Austral Journal of Veterinary Sciences

Austral J Vet Sci 57, e5702 (2025)
https://doi.org/10.4206/ajvs.57.02

CASE REPORT

Application of a patient-specific saw guide for patellar groove replacement in a dog with medial patellar luxation, osteoarthritis, and femoral varus: A case report

Jongchan Ko, Yong Yu, Namsoo Kim, Suyoung Heo*

Department of Veterinary Surgery, College of Veterinary Medicine, Jeonbuk National University, Iksan, Republic of Korea.

Article History
Received: 12.10.2024
Accepted: 13.01.2025
Published: 20.03.2025

Corresponding author
* Suyoung Heo
syheo@jbnu.ac.kr

ABSTRACT. This case report describes the application of a patient-specific saw guide (PSSG) for patellar groove replacement (PGR) in a dog with severe medial patellar luxation, stifle osteoarthritis, and minor femoral varus deformity. The design, fabrication, and surgical implementation of the PSSG is described, highlighting its feasibility and potential to improve the precision of osteotomy and implant placement in complex orthopedic cases.

Keywords: Bone deformity, dog, guide, implant, patellar luxation.

INTRODUCTION

Patellar groove replacement (PGR) is a potential treatment for severe femoropatellar osteoarthritis (OA) (Dokic *et al*., 2015), since PGR prostheses have a low-friction surface that aids smooth patella gliding, reducing tissue damage and inflammation. In addition, moderate limb deformities can be compensated using PGR. The surgeon's experience is crucial for actualizing preplanned osteotomy and inserting the implant at the correct angle to decrease intraoperative complications (Panichi *et al*., 2024).

The application of patient-specific saw guides (PSSGs) has significantly enhanced orthopedic surgical precision and outcomes in humans, facilitating more accurate osteotomies, reducing intraoperative blood loss, shortening operating times, and improving patient safety and surgical efficiency, as demonstrated in human cadaveric studies (Meng *et al*., 2022; Aiba *et al*., 2023). Furthermore, successful use of a 3D-printed patient-specific guide has been reported in cats with comminuted mid-diaphyseal humeral fractures (Oxley, 2018).

Correcting femoral varus deformity during PGR is essential for optimal joint alignment and function. A large anatomical lateral distal femoral angle (aLDFA) contributes to medial patellar luxation (MPL) in canines owing to altered mechanical forces (Tomlinson *et al*., 2007; Perry *et al*., 2017). Addressing biomechanical issues by correcting the aLDFA can reduce the risk of MPL recurrence. Therefore, this case report aims to investigate the feasibility and potential benefits of utilizing a PSSG to enhance the surgical outcome of PGR in a dog with MPL, severe stifle joint OA, and minor femoral varus deformity.

A nine-year-old castrated male Dalmatian, weighing 26.9 kg, was referred to the Jeonbuk Animal Medical Center (Jeonbuk National University, College of Veterinary Medicine, Jeollabuk-do, South Korea) for evaluation of non-weight-bearing lameness in the left hindlimb. Gait analysis identified grade 3 lameness (Witte & Scott, 2011). A static weight-bearing ratio of 3:7 between the left and right hindlimbs was recorded using a force-sensing resistor (MS9717; Kitronyx, Seoul, South Korea). Advanced degenerative joint disease (DJD) was diagnosed with grade 4 MPL and joint thickening. Radiographic and computed tomography (CT) evaluations of the left stifle joint conducted using an Alexion TSX-034A scanner (Canon Medical Systems, Tokyo, Japan) revealed an aLDFA of 104.6°, no evidence of femoral torsional deformity, and a mechanical medio-proximal tibial angle of 88° (Figure 1). Owing to irreversible cartilage degeneration, PGR was deemed necessary, and PSSG was employed to ensure precise removal of the degenerated areas and accurate placement of the implant.

The PSSG was designed to achieve three main objectives: secure rigid contact with the bone, precise cutting of the degenerated femoral trochlea, and accurate positioning of the PGR implant to address the femoral varus deformity (Figure 1). Preoperative surgical simulation involved a 3D-printed bone model (Figure 1). For PSSG fabrication, CT scans were used for surgical planning and 3D modeling. CT images in DICOM format were converted into STL files using Mimics Medical software (Materialize, Leuven, Belgium). The PSSG was designed using Fusion 360 (Autodesk, California, USA) and printed with a Pixel One resin printer (Zerone, Gyeonggi, Republic of Korea) using a medical-grade resin (clear-SG, One Digital System, Incheon, South Korea).

During surgery, the patella was medially luxated in dorsal recumbency using a lateral parapatellar approach. Although

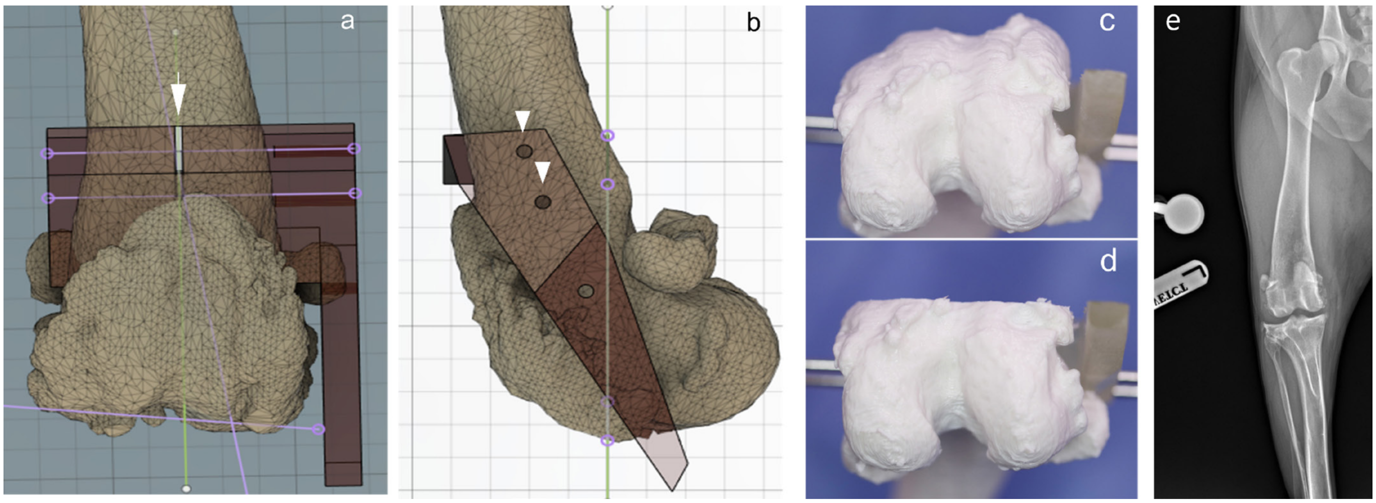

Figure 1.
Frontal view (a) and sagittal view (b) of the patient-specific saw guide (PSSG) of the left femur. The anatomical axis (green line) was measured and marked on the PSSG (arrow) to ensure correct implant alignment. Two 1.8 mm K-wire holes (arrowhead) were designed to temporarily fix the implant with the bone. The patient-specific saw guide (PSSG) was installed on a bone model with two 1.8 mm K-wires (c) and osteotomy was performed (d). The bone was printed with Polylactic acid (PLA) filament, and the PSSG was made with medical-grade resin. Preoperative craniocaudal radiograph of the left femur (e).

joint fluid aspiration did not yield specific findings, stifle joint exposure confirmed the integrity of the cruciate ligaments and the lateral digital extensor tendon. The PSSG was secured with 1.4 mm K-wires and osteotomy was guided by the PSSG to correct the anatomical lateral distal femoral angle by 10º. The subsequent steps included securing the base plate, press-fitting the trochlear prosthesis, conducting patelloplasty, medial fascial release, and lateral imbrication to accommodate the patella and alleviate tension (Figure 2).

The PGR procedure using the PSSG was executed seamlessly with no intraoperative complications. Subsequent orthogonal postoperative radiography confirmed the osteotomy line, and the implant was positioned at the initially planned angle. Radiographic examinations and gait assessments were performed. Nine days postoperatively, the pressure sensor evaluations indicated that the weight distribution between the right and left sides was normalized to a 50:50 ratio. However, at eight weeks post-procedure, MPL recurrence (grade 3) was observed. This was addressed with a tibial tuberosity transposition (TTT) using the tibial tuberosity transposition tool and tension band wiring. One-month post-intervention, pressure sensor assessments indicated that the weight distribution between the right and left sides was adjusted to a 56:44 ratio, signaling a move towards normalization.

Severe OA of the stifle joint can present significant contraindications to traditional trochleoplasty due to extensive cartilage erosion and osteophyte formation. In such cases, PGR is a viable option for restoring joint function and stability in dogs (Dokic *et al.*, 2015; Jaworski *et al.*, 2022). The use of PSSG for PGR in severe OA presents significant advantages, particularly when addressing complex bone deformities and ensuring precise surgical outcomes (Aiba *et al.*, 2023). Osteoarthritis poses substantial challenges in PGR procedures due to osteophytes, altered bone quality, and joint deformities, which complicate osteotomy and implant placement (Aiba *et al.*, 2023; Lawless *et al.*, 2022). However, the implementation of PSSG facilitates precise cutting and accurate positioning of implants, thereby overcoming these obstacles.

The stable positioning of the implant and the absence of postoperative complications demonstrate the feasibility of using PSSG for PGR. This suggests that PSSG may offer potential benefits in complex orthopedic surgeries. This precise alignment and stable positioning of the implant contributed to improved joint function and reduction in postoperative complications, demonstrating the significant benefits of using PSSG for complex orthopedic surgeries. In this case, the PSSG enabled precise osteotomy and implant placement, resulting in no complications. Postoperative evaluation revealed that by day nine, the dog had achieved a balanced weight distribution of 50:50 between both hindlimbs, indicating significant functional recovery (Linder *et al.*, 2021), which underscores the potential of PSSG in PGR procedures to achieve satisfactory results. The use of PSSG is pivotal for ensuring the correct alignment and stability of the implant, potentially leading to an optimal surgical outcome and enhanced postoperative recovery.

PGR procedures can correct femoral varus deformities of up to 10°, which is crucial for restoring the proper biomechanics in the stifle joint. Additionally, a high aLDFA contributes to the incidence of MPL in canines owing to altered mechanical forces (Perry *et al.*, 2017). In this case, the aLDFA was corrected by rotating the PGR implant, ultimately adjusting the aLDFA to 94°, addressing the biomechanical issues and reducing the risk of MPL recurrence. Postoperative evaluations confirmed successful correction, with the implant accurately positioned and a balanced

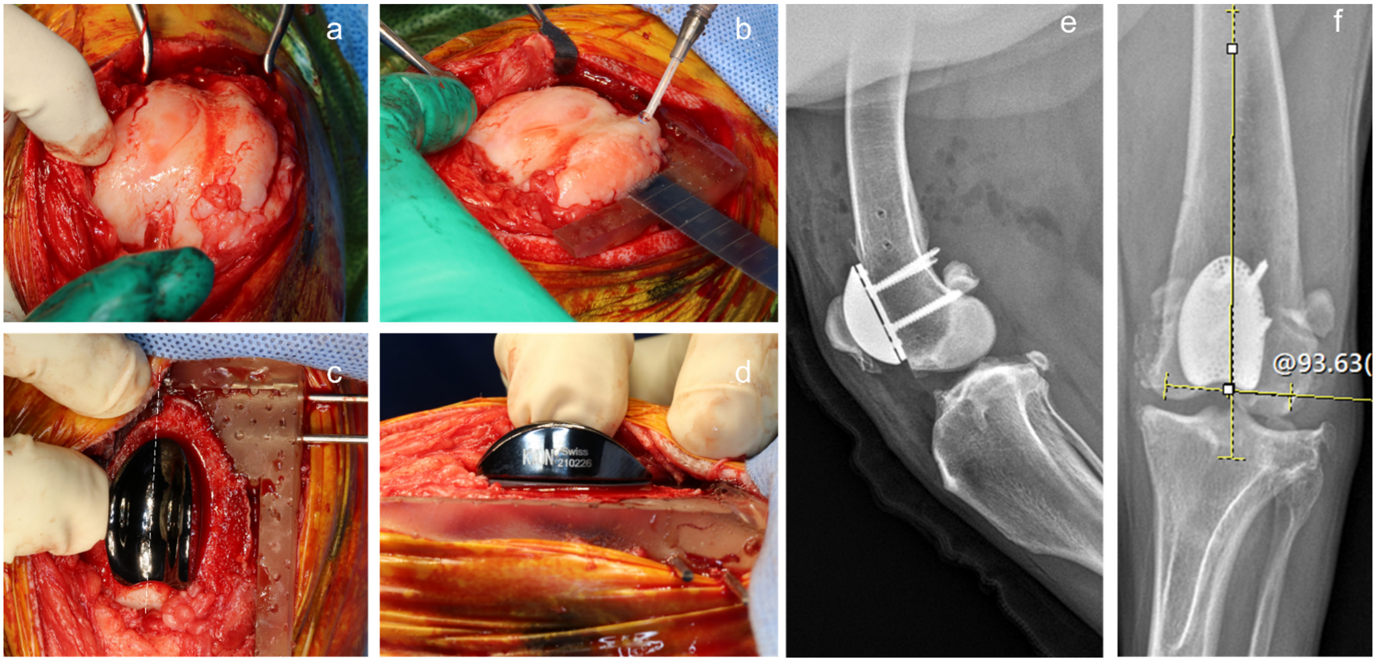

Figure 2.
A lateral parapatellar approach was used and the patella was luxated medially (a). The tissue surrounding the site of the PSSG was undermined, the PSSG was secured with K-wires, and then osteotomy was performed (b). The patellar groove replacement implant was aligned and applied according to the mark (white dashed line) (c). The osteotomy line was confirmed from the lateral view (d). Post-operative X-ray images: on lateral view (e), the osteotomy line was made above the long digital extensor tendon as preplanned, and two radiolucent K-wire holes were verified (arrowhead) and shown to have resolved gradually without complications; on craniocaudal view (f), the patellar groove replacement implant was applied accurately to the intended angle (anatomic lateral distal femoral angle: 94°).

weight distribution between both hind legs by day nine. This demonstrates the potential of PGR to achieve satisfactory anatomical correction, enhance surgical outcomes, and mitigate postoperative complications in complex orthopedic cases.

The recurrence of MPL in this case was likely due to inadequate postoperative restriction of physical activity. The dog's postoperative regimen may not have been sufficiently stringent to prevent undue stress on the stifle joint. Early postoperative exercise can hinder soft tissue healing and compromise the stability of the implant, leading to MPL recurrence. Strict adherence to postoperative care, including limiting physical activity, is crucial for successful outcomes in orthopedic procedures involving complex implants (Oxley, 2018), and is vital to mitigate complications such as MPL recurrence (Perry *et al.*, 2017). Another significant consideration is biomechanical alterations following PGR. Despite precise implant placement, the inherent biomechanical stresses on the joint may predispose patients to recurrent luxation. Achieving optimal alignment and stability postoperatively is critical to reduce the risk of recurrence in joint replacement procedures (Meng *et al.*, 2022). The complexity of MPL cases with concurrent OA necessitates meticulous surgical planning and execution to ensure long-term stability and functionality of the joint. In this case, despite achieving an initially balanced weight distribution postoperatively, recurrence suggested that further biomechanical stabilization measures, such as enhanced soft tissue reconstruction or additional osteotomies, may be required to sustain surgical outcomes. Subsequent TTT was performed, leading to significant functional recovery at eight weeks postoperatively.

Although this case highlights the potential benefits of PSSG in PGR, it is crucial to acknowledge its limitations. As a single case report, the findings may not be generalizable, and further studies with larger and more diverse patient populations are warranted to validate these results. Moreover, the costs of CT imaging, 3D modeling, and printing, along with the technical expertise required for PSSG fabrication, may limit its widespread adoption.

In conclusion, this case report demonstrates the feasibility and potential benefits of the patient-specific saw guide for patellar groove replacement in dogs with severe medial patellar luxation, stifle osteoarthritis, and minor femoral varus deformities. Precise osteotomy and accurate implant placement achieved with a patient-specific saw guide are essential for restoring joint function and stability, although the recurrence of medial patellar luxation highlights the need for stringent postoperative management and adaptive surgical strategies.

DECLARATIONS

Competing Interests Statement

The authors declare that they have no competing interests.

Ethical Statement

Informed consent was obtained from the dog's owner for this study.

Author Contributions

Conceptualization: Ko J.C., Yu Y.; Data curation: Ko J.C., Yu Y.; Investigation: Yu Y.; Supervision: Heo S.Y.; Writing - original draft: Ko J.C. Writing - review & editing: Kim N.S., Heo S.Y.

Funding

This research received no external funding.

Acknowledgements:

The authors would like to thank the Department of Veterinary Surgery at Jeonbuk National University for assistance with the experiments.

REFERENCES

Aiba, H., Spazzoli, B., Tsukamoto, S., Mavrogenis, A. F., Hermann, T., Kimura, H., Murakami, H., Donati, D. M., & Errani, C. (2023). Current concepts in the resection of bone tumors using a patient-specific three-dimensional printed cutting guide. *Current Oncology*, *30*(4), 3859–3870. https://doi.org/10.3390/curroncol30040292

Dokic, Z., Lorinson, D., Weigel, J. P., & Vezzoni, A. (2015). Patellar groove replacement in patellar luxation with severe femoro-patellar osteoarthritis. *Veterinary and Comparative Orthopaedics and Traumatology*, *28*(02), 124–130. https://doi.org/10.3415/VCOT-14-07-0106

Jaworski, J., Krukowski, M., Gosling, M., & Burton, N. (2022). Patellar groove replacement in a cat. *VCOT Open*, *05*(02), e71–e77. https://doi.org/10.1055/s-0042-1751071

Lawless, M., Swendseid, B., Von Windheim, N., VanKoevering, K., Seim, N., & Old, M. (2022). Review of cost and surgical time implications using virtual patient specific planning and patient specific implants in midface reconstruction. *Plastic and Aesthetic Research*, *9*, 26. https://doi.org/10.20517/2347-9264.2021.108

Linder, J. E., Thomovsky, S., Bowditch, J., Lind, M., Kazmierczak, K. A., Breur, G. J., & Lewis, M. J. (2021). Development of a simple method to measure static body weight distribution in neurologically and orthopedically normal mature small breed dogs. *BMC Veterinary Research*, *17*(1), 110. https://doi.org/10.1186/s12917-021-02808-x

Meng, M., Wang, J., Sun, T., Zhang, W., Zhang, J., Shu, L., & Li, Z. (2022). Clinical applications and prospects of 3D printing guide templates in orthopaedics. *Journal of Orthopaedic Translation*, *34*, 22–41. https://doi.org/10.1016/j.jot.2022.03.001

Oxley, B. (2018). A 3-dimensional-printed patient-specific guide system for minimally invasive plate osteosynthesis of a comminuted mid-diaphyseal humeral fracture in a cat. *Veterinary Surgery*, *47*(3), 445–453. https://doi.org/10.1111/vsu.12776

Panichi, E., Sassaroli, S., Ciccarese, G. M., Riccio, V., Balestriere, C., Barbaccia, M., Cappellari, F., Burkhan, E., & Palumbo Piccionello, A. (2024). Use of a custom-made patellar groove replacement in an american staffordshire terrier puppy with a severe bone defect in the femoral trochlea caused by hematogenous osteomyelitis. *Animals*, *14*(6), 909. https://doi.org/10.3390/ani14060909

Perry, K., Adams, R., Andrews, S., Tewson, C., & Bruce, M. (2017). Impact of femoral varus on complications and outcome associated with corrective surgery for medial patellar luxation. *Veterinary and Comparative Orthopaedics and Traumatology*, *30*(04), 288–298. https://doi.org/10.3415/VCOT-16-09-0132

Tomlinson, J., Fox, D., Cook, J. L., & Keller, G. G. (2007). Measurement of femoral angles in four dog breeds. Veterinary Surgery, 36(6), 593–598. https://doi.org/10.1111/j.1532-950X.2007.00309.x

Witte, P., & Scott, H. (2011). Investigation of lameness in dogs. *In Practice*, *33*(2), 58–66. https://doi.org/10.1136/inp.d453