large-breed dogs, the authors concluded that the patella had a more proximal position in dogs with medial patellar luxation (6).

Mostafa and colleagues evaluated the L:P ratio in medium to large breed dogs using a modified L:P method in which “L” is the distance between the point of origin of the ligament on the apex of the patella to its insertion on the proximal extension of the tibial tuberosity (7). An L:P ratio greater than 2.06 was indicative of patella alta. These authors concluded that medial patellar luxation is associated with a relatively long patellar ligament in medium to giant breed dogs (7). The findings of these studies suggest that proximal displacement of the patella in medium, large, and giant breed dogs with patella alta may create a patella-femoral articulation that extends proximal to the femoral trochlear groove during extension of the stifle, resulting in a loss of the buttressing effects of the proximal end of the trochlear ridges (5–7). The loss of patellar pressure at the femoral condyle can facilitate medial luxation of the patella (6–7). Only two studies have evaluated the L:P ratio in small-breed dogs with medial patellar luxation (8, 9). Neither
study found a significant difference in L:P ratio; however, as the studies did not include breed-matched controls without patellar luxation, it is not possible to draw conclusions about the L:P ratio in small-breed dogs with medial patellar luxation (8–9).

The objectives of the present study were to determine whether the L:P ratio is influenced by the stifle angle (75°, 96°, 113°, 130°, and 148°) in small dog breeds and to compare the L:P ratio in dogs of three small dog breeds with and without medial patellar luxation.

**Material and methods**

Twenty-six hindlimbs were collected from the cadavers of 14 skeletally mature small-breed dogs (7 Pomeranians, 3 Toy Poodles, 3 Yorkshire Terriers, 1 Miniature Pinscher) which were euthanatized for non-orthopaedic-related reasons. Clinically, patellar assessment prior to euthanasia found 17 normal stifle joints, four stifle joints with grade 1 medial patellar luxation, and five with grade 2 medial patellar luxation. The stifle joints were mounted on a positioning device that allowed a full range-of-motion. Mediolateral radiographic views were obtained with the stifle joints positioned at 75°, 96°, 113°, 130°, and 148°, using a horizontal beam. Each radiograph was centred on the stifle joint (Figure 1). The L:P ratio was calculated for each angle and for each stifle joint.

The medical records and stifle radiographic images taken of a normal stifle of a Pomeranian cadaver at the following angles: A) 75°, B) 96°, C) 113°, D) 130°, and E) 148°.

The modified L:P ratio was used, as previously described (7). First, the L:P ratio was calculated for the five stifle angles (75°, 96°, 113°, 130°, and 148°) for the cadavers (dogs with and without medial patellar luxation). Then the L:P ratio was measured in 194 Pomeranians (99 female), 74 Chihuahuas (36 female), and 41 Toy or Standard Poodles (27 female) with or without medial patellar luxation. The L:P ratio was measured using radiographs obtained after reduction of the patella.

All measurements were performed by one clinician (CW). The L:P ratio (mean ± standard deviation) for each of the five stifle angles was calculated for the 26 cadaveric hindlimbs. Repeated ANOVA was used to compare differences in the L:P ratio in the five stifle angles. Only one stifle joint of each dog was used for analysis. The L:P ratio (mean ± standard deviation) was calculated for normal stifles and stifles with medial patellar luxation grades 1, 2, and 3 for each breed (Table 1). Two-way ANOVA was used to compare differences in the L:P ratio among the three breeds, among the four groups (normal, medial patellar luxation grade 1–3 stifles) overall, and among the four groups in each breed. A p-value of <0.05 was considered significant.

### Results

In the cadaveric study, the L:P ratios at stifle angles of 75° (1.83 ± 0.18), 96° (1.84 ± 0.19), 113° (1.82 ± 0.22), 130° (1.78 ± 0.23), and 148° (1.78 ± 0.21) were not significantly different (p = 0.195).

The mean ages of the dogs of the three breeds are reported in Table 1. The L:P ratio in normal stifle joints was 1.82 ± 0.18 in Pomeranians (n = 35), 1.85 ± 0.18 in Chihuahuas (n = 24), and 1.79 ± 0.11 in Poodles (n = 16). The L:P ratio in stifle joints with medial patellar luxation grade 1 was 1.85 ± 0.17 in Pomeranians (n = 30), 1.92 ± 0.24 in Chihuahuas (n = 9), and 1.76 ± 0.25 in Poodles (n = 3). In stifle joints with medial patellar luxation grade 2, the L:P ratio was 1.81 ± 0.19 in Pomeranians (n = 80), 1.81 ± 0.14 in Chihuahuas (n = 34), and 1.84 ± 0.16 in Poodles (n = 11). In joints with grade 3 medial patellar luxation,
this ratio was 1.80 ± 0.18 in Pomeranians (n = 49), 2.0 ± 0.18 in Chihuahuas (n = 7), and 1.73 ± 0.21 in poodles (n = 11) (Table 2). The L:P ratio was not significantly different between or within these small dog breeds (p = 0.135), regardless of the presence or absence of medial patellar luxation (p = 0.19).

### Discussion

The modified L:P method of Mostafa and colleagues was used to investigate whether the L:P ratio is affected by the stifle joint angle and by the presence of medial patellar luxation in small-breed dogs (7). The modified method was chosen because in small-breed dogs, it is easier to measure the distance between the point of origin of the ligament on the apex of the patella to its insertion on the proximal extension of the tibial tuberosity (L), than to measure the distance along the caudal aspect of the patellar ligament from its origin on the apex of the patella to its insertion on the tibial tuberosity. Stifle joint angle did not affect the L:P ratio in the small dog breeds investigated. This is consistent with the findings of other investigators who found the patellar ligament to be non-elastic and the L:P ratio to be independent of stifle angle in clinically affected large breed dogs (5). Mostafa and colleagues showed a curvilinear relation between stifle angles and L:P ratios, with the largest ratios occurring at an angle of approximately 90° using a large cohort of affected and non-affected dogs (7). However, they did study the relation between stifle angles and L:P within one dog. Our evaluation of the L:P ratio at three stifle angles: <90°, 90–110°, and <110° within each cadaveric stifle showed no relation and validated our measurements in the study cohorts. Therefore, mediolateral radiographs with stifle angles ranging from 75° to 148° were used to evaluate the L:P ratio in the referred small-breed dogs with and without medial patellar luxation.

In our study, the L:P ratio in normal stifle joints in Pomeranians, Chihuahuas, and Toy or Standard Poodles was not significantly different from that of stifle joints with medial patellar luxation in dogs of these three breeds. This finding was consistent with earlier findings for small to medium breed dogs with medial patellar luxation (8-9). In contrast, Mostafa and colleagues reported that the modified L:P ratio of clinically normal stifle joints (2.02 ± 0.2) was lower than that of stifle joints with medial patellar luxation (2.23 ± 0.23) in medium to large breed dogs (7).

Transposition of the tibial tuberosity both distally and laterally has been suggested as a method to correct medial patellar luxation in dogs with patella alta, in order to decrease recurrent luxation (5-7, 10). This recommendation is supported by the work of Segal and colleagues, who reported that latero-distal transposition of the tibial tuberosity in dogs with patella alta decreased patellar relaxation (11). In contrast, Cashmore and colleagues diagnosed preoperative patella alta in dogs with a bodyweight greater than 11 kg, and did not find patella alta to be correlated with the incidence of patellar relaxation, whether preoperatively or postoperatively (12). In the studies of femoral varus angle and medial patellar luxation in Pomeranians, the overall recurrence rate after surgical correction of medial patellar luxation was 10%, but 36% in dogs with grade IV luxation (13, 14). Nonetheless, there was no evidence reported for any relationship of medial patellar luxation or high recurrence rate and patella alta. Kalff and colleagues suggested that a low L:P ratio did not necessarily indicate patella baja in dogs with lateral patellar luxation, but that it might be normal anatomical variation among affected breeds (15).

Patella alta was defined from a limited number of studies and no breed-matched controls without patellar luxation were included, so it was not possible to compare patella alta in the presence or absence of medial patellar luxation.

In this study, medial patellar luxation was not associated with patella alta in Pomeranians, Chihuahuas, or Toy or Standard Poodles. As patella alta does not play a role in the pathophysiology of medial patellar luxation in these breeds, latero-distal transposition of the tibial tuberosity is not associated with patella alta in Pomeranians, Chihuahuas, or Toy or Standard Poodles.

### Table 1

<table>
<thead>
<tr>
<th>Breed</th>
<th>Number</th>
<th>Sex</th>
<th>Age (range and mean ± SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pomeranian</td>
<td></td>
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<tr>
<td>Chihuahua</td>
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<td>Poodle</td>
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</tbody>
</table>

**Table 2** Ratio of patellar ligament length (L) to patellar length (P) (Mean ± SD), expressed as normal as well as with medial patellar luxation (MPL) grade 1, 2, and 3, in Pomeranians, Chihuahuas, and Toy or Standard Poodles.

<table>
<thead>
<tr>
<th>Breed</th>
<th>Normal</th>
<th>MPL grade 1</th>
<th>MPL grade 2</th>
<th>MPL grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pomeranian</td>
<td>1.82 ± 0.18</td>
<td>1.85 ± 0.18</td>
<td>1.79 ± 0.11</td>
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</tr>
<tr>
<td>Chihuahua</td>
<td>1.85 ± 0.17</td>
<td>1.92 ± 0.24</td>
<td>1.76 ± 0.25</td>
<td></td>
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<tr>
<td>Poodle</td>
<td>1.81 ± 0.19</td>
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necessary for correction of medial patellar luxation in these small-breed dogs.

On the basis of these findings, unlike large-breed dogs, medial patellar luxation does not appear to be associated with a more proximal patellar position in small breed dogs (6–7). In fact, the pathophysiology of patellar luxation may be influenced not only by breed and size, but also by age and musculoskeletal abnormalities, including coxofemoral and tibiotarsal joints, and the presence of muscle and soft tissue adjacent to the stifle joint (10). These factors explain various abnormalities seen in dogs with patellar luxation. A proximal position of the patella in the trochlear groove in stance may coincide with bidirectional patellar luxation in Pomeranians, even though the L:P ratio is normal (13). This might be because functional patella alta is a result of hyperextension of the stifle joint during locomotion rather than a long patellar ligament (16).

Conclusion

Although patella alta has been implicated in the pathophysiology of patellar luxation in large-breed dogs, this is not true in small-breed dogs. The proximo-distal position of the patella was not different in three small dog breeds, regardless of the presence and severity of medial patellar luxation. The proximo-distal position of the patella was not associated with medial patellar luxation in Pomeranians, Chihuahuas, and Toy or Standard Poodles. Thus a longer length of the patellar ligament does not play a role in the pathophysiology of medial patellar luxation in these small-breed dogs.

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Conflict of interest

None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper.

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