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Original Research

Quantitative Computed Tomographic Assessment of Feline Stifles Following Block Recession Trochleoplasty and Tibial Tuberosity Transposition for Medial Patellar Luxation

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ABSTRACT

Objective This prospective study aimed to report femoro-patellar joint congruency assessed by computed tomography (CT) following block recession trochleoplasty (BRT) and tibial tuberosity transposition (TTT) in cats with medial patellar luxation (MPL).

Materials and Methods Six cats (median age 56 months; range 15–86 months) with 10 stifles with grades 2 ($n = 5$) and 3 ($n = 5$) MPL were enrolled. Standard BRT and TTT were performed. Standardized CT measurements of the trochlear groove (width, depth, and area) and patella (recessed area) were performed preoperatively (T0), immediately postoperatively (T1), and at a 6-week re-examination (T6) with stifles in extended and flexed positions.

Results Mean femoral trochlear area and depth increased significantly between T0–T1, T1–T6, and T0–T6 ($p < 0.05$). Mean recessed patellar area significantly increased between all time points when the stifle was flexed and between T0–T1 and T0–T6 when the stifle was extended ($p < 0.05$). Mean trochlear width increased significantly between T0 and T6 ($p < 0.05$). No cats had MPL recurrence at the 6-week follow-up.

Conclusion Block recession trochleoplasty combined with TTT improved patellar congruency immediately after surgery, with further improvement documented at the 6-week postoperative re-examination.

Keywords feline, medial patellar luxation, block recession trochleoplasty, computed tomography, stifle joint

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Introduction

The development of medial patellar luxation (MPL) is multifactorial but generally thought to involve anatomical abnormalities in the pelvic limb that result in quadriceps mechanism malalignment. Recent research has shown that cats with MPL have decreased proximal anteversion of the femur, decreased anatomical lateral distal femoral angle, medialization of the tibial tuberosity, and a shallow trochlear groove.[1,2] Due to these structural abnormalities, various surgical interventions have been proposed as potential solutions to rectify these anatomical irregularities.[3,4]

Block recession trochleoplasty (BRT) is a commonly performed surgical technique to deepen the femoral groove and improve femoro-patellar joint congruity. It is often combined with tibial tuberosity transposition (TTT) and soft tissue balancing procedures, including medial capsular/retinacular release and lateral fascial imbrication.[3,5,6]

While BRT has been well documented in dogs, there are limited clinical studies specifically focusing on its efficacy and outcomes in cats.[6]

Anatomical characteristics of the cat's stifle have been reported, and it has been observed that the patella is typically wider than the trochlea by approximately 1 mm.[7] Moreover, in normal cats, only a small portion, comprising roughly 10 to 20% of the patella's craniocaudal patellar thickness, is recessed beneath the trochlear ridges.[7] Recent advanced imaging studies using three-dimensional geometric morphometrics have further confirmed that the feline patella has a distinct and more uniform morphology compared with the wide variation seen in dogs, reinforcing the need for species-specific surgical considerations.[8]

To address the size discrepancy between the patella and trochlea, partial parasagittal patellectomy (PPP) has been purported as a potential solution.[7] This procedure involves removing the abaxial patellar surfaces to enhance the congruency between the patella and femoral trochlear groove. The results of a cadaveric-based study showed that PPP improves the area of femoro-patellar contact and the depth of patellar recession in cats. This study was conducted on cadaveric feline stifles not affected by MPL and did not provide evidence of clinical benefit in the short and long term to support the routine use of PPP in conjunction with BRT.[4,7]

To the best of our knowledge, no clinical studies have used computed tomography (CT) to evaluate changes in the femoro-patellar joint following BRT in feline patients affected by patellar luxation.

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The objectives of this study were to characterize the changes in femoral trochlear width and depth, recessed patellar area, and femoral trochlear area covered by the patella by performing a CT assessment of feline stifle joints after undergoing BRT combined with TTT at two specific time points: immediately after surgery and at 6 weeks after surgery. Specifically, we hypothesized that BRT would lead to an immediate increase in the proportion of recessed patellar area within the trochlear groove postoperatively and that further recession would occur between the immediate postoperative period and the 6-week re-examination.

Material and Methods

Cats presenting to Langford Vets Small Animal Referral Hospital were prospectively recruited into the study between 2020 and 2022. Ethical approval was obtained from the University of Bristol Welfare and Ethical Review Body, and informed consent was obtained from owners.

The initial diagnosis of MPL was established through an orthopedic examination performed by a board-certified surgeon or a supervised resident. The degree of patellar luxation was graded on a scale of 1 to 4.[9] Cats were excluded if they had systemic or neurological diseases or failed to report for the 6-week follow-up.

Computed tomography image acquisition: Under sedation or general anesthesia, preoperative (T0), postoperative (T1), and 6-week (T6) CT scans (Siemens 16 slice CT scanner; Siemens, Munich, Germany) were performed. Anesthetic and sedative protocols varied but typically involved combinations of dexmedetomidine, an opioid (methadone or fentanyl), and an induction agent (propofol or alfaxalone), with maintenance on isoflurane or sevoflurane. During the CT scan, cats were in sternal recumbency with hindlimbs positioned in both extension (150–165 degrees) and flexion (approximately 90 degrees), maintained with foam wedges.

Surgical procedure: All surgical procedures were performed by a board-certified surgeon or a supervised resident. Following a lateral parapatellar approach and joint exploration, a BRT was performed as previously described.[3,10] The recession was created using parallel saw cuts centered on the cranial aspect of the trochlear ridges, with the block recessed using a modular osteotome and mallet. Subsequently, tibia tuberosity transposition, medial capsular/retinacular release, and lateral imbrication were performed in all cases. TTT was performed by creating an osteotomy of the tibial tuberosity, transposing it laterally to align the quadriceps mechanism, and securing it with Kirschner wires and a tension band. The postoperative (T1) CT scan was performed prior to recovery.

Re-examination protocol: Approximately 6 weeks after surgery, all cats were re-examined. Sedated CT scans (T6) were performed identically to the initial examination.

Computed tomography image interpretation: A commercial DICOM viewer (Horos 64-bit v.4.0; Horos Project, Annapolis, MD,

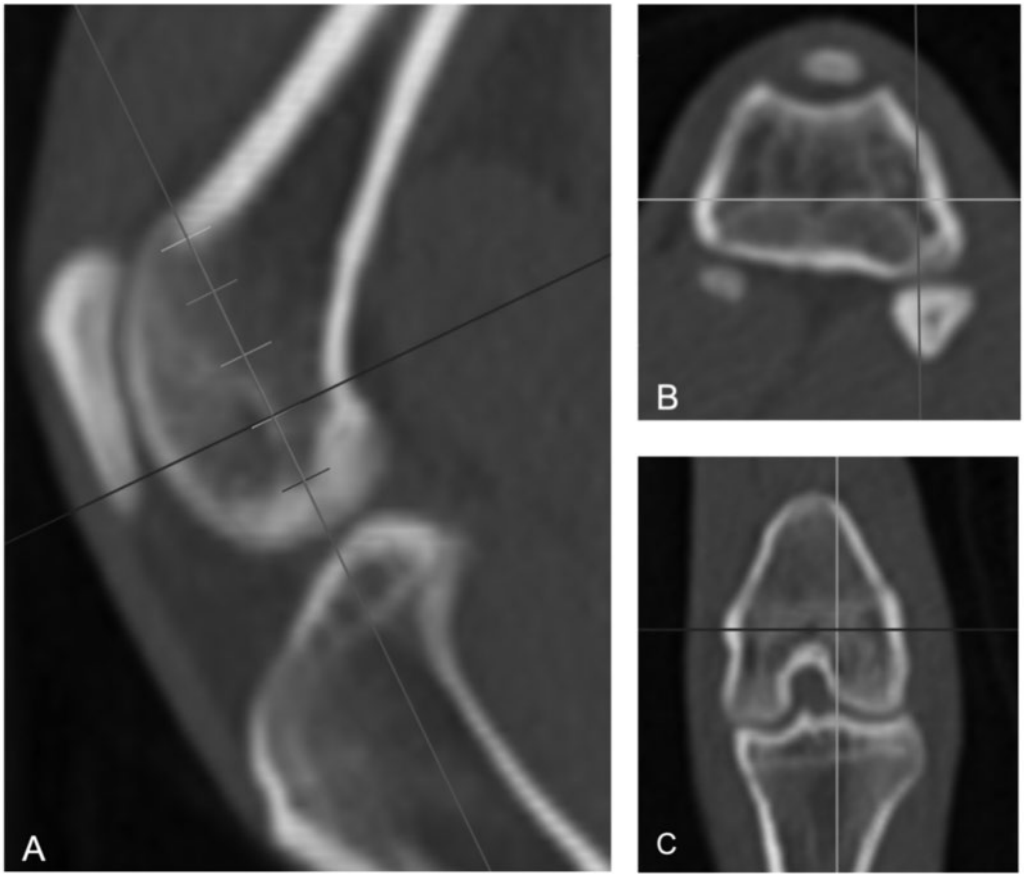


Fig. 1 CT multiplanar reconstructions for measurement planning. (**A**) Sagittal view showing five equidistant points on the lateral femur used to select transverse image planes. (**B**) A representative transverse image used for measurements. (**C**) Frontal view used for alignment.

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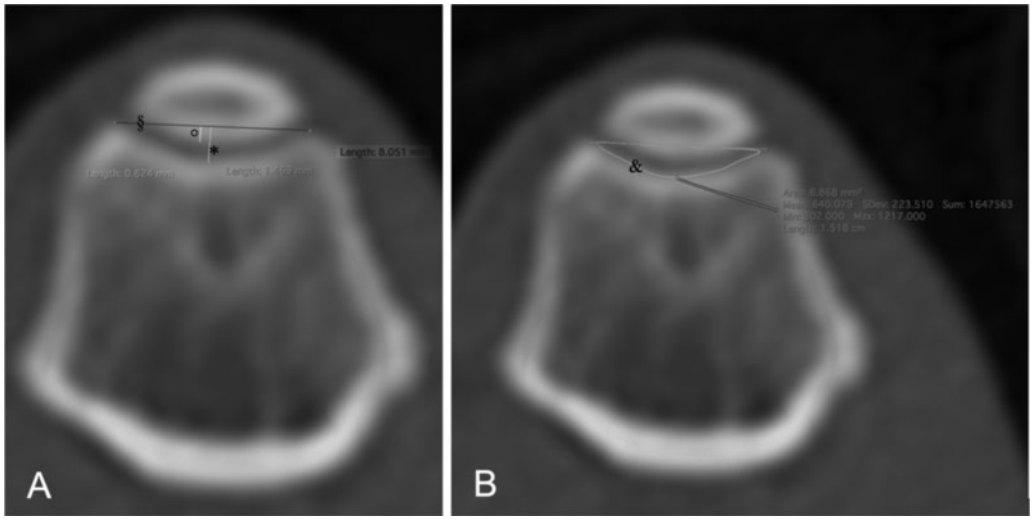


Fig. 2 Measurements on a preoperative transverse CT image. (**A**) Measurement of femoral trochlea width (§), trochlear depth (*), and recessed patellar depth (°). (**B**) Measurement of the femoral trochlear area (&), traced using the "close polygon" tool.

USA) was used to generate three-dimensional multiplanar reconstructions (MPR). An ECVS surgical resident performed the measurements. Measurements were performed once for each time point.

The MPR was manipulated to establish a transcondylar axis in the transverse plane of the femur (**Fig. 1**). In the sagittal plane, a line was drawn from the center point of the extensor fossa to the most proximal aspect of the trochlea. Along this line, five equidistant points were identified, which were used to select five individual transverse images for subsequent measurements. Although our specific protocol was developed for this study, the principles of using multiplanar reconstructions and defined anatomical landmarks for trochlear assessment are based on established techniques in both dogs and cats.[11–13] These measurements were performed for all scans (T0, T1, and T6) in both flexed and extended positions.

The femoral trochlear width and depth were measured (**Fig. 2**). A line was drawn across the most cranial aspect of the trochlear ridges. The distance between the ridges' most lateral and medial points was the femoral trochlear width. The trochlear depth was a perpendicular line from the first line to the center of the trochlear surface.

The patellar area and the recessed patellar area were measured in mm^2 (**Fig. 3**). The recessed patellar area was measured by outlining the area of the patella that fell below the line drawn across the trochlear ridges. This represents the portion of the patella engaged within the trochlear groove.

Femoral trochlear area was measured in mm^2 by tracing along the internal surface of the trochlear groove. The line across the trochlear ridges served as the dorsal limit.

The femoral trochlear area covered by the patella was measured as a percentage, calculated from the difference between the femoral trochlear area and the recessed patellar area values. This calculation provided an index of patellofemoral contact.

Data analysis: Descriptive statistics were calculated. Differences between time points (T0, T1, T6) were assessed using a two-sample *t*-test with Holm-Bonferroni adjustment ($p < 0.05$). The relationship between recessed patellar area and femoral trochlear area was analyzed using Pearson's correlation test.

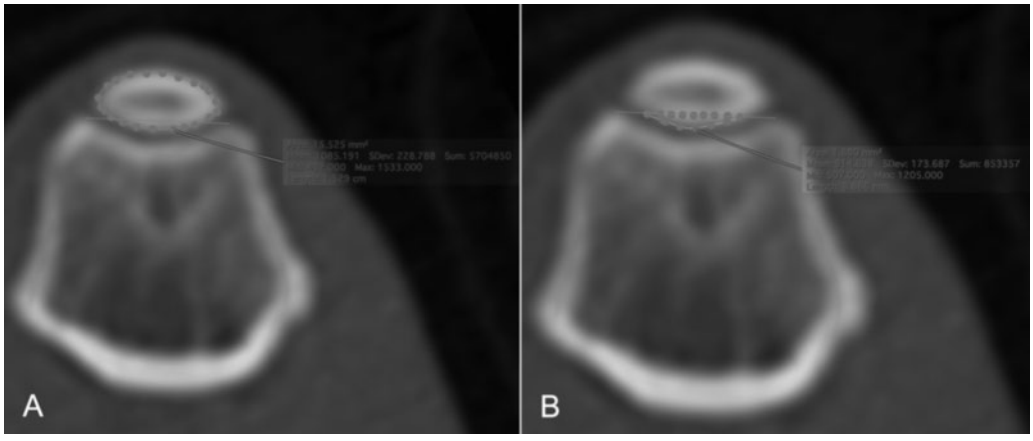


Fig. 3 Measurement of (**A**) total patellar area and (**B**) recessed patellar area on preoperative transverse CT images.

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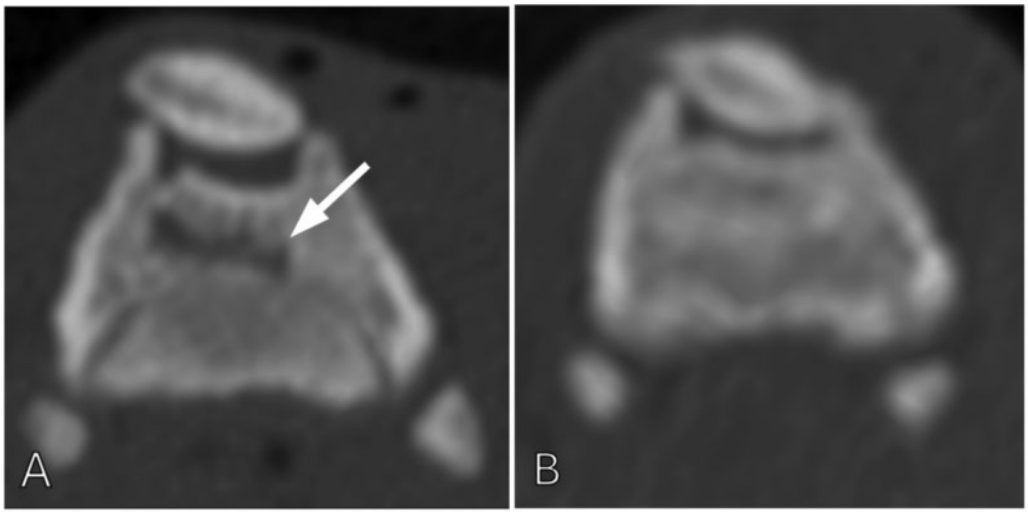


Fig. 4 Transverse CT images from one cat. (**A**) Immediately postoperative (T1), showing a gas-filled gap (arrows) caudal to the recessed block. (**B**) At 6 weeks postoperatively (T6), showing resolution of the gap, suggesting block subsidence.

Results

Six cats were recruited for this study. The breeds included Domestic Short Hair ($n = 2$), Maine Coon ($n = 2$), British Short Hair ($n = 1$), and Ragdoll ($n = 1$). The cats ranged in age from 15 to 86 months (median = 56 months), and all were neutered (4 males, 2 females). Four cats had bilateral MPL, while two had unilateral MPL, for a total of 10 operated stifles. The 10 limbs with MPL were graded as follows: 5 were grade 2 and 5 were grade 3. One cat did not have a preoperative extended leg CT scan; statistical analysis was corrected accordingly. The follow-up CT scan was performed a mean of 40 days following surgical procedures (range 28–53 days).

All surgeries were performed without intraoperative complications. The patella was assessed to be in the correct anatomical position within the groove immediately post operation based on direct intraoperative visualization and palpation. There were no postoperative complications at the 6-week re-examination, and the patella was stable in all patients. Immediate postoperative CT scans (T1) revealed the presence of gas-filled gaps beneath the newly created block in all cases (**Fig. 4**), which were absent in the T6 CT scans. Additionally, mild patellar tipping was observed in some cases at T1, which had resolved by the 6-week re-examination (**Fig. 5**).

Femoral trochlear width: Femoral trochlear width significantly increased from T0 to T6 ($p < 0.05$) (**Table 1**).

Femoral trochlear depth: Femoral trochlear depth was significantly increased between T0 and T1 ($p < 0.05$), T1 and T6 ($p < 0.05$), and T0 and T6 ($p < 0.05$) (**Table 1**).

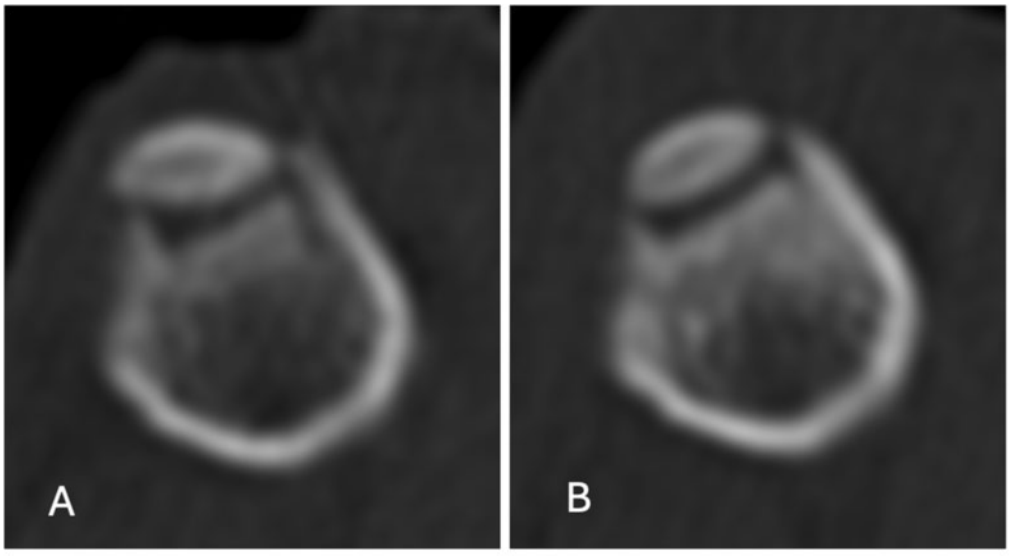


Fig. 5 Transverse CT images from one cat. (**A**) Immediately postoperative (T1), showing mild patellar tipping. (**B**) At 6 weeks postoperatively (T6), showing resolution of the tipping and improved patellar tracking.

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Table 1 Measured parameters at each time point (mean ± standard deviation)

	T0	T1	T6
Femoral trochlear width (mm)	7.07 ± 1.66	7.32 ± 1.12	8.02 ± 1.83[a]
Femoral trochlear depth (mm)	1.16 ± 0.25	1.95 ± 0.34[a]	2.36 ± 0.53[ab]
Femoral trochlear area (mm^2)	5.93 ± 1.92	11.41 ± 3.57[a]	15.83 ± 5.31[ab]
Recessed patellar area Ext (mm^2)	0.13 ± 0.34	1.61 ± 0.83[a]	1.55 ± 1.10[a]
Recessed patellar area Flex (mm^2)	0.43 ± 0.67	2.33 ± 0.69[a]	4.97 ± 2.77[ab]
Femoral trochlear area covered by patella Ext (%)	3% ± 8%	13% ± 7%[a]	10% ± 8%[a]
Femoral trochlear area covered by patella Flex (%)	5% ± 8%	19% ± 6%[a]	30% ± 9%[ab]
Patellar area (mm^2)	15.54 ± 5.22	13.23 ± 4.11	13.79 ± 3.26

[a]Indicates a statistically significant increase compared with T0–T1 and T0–T6.
[b]Indicates a statistically significant increase between T1 and T6.

Femoral trochlear area: The femoral trochlear area showed a statistically significant increase at T0–T1 ($p < 0.05$), T1–T6 ($p < 0.05$), and between T0 and T6 ($p < 0.05$) (Table 1).

Patellar area: The total patellar area was not significantly different between time points, with $p = 0.12$ at T0–T1, $p = 0.63$ at T1–T6, and $p = 0.12$ at T0–T6 (Table 1).

Recessed patellar area: A significant increase was present between all time points when the stifle was flexed: T0–T1 ($p < 0.05$), T1–T6 ($p < 0.05$), and T0–T6 ($p < 0.05$). When the stifle was extended, the difference was only present at T0–T1 and T0–T6 ($p < 0.05$) (Table 1).

Femoral trochlear area covered by the patella: A significant increase ($p < 0.05$) was present between all time points when the stifle was flexed. When extended, the difference was only present at T0–T1 and T0–T6 ($p < 0.05$) (Table 1).

Correlation between recessed patellar area and femoral trochlear area: A positive correlation was found at T1 and T6 only when the stifle was flexed ($p < 0.05$, respectively).

Discussion

The primary objective of our study was to examine the changes in the trochlea and patellar position in cats affected by MPL following BRT combined with TTT. We initially hypothesized that the surgical procedure would have an immediate impact on the position of the patella and the trochlear groove. In accordance with our hypotheses, statistically significant increases occurred in several key parameters, including femoral trochlear depth, area, recessed patellar area, and the area of the trochlea covered by the patella between the initial surgery and the 6-week follow-up examinations.

The increase in recessed patellar area found in our study contradicts the findings of a previous cadaveric study, which suggested an increase in the recessed patellar area only occurs when BRT is combined with PPP.[7] Our study demonstrates that BRT effectively increases the recessed patellar area, resulting in improved coverage of the newly created groove supporting our first hypothesis. The differences between our findings and those of the previous cadaveric study may be explained by the fact that our study involved cats with clinical patellar luxation and pre-existing anatomical abnormalities, whereas the cadaveric study was conducted on cats with normal distal femoral anatomy.

We did not intentionally perform a wider BRT; the dimensions of the trochleoplasty were based on the standard technique. Given the relatively broad patella in these cases, a wider BRT may be a natural consequence of applying the standard technique to a dysplastic, shallower groove. Furthermore, performing BRT on a shallower groove may inherently allow for a greater degree of recession compared with procedures on anatomically normal trochleae.

Furthermore, recent investigations into alternative trochleoplasty techniques support the concept that sulcoplasty alone is sufficient. A clinical study using semi-cylindrical recession trochleoplasty (SCRT) reported successful short-term outcomes without requiring PPP.[14] This is consistent with biomechanical data showing that both BRT and SCRT are effective at restoring normal patellofemoral contact pressures, reinforcing that a properly executed trochleoplasty is the critical corrective procedure.[15]

We further documented the progression of morphological changes in the femoral trochlear area, depth, and width, as well as recessed patellar area and area of the trochlea covered by the patella, therefore validating our second hypothesis. We speculated that the significant increase in these values could indicate an ongoing process of remodeling and expansion of the trochlear groove and the positioning of the patella following BRT. These changes can be attributed to the subsidence of the block. As noted in the results, gas-filled gaps present beneath the block at T1 had resolved by T6, supporting the occurrence of subsidence. Alternatively, it is plausible that the surgical intervention, along with the restoration of the correct patellar positioning, induced bone remodeling changes that contributed to the observed alterations.

Previous studies have documented that bone remodeling does indeed occur and have emphasized the crucial role of patellar position within the groove in the proper development of the femoral trochlear groove in young humans and growing laboratory animals.[16–18] Although our study focuses on adult cats, it is important to highlight that bone remodeling is possible and may also occur in larger, more mature subjects. We also observed a significant change in femoral trochlear width

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between T0 and T6 but not between T0 and T1 or T1 and T6, supporting the hypothesis of bone remodeling. The BRT procedure is not expected to significantly impact the width of the groove, as confirmed by the absence of significant changes between T0 and T1. Although the increase between T1 and T6 ($p < 0.08$) did not reach statistical significance, in our opinion, these findings suggest a potential bone remodeling process occurring in the femoral trochlear groove during this period. It is also plausible that a combination of the two aforementioned processes, subsidence of the block and bone remodeling processes, equally contributes to the observed changes. Furthermore, the resolution of transient postoperative patellar tipping observed in some cases by the 6-week re-examination (**Fig. 5**) provides additional evidence of favorable joint adaptation in the live patient, contrasting with the static nature of cadaveric assessments. The surgical intervention likely initiated a cascade of remodeling processes led by the correct position of the patella and subsequent bone adaptation.

During the recovery period (T1–T6), significant changes in the recessed patellar area and the area of the trochlea covered by the patella were observed exclusively during flexion, whereas no significant changes were observed during extension, as previously documented (T0–T1). This discrepancy can be attributed to the increased forces exerted on the patella–trochlea complex during flexion, which are significantly reduced during extension due to the relaxation of the flexor muscles of the stifle. Our clinical study found no statistically significant changes in patellar area despite some variation in value (**Table 1**). This could be attributed to the patella's mobility and our use of femoral landmarks for measurement. These findings suggest that in cats with medial patellar luxation treated with this protocol, patellar recession can be improved without patellar intervention, and the combination of BRT with TTT was associated with stable patellae at 6 weeks.

Although all cases in our study exhibited stable patellae in the immediate postoperative period, it remains unclear whether the BRT and improved patellar recess significantly contributed to this stability. Given the considerable patellar laxity observed in normal cats, TTT alone may be sufficient to correct patellar luxation in this species. Although the precise effect of TTT in cats requires further study, its importance in correcting the quadriceps mechanism alignment has been well-documented in dogs using similar CT-based assessments.[19] A prospective study comparing TTT alone to TTT combined with BRT in cats is warranted.

This study has certain limitations that need to be considered. First, the relatively small number of cases. Second, the relatively short time between the postoperative scan and the re-examination may not have been sufficient to identify all the anatomical changes at the trochlear level, especially considering the adult age of the cats. A longer-term follow-up, for instance at 6 months, would be beneficial to assess for ongoing bone remodeling and, importantly, to evaluate for the potential development of secondary osteoarthritis, which could be a consequence of altering joint mechanics. Lastly, measurements were performed by a single investigator and were not repeated, so intra-observer variability was not assessed.

In conclusion, our study demonstrated significant morphological changes in the trochlear groove following BRT and TTT, leading to improved positioning of the patella. Over time, we observed a progressive enhancement in the patella's position within the trochlear groove, which could indicate ongoing remodeling and adaptation of the joint structures. The clinical relevance of our findings suggests that patellar luxation treated via BRT associated with TTT may enhance femoro-patellar stability, and additional procedures such as PPP may not be required.

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Statements and Additional Information

Conflict of Interest The authors declare that they have no conflict of interest.

Contributors' Statement L.B. contributed to collecting of the data, performed the analysis, contributed data or analysis tools; S.L.-H. conceived and designed the analysis, contributed data or analysis tools, and wrote the paper; J.W. contributed in grant and ethical approval application; N.B. conceived and designed the analysis, contributed data or analysis tools, and wrote the paper.

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