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Patellar Morphology in Small Breed Dogs With Medial Patellar Luxation

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THE aim of the present study was to assess the morphology of patella on tangential radiographs in healthy dogs and dogs affected with grade II and III medial patellar luxation (MPL). The study was done on 57 dogs (42 with MPL and 15 healthy) from Mini-Pinscher, Pomeranian, Yorkshire Terrier, and Chihuahua breeds. Seven morphometric parameters associated with patellar shape were measured – retropatellar angle of Wiberg, lateral and medial patellar facet angles, lateral and medial facet lengths, horizontal patellar diameter and patellar thickness. The results demonstrated altered shape and thickness of the patella in stifle joints affected with MPL, which were more pronounced in grade III. Medial patellar luxation resulted in statistically significantly increased values of Wiberg angles and substantial reduction of lateral facet angle and patellar thickness. Altered shape of the patella was manifested with hypoplasia of patellar apex, lower patellar thickness and concave aspect of its lateral facet. These changes in patellar morphology in small breed dogs with grade II and III MPL suggested that the altered shape and thickness of the kneecap occurred consequently to the condition.

Keywords: Medial patellar luxation, Patellar morphology, Patellar thickness, Wiberg angle, Small dog breeds.

Introduction

Medial patellar luxation (MPL) is a frequent orthopaedic pathology in small dog breeds including Chihuahuas, Poodles, Maltese, Pomeranians, Papillons, Yorkshire terriers and others. The Orthopedic foundation for animals has ranked Pomeranians as the breed with the highest incidence of patellar luxation, with 41.2% of dogs being affected [1, 2].

It originates as a result of complex skeletomuscular morphological abnormalities affecting the pelvic limb, with leading role of abnormal development (dysplasia) of the trochlear groove, proximal or distal positioning of the patella (patella alta, patella baja), and disproportionate pull force of the four quadriceps muscles: m. rectus femoris, m. vastus intermedius, m. vastus lateralis, m.vastus medialis [3]. The proper functioning of the femoropatellar joint requires alignment of m. quadriceps femoris, the patella, the patellar ligament, the trochlear groove and tuberositas tibiae [4,5]. The morphology of the trochlea is essential to maintain patellar stability. Dogs with MPL have abnormal trochlear groove development and the degree of trochlear dysplasia varies from almost normal trochlea to lack of trochlear groove [6]. Patellar luxation may be diagnosed at birth, during the growth or later in life [7,8] .

The kneecap is exceptionally important for stifle biomechanics and stability during flexion and extension. It acts as a biomechanical lever arm and improves the effective extension capacity of the quadriceps muscle [9]. That is why the

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investigations on its position with respect to the trochlear groove, its thickness and congruency angle (retropatellar angle of Wiberg) are important in the examination of stifle joints, especially those with femoral trochlear dysplasia [10-12]. The shape of the patella in men is described by the classification of Wiberg based on the asymmetry between medial and lateral patellar facets. This classification defines three types of patellar shapes: Wiberg type I: the medial and lateral patellar facets are symmetrical; Wiberg type II: medial and lateral facets are concave, the former being shorter than the latter and Wiberg type III: shorter convex medial facet and concave or flat lateral facet [13].

Except for patellar thickness, no literature data on canine patellar shape and morphology have been reported. The purpose of the present study was to assess patellar morphology in healthy and MPL-affected small breed dogs on tangential radiographs.

Materials and Methods

Animals

Fifty-seven small breed dogs (25 Mini-Pinschers; 14 Pomeranians; 12 Chihuahuas and 6 Yorkshire terriers) were used. Forty-two dogs (70 stifle joints) had medial patellar luxation (MPL) – 39 joints with MPL grade II and 31 joints with MPL grade III after routine clinical examination. Six Mini-Pinschers, 3 Pomeranians, 3 Chihuahuas and 3 Yorkshire terriers (15 dogs; 30 joints) free of orthopaedic or neurological disorders were used as control group. The orthopaedic exam comprised patellar displacement test and dancing patella test, both of which were negative in the healthy group. Furthermore, no asymmetry of femoral and gluteal muscles was identified by palpation. Neurological status exams consisted of proprioceptive positioning by flexing the paw so the dorsal surface was on the floor; the response in all dogs was immediate return to normal position. The lack of worn nails or trophic ulcers provided evidence for lack of long-term proprioceptive dysfunction. Patellar reflex and withdrawal reflex were normal.

Radiography and measurements

Radiographs were obtained in tangential projection or skyline view using a Bucky Diagnost CS4 stationary X-ray equipment with iQ-CR ACE acquisition station and iQ-VIEW/PRO version 2.7 software (exposure 50 kV, 10 mAs) after sedation with 0.075 mg/kg medetomidine hydrochloride (Dorbene vet®, 1 mg/ml) and 7.5 mg/kg ketamine hydrochloride (Anaket®, 100 mg/ml) applied intramuscularly. The dogs were in ventral recumbency, the knee bent as much as possible, X-ray beam focused between the femoral condyles.

Patellar morphometric parameters were measured as followed: The retropatellar Wiberg angle (Fig. 1) was formed by the medial and the lateral patellar facet tangent [14]. The lateral and medial patellar facet angles (L-FA, M-FA) (Fig. 1) were determined as described by Jimenez et al. [15]. The L-FA is formed between the patellar horizontal diameter and the lateral patellar facet tangent, whereas M-FA was formed between the horizontal diameter and the medial facet tangent.

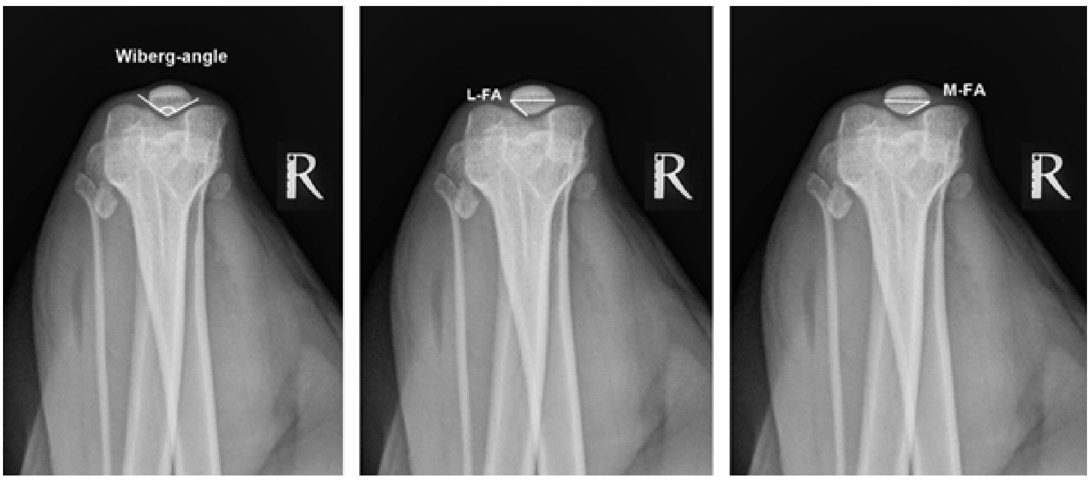

Fig. 1. Measurement of Wiberg angle [13], lateral (L-FA) and medial (M-FA) patellar facet angles [15].

The lengths of lateral and medial patellar facets (Fig. 2) were measured by passing a line from the most lateral and medial edge of the patella, respectively, to its apex [13]. The length between the most medial edge (*m*) and the most lateral edge (*l*) of the patella was defined as horizontal diameter (Fig. 2), whereas the vertical diameter e.g. thickness of the patella was measured from the farthest anterior (*a*) and posterior (*p*) poles of the patella [16].

All measurements were made by the same investigator with the image analysis system of the X-ray equipment software after preliminary calibration with a template.

Statistical analysis

The results are presented as median and minimum-maximum range. Differences between healthy and MPL joints from both grades were evaluated with the non-parametric Mann-Whitney test at $P<0.05$ (MedCalc v.10.2.0.0, MedCalc Software, Belgium).

Results

The measured patellar morphological parameters in sound dogs and dogs with grade II/III MPL from the four small breeds are presented (Table 1). The median Wiberg angle of healthy stifles (122°) was statistically significantly lower than that of stifles with grade II MPL (129°; $P<0.001$) and grade III MPL (132°; $P<0.001$). The Wiberg angle values were also substantially difference between stifles with grade II and grade III MPL ($P<0.05$).

The median lateral facet angle (L-FA) of joints with grade III MPL was smaller compared to those in healthy dogs (33° vs 39.5°; $P<0.001$). The differences between L-FA of joints with grade III MPL and those with grade II MPL (38°) were also significant ($P<0.001$). Conversely, the medial patellar facet angle (M-FA) was smaller ($P<0.05$) in grade II MPL (34°) than in joints with grade III MPL (39°).

The median patellar thickness (PaT) of healthy joints was higher (3.1 mm) than that of joints with grade II MPL (2.8 mm; $P<0.01$) and grade III MPL (2.6 mm; $P<0.01$). There were no statistically significant differences among the three groups as the horizontal diameter of the patella was concerned.

The lateral facet (LF) length in grade III MPL was slightly decreased compared to joints with grade II (2.7 vs 2.8 mm). The opposite was established for medial facet (MF), which was slightly higher in joints with grade III MPL length (3 vs 2.9 mm). In healthy joints, median values of LF and MF lengths were equal – 2.6 mm.

Discussion

Patellar morphology in human stifles, healthy or MPL-affected, is described in detail [16-18]. It was reported that in joints with patellar luxation, the Wiberg type III patellae were the most commonly encountered [18,19]. Others have demonstrated hypoplasia of patellar apex in joints with patellar luxation compared to

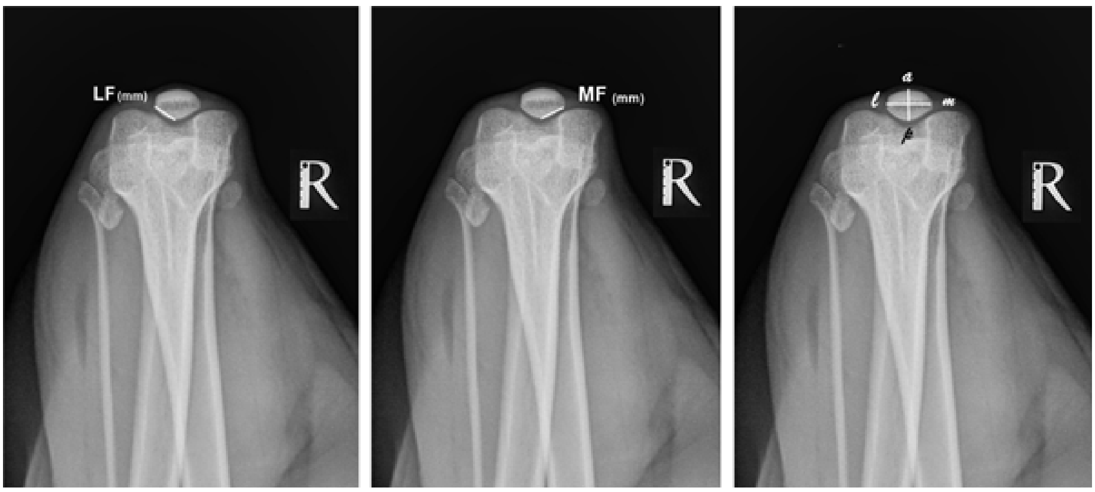

Fig. 2. Measurement of lateral facet (LF) and medial facet (MF) lengths [13] and of patellar diameters. The horizontal patellar diameter is the distance between the most medial edge (m) and the most lateral edge (l) of the patella. The patellar thickness is the distance between its farthest anterior (a) and posterior (p) edges [16].

TABLE 1. Trochlear angles, trochlear depth and patellar thickness in healthy canine stifle joints and joints with medial patellar luxation (MPL) grade II and III. Data are presented as median (minimum-maximum).

	Healthy joints (n=30) j	MPL grade II joints (n=39) k	MPL grade III joints (n=31) l	Between-group P value
Horizontal diameter, mm	5.2 (2.7-7.6)	5.4 (2.7-6.6)	5.3 (2.5-6.3)	
Patellar thickness, mm	3.1 (1.8-5.0)	2.8 (1.3-4.1)	2.6 (1.8–3.7)	P_{1-2}<0.01; P_{1-3}<0.01
LF length, mm	2.6 (1.7-4.4)	2.8 (1.5-4.3)	2.7 (1.3–3.7)	
MF length, mm	2.6 (1.6-4.8)	2.9 (1.6-4.1)	3.0 (1.0–3.9)	
LF angle, °	39.5 (30-52)	38 (30-69)	33 (28-54)	P_{1-3}<0.001;P_{2-3}<0.001
MF angle, °	35 (28-51)	34 (28-57)	39 (29-58)	P_{2-3}<0.05
WA, °	122.5 (112–135)	129 (110–147)	132 (115–178)	P_{1-2}<0.01; P_{1-3}<0.001 P_{2-3}<0.05

n – number of joints; LF – lateral facet of the patella; MF – medial facet of the patella; WA - retropatellar Wiberg angle.

healthy joints on 30° mediolateral radiographs [18]. The patellar morphology was altered in different forms of trochlear dysplasia, whereas the trochlear groove shape is formed at the time of embryonic development and does not change during the growth [20].

To the best of our knowledge, this is the first report investigating the shape of patella in healthy dogs and dogs of small breeds with MPL. The selected metric parameters, determined on tangential radiographs allowed for satisfactory assessment of patellar shape.

No close relationship between patellar shape and trochlear groove shape was reported in men [15]. In our opinion, patella location is one of factors for the proper functioning of the stifle joint. In healthy joints, the patella fits perfectly to trochlear shape and depth, allowing the patella to move smoothly in the central trochlea during stifle flexion and extension [6].

In healthy canine stifle joints, the kneecap shape corresponded to that of Wiberg type I, as confirmed by the equal lateral and medial facet lengths (2.6 mm). In stifles with grade III MPL, the kneecap shape corresponded to that of Wiberg type III –LF length smaller than MF length (2.7 vs 3 mm), L-FA smaller than M-FA (33° vs 39°), convex shape of medial patellar facet. The cause in our belief is the increased stress exerted from lateral patellar surface on medial structures as a result of impaired quadriceps mechanism. With time, the lateral surface becomes flatter while the medial remains rounded (convex). Reported data [5,21,22] showed that the higher quadriceps angle in stifles affected with MPL was associated with stronger patellar pulling force in medial direction.

Panni et al. [23] affirmed that the patellar shape was not a factor predisposing to onset of patellar luxation, yet trochlear dysplasia may result in alteration of the shape. Increased lateral stresses produce a Wiberg type C patella, with a hypoplastic medial facet and a more developed lateral facet. The reduction of this unbalance was suggested to decrease the incidence of type C patella in young patients. Our study confirmed that stifles with grade II and III MPL had altered shape and thickness compared to sound stifles. This was confirmed by increased median Wiberg angle (grade III MPL – 132°; P<0.01), thinner patella (2.6 mm; P<0.01) and lower L-FA (33°; P<0.001). This is anticipated because despite the occasional or permanent lameness, dogs continued to bear weight on the affected limb, which led to wearing of articular surfaces and changed patellar shape. This statement disagrees with another study in dogs with grade IV MPL, that reported no change in patellar shape, because the affected limb was not used, was kept flexed and weight was born by healthy legs [24].

In line with earlier reports demonstrating that the Wiberg angle (WA) was greater in stifles with trochlear dysplasia and patellar luxation, our study confirmed statistically significantly greater median WA values due to impaired articulation between the patella and the trochlear groove resulting from the medial shift of the entire quadriceps mechanism. The consequence is flattening of retropatellar surface of the kneecap.

Another human study reported shorter horizontal patellar diameter in stifles with patellar luxation and trochlear dysplasia compared to healthy controls [14]. Conversely, in experimentally induced patellar instability in a rabbit model [9], the mean horizontal patellar diameter was significantly greater longer than in controls (P<0.001), while the patellar thickness was not significantly changed, resulting in a flatter shape. The mean Wiberg angle was higher in the patellar instability group (P<0.001), leading to flattened articular surface of the kneecap. Our study in dogs has identified only significantly reduced kneecap thickness (P<0.01). Thinner patella and greater Wiberg angle indicated hypoplasia of the patellar apex in canine stifles with grade II and III MPL.

The question whether the patellar shape is a cause of consequence of patellar luxation, is still disputable. The observed changes in patellar morphology in grade II and III MPL in dogs allowed affirming that the altered shape and thickness of the kneecap occurred consequently to the condition.

The limitations of the present study are the small number of examined canine stifles and the use of a single diagnostic imaging technique. Suggestions for future studies are increased number of healthy dogs and patients with MPL as well as use of other contemporary imaging techniques (computed tomography, magnitic resonance imaging) to compare and confirm the findings.

Conclusion

The results from this study allowed assuming that patellar shape was not a factor predisposing to onset of medial patellar luxation in small dog breeds. The increased retropatellar Wiberg angle and substantially decreased lateral patellar facet angle and patellar thickness, measured on tangential radiographs in joints with grade II and III MPL, provided evidence about hypoplasia of the patellar apex, decreased thickness and concave lateral facet of the patella resulting from the stronger pulling force exerted by m. quadriceps femoris in medial direction.

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Conflict of interest

The author report no conflicts of interest and is fully responsible for the content and writing of the paper.

References

Perry, K.L. and Déjardin, L.M., Canine medial patellar luxation. *J. Small Anim. Pract.*, **62**, 315-335 (2021).

Kim, D., Hwang, Y., Yoo, S., Oh, H. and Kim, G., Evaluation of diseases affecting hindlimb lameness in domestic small breed dogs. *J. Vet. Clin.* **37**(6), 297-300 (2020).

Andrade, M.C., Slunsky, P., Klass, L.G. and Brunnberg, L., Patellar luxation and concomitant cranial cruciate ligament rupture in dogs – a review. *Vet. Med. (Praha)* **67**(4), 163-178 (2022).

Ševčík, K., Hluchý, M., Ševčíková, M., Domaniža, M. and Ledecký, V., Inter-and intra-observer variations in radiographic evaluation of pelvic limbs in Yorkshire terriers with cranial cruciate ligament rupture and patellar luxation. *Vet. Sci.*, **9**(4), 179 (2022).

Aghapour, M., Bockstahler, B. and Vidoni, B. Evaluation of the femoral and tibial alignments in dogs: a systematic review. *Animals (Basel)* **11**(6), 1804 (2021).

Garnoeva, R., Evaluation of trochlear dysplasia in dogs with medial patellar luxation - comparative studies. *Acta Sci. Vet.*, **49**, 1845 (2021).

L'Eplattenier, H. and Montavon, P., Patellar luxation in dogs and cats: pathogenesis and diagnosis. *Compend. Contin. Educ Pract. Vet*., **24**, 234-240 (2002).

Souza, M.M.D., Rahal, S.C., Padovani, C.R., Mortari, A.C. and Mendes, P.N., Estudo retrospectivo de cães com luxação patelar medial tratados cirurgicamente. *Cienc. Rural*, **40**(6), 31–36 (2010).

Niu, J., Qi, Q., Niu, Y. Dong, C., Dong, Zh., Cui, P. and Wang, F., Patella morphological alteration after patella instability in growing rabbits. *J. Orthop. Surg. Res.*, **12**, 106 (2017).

Dejour, H., Walch, G., Nove-Josserand, L. and Guier, C., Factors of patellar instability: an anatomic radiographic study. *Knee Surg. Sports Traumatol. Arthrosc.,* **2**, 19-26 (1994).

Diks, M.J., Wymenga, A.B. and Anderson, P.G., Patients with lateral tracking patella have better pain relief following CT-guided tuberosity transfer than patients with unstable patella, *Knee Surg. Sports Traumatol. Arthrosc.,* **11**, 384-388 (2003).

Meissburger, V., Rougereau, G., Langlais, T., Boisrenoult, P. and Pujol, N., The severity of patellar and trochlear dysplasia are correlated. *Knee Surg. Sports Traumatol. Arthrosc.* Springer link, March 26 (2022). https://doi.org/10.1007/s00167-022-06945-0

Wiberg, G., Roentgenographic and anatomic studies on the femoropatellar joint. *Acta Orthop. Scand.,* **12**(1-4), 319-410 (1941).

Fucentese, S.F., von Roll, A., Koch, P.P., Epari, D.R., Fuchs, B. and Schottle, P.B., The patella morphology in trochlear dysplasia - a comparative MRI study. *Knee*, **13**(2), 145-150 (2006).

Jimenez, A.E., Levy, B.J., Grimm, N.L., Andelman, S.M., Cheng, C., Hedgecock, J.P., Cohen, A. and Pace, J.L., Relationship between patellar morphology and known anatomic risk factors for patellofemoral instability, *Orthop. J. Sports Med.,* **9**(3): 2325967120988690 (2021). doi: 10.1177/2325967120988690

Stäubli, H.U., Durrenmatt, U., Porcellini, B. and Rauschning, W., Anatomy and surface geometry of the patellofemoral joint in the axial plane. *J. Bone Joint Surg. Br.,* **81**(3), 452-458 (1999).

Pfirrmann, C.W., Zanetti, M., Romero, J. and Hodler, J., Femoral trochlear dysplasia: MR findings. *Radiology*, **216**(3):858-864 (2000).

Servien, E., Ait Si Selmi, T. and Neyret, P. Study of the patellar apex in objective patellar dislocation. *Rev. Chir. Orthop. Reparatrice Appar. Mot.,* **89**(7), 605-612 (2003).

Askenberger, M., Janarv, P-M., Finnbogason, T. and Arendt, E.A., Morphology and anatomic patellar instability risk factors in first-time traumatic lateral patellar dislocations, *Am. J. Sports Med.*, **45**(1), 50-58 (2017).

Parikh, S.N., Rajdev, N. and Sun, Q. The growth of trochlear dysplasia during adolescence, *J. Pediatr. Orthop.*, **38**(6), e318–e324 (2018).

Dickschas, J., Harrer, J., Bayer ,T., Schwitulla, J. and Strecker, W., Correlation of the tibial tuberosity–trochlear groove distance with the Q-angle, *Knee Surg. Sports Traumatol. Arthrosc.,* **24**, 915–920 (2014).

Garnoeva, R., Roydev, R., Paskalev, M. and Peichamperi, M., Radiographic measures of pelvic limb malaligment in small breed dogs with various grade of medial patellar luxation. *Comp. Clin. Pathol.,* **27**, 1551-1555 (2018).

Panni, A.S., Cerciello, S., Maffulli, N., Di Cesare, M., Servien, E. and Neyret, P., Patellar shape can be a predisposing factor in patellar instability. *Knee Surg. Sports Traumatol. Arthrosc.* **19**, 663-670 (2011).

Piermattei, D.L., Flo, G.L. and DeCamp, C.E., The stifle joint. In: *Brinker, Piermatei and Flo's Handbook of Small Animal Orthopaedics and Fracture Repair*, 4th ed. Philadelphia: Saunders, pp: 562-581 (2006).