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Journal

Veterinary Surgery, 53(5)

ISSN

0161-3499

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Publication Date

2024-07-01

DOI

10.1111/vsu.14113

Peer reviewed

Received: 4 December 2023 | Revised: 22 April 2024 | Accepted: 5 May 2024

DOI: 10.1111/vsu.14113

CLINICAL RESEARCH

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The impact of surgery resident training on the duration of tibial plateau leveling osteotomy surgery

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Abstract

Objective: To investigate the impact of surgery resident training on surgery duration in tibial plateau leveling osteotomy (TPLO) and evaluate whether surgery duration differs with each year of residency training.

Study design: Retrospective medical record review.

Animals: A total of 256 client-owned dogs underwent TPLO.

Methods: Records of dogs that underwent TPLO between August 2019 and August 2022 were reviewed. The effects of the surgeon (faculty/resident) and the procedure (arthrotomy/arthroscopy) on TPLO surgery duration were examined with an analysis of variance, and geometric least squares means (GLSM) were compared. A linear mixed effects model (LMM) was fitted to quantify fixed and random effects.

Results: Four faculty surgeons performed 74 (29%) TPLOs, while 10 residents performed 182 (71%) TPLOs under the direct supervision of a faculty surgeon. All TPLOs were conducted with arthrotomy (109; 43%) or arthroscopy (147; 57%). Overall, residents (GLSM, 153 min) required 54% more surgery duration than faculty surgeons (GLSM, 99 min). Surgery duration among first-year residents (GLSM, 170 min) was 15% longer than second- (GLSM, 148 min) and third-year (GLSM, 147 min) residents, whereas the duration did not differ statistically between second- and third-year residents. Arthroscopy, meniscal tear treatment, surgery on the right stifle, and increasing patient weight were also associated with longer surgery duration.

Conclusion: The duration of TPLO surgery significantly decreased after the first year of residency, but did not decrease afterward.

Clinical significance: The results will aid with resource allocation, curricula planning, and cost management associated with resident training.

Meeting: The results of the study were presented at the 2024 Veterinary Orthopedic Society meeting.

1 | INTRODUCTION

Tibial plateau leveling osteotomy (TPLO) is a surgical technique commonly used in veterinary surgery to treat cranial cruciate ligament rupture in dogs.[1,2] Since TPLO has a high success rate with a low complication rate, it is considered an effective surgical technique for treating this condition and has become increasingly popular among veterinary surgeons.[3–7] However, TPLO requires a high level of skill and training to achieve optimal outcomes.

Training constitutes an essential aspect in acquiring proficiency in learning any new surgical procedures. The learning process for surgery has been characterized in several studies.[8–10] These studies found that substantial training was required to be proficient in new surgical procedures with a high success rate and a low complication rate. While training veterinary surgery residents is essential to prepare them to become well-qualified board-certified surgeons, the time and cost required for resident training have important implications. In human medicine, training surgery residents to perform surgical procedures is significantly associated with increased surgery duration and cost.[11–14] As in human medicine, surgical procedures in veterinary medicine can be costly, and reducing surgery duration leads to cost savings. However, the change in surgery duration associated with resident training in TPLO has not been investigated.

The objectives of this study were to investigate the impact of resident training in TPLO on surgery duration and evaluate whether surgery duration differs with each year of residency training. We hypothesized that TPLO performed by a resident under the direct supervision of a faculty surgeon (FS) would be associated with increased surgery duration relative to surgery performed by an FS without a resident, but that surgery duration would decrease as the resident progressed through their three-year training program.

2 | MATERIALS AND METHODS

2.1 | Study population

Medical records of client-owned dogs that underwent TPLO between August 2019 and August 2022 at the William R. Pritchard Veterinary Medical Teaching Hospital of the University of California, Davis, were retrospectively reviewed. Subjects included in the study were dogs that underwent TPLO during the study period. Subjects were excluded from the study if they underwent additional procedures during the same anesthesia events, received reoperation after immediate postoperative radiographs, had technique modifications from a routine TPLO, or if information about surgery duration was unavailable. All TPLOs were performed by an FS without the presence of students or surgery residents but with the assistance of two veterinary technicians or were performed by an American College of Veterinary Surgeons (ACVS) resident with an FS and a senior-year veterinary student scrubbed in to assist in the operating room.

2.2 | Independent variables

Fixed effects of the study were patient signalment, including breed, age, sex, weight (kg), and body condition score (BCS) on a 9-point scale, the American Society of Anesthesiologists (ASA) classification of physical status, side of the stifle joint receiving TPLO, procedure (TPLO with arthrotomy or TPLO with arthroscopy), meniscal treatment (yes or no), ACVS resident and student participation in TPLO (yes or no), and primary surgeon (FS, year of residency-1 [YR-1], YR-2, or YR-3). Random effects of the study were individual faculties and residents. All independent variables were collected for each patient as documented in medical records and anesthesia records.

2.3 | Outcome variables

The primary outcome of our study was surgery duration. For dogs that underwent TPLO with arthrotomy, the surgery duration was defined as the elapsed time from the start of skin incision for stifle arthrotomy and tibial osteotomy to the completion of skin closure. For dogs that underwent TPLO with arthroscopy, the surgery duration was recorded as the total time of arthroscopy duration, defined as from the beginning of portal establishment to complete removal of arthroscopic instruments, arthroscope, and fluid egress, and tibial osteotomy duration, defined as from the beginning of extending the incision for a routine TPLO approach to the completion of skin closure. The outcome information for each subject was collected as documented in anesthesia records.

2.4 | Statistical analysis

A two-way analysis of variance (ANOVA) was performed to evaluate the effects of the procedure (TPLO with arthrotomy or TPLO with arthroscopy) and the ACVS resident participation on surgery duration, and the effects of the procedure and the surgeon (FS, YR-1, YR-2, or YR-3) on surgery duration. For dogs that underwent TPLO with arthroscopy, a one-way ANOVA was also conducted to analyze the effect of the surgeon on arthroscopy duration and tibial osteotomy duration. Geometric least squares means (GLSM) were calculated with the antilog of the least squares means (LSM) of $\log_e$-transformed values and reported with 95% CI. GLSM ratio (GLSMR), calculated with the antilog of the LSMs difference, and its 95% CI were used for pairwise comparisons. An adjustment for multiple comparisons was made using the Tukey–Kramer method. The estimated values of the outcomes were also calculated using a linear regression model (LRM).

Subjects that had missing data in one of the independent variables were excluded from the following analysis to avoid bias. For all recorded independent variables, multicollinearity was checked by using the Spearman correlation coefficient (r_s). Independent variables pairs that showed a strong correlation ($r_s > .7$) were removed from the following analyses. A univariate LRM of $\log_e$-transformed values was then fitted for each independent variable. For all significant independent variables identified in the univariate analysis, interaction effects were assessed using an LRM, and a stepwise variable selection was conducted to find the lowest akaike information criterion (AIC) model. A linear mixed effects model (LMM) of $\log_e$-transformed values was estimated with fixed effects identified in the stepwise selection and random effects to test if the independent variables of this study significantly predicted surgery duration, and parameter estimates of the LMM were reported. The normality of residuals was assessed by a nonsignificant Shapiro–Wilk test and a quantile-quantile (Q-Q) plot of studentized residuals. The homoscedasticity of residuals was evaluated by a studentized residuals versus fitted values plot. For nonnormally distributed or nonhomogeneity data, a $\log_e$-transformation was applied to the outcome variable. A *p*-value less than .05 was considered statistically significant. All tests were two-tailed. Statistical analyses were performed with the commercial software (SAS On Demand for Academics, SAS Institute, Cary, NC).

3 | RESULTS

3.1 | Demographics

A total of 294 cases were eligible for the study, and 38 cases were excluded from the study due to additional procedures performed ($n = 17$), lack of information about surgery duration (16), reoperation after immediate postoperative radiographs (4), and technique modifications from a routine TPLO (1). The 256 cases included in the analysis consisted of 153 neutered females (60%), 86 neutered males (34%), eight intact females (3%), and nine intact males (3%). The breeds included: mixed breed ($n = 99$), Labrador retriever (28), Golden Retriever (22), pit bull terrier (21), German shepherd (11), Staffordshire terrier (7), Rottweiler (6), Australian cattle dog (5), Australian shepherd (5), Bernese mountain dog (5), Great Pyrenees (5), Mastiff (5), Doberman pinscher (4), English bulldog (4), Siberian husky (4), Alaskan husky (2), Bullmastiff (2), English springer spaniel (2), Plott hound (2), and one each of Akita, Alaskan Malamute, American bulldog, American cocker spaniel, American Eskimo, Anatolian shepherd, Australian terrier, Beagle, Boxer, Catahoula hog dog, Flat coated retriever, German shorthaired pointer, German wirehaired pointer, Newfoundland, Saint Bernard, Shiba Inu, and Weimaraner. Mean $\pm$ SD age at surgery was 6.1 ± 2.8 years. Mean bodyweight was 33.6 ± 13.6 kg.

3.2 | Surgical information

Four board-certified FS and 10 ACVS residents performed TPLOs during the study period. All four FS during the study period had at least 4 years of experience after residency. Of the 256 cases, 74 TPLOs (29%) were performed by an FS, and 182 TPLOs (71%) were performed by an ACVS resident under the direct supervision of an FS. The median (range) number of TPLOs performed by each FS was 17 (10 to 31), and the median number of TPLOs performed by each resident was 18 (1 to 36). All TPLOs were conducted in combination with stifle arthrotomy or arthroscopy. A total of 109 (43%) cases received arthrotomy, whereas 147 (57%) cases received arthroscopy. Meniscal treatment (meniscectomy, meniscal release, or both) was conducted in 203 (80%) cases during stifle arthrotomy or arthroscopy, whereas only stifle inspection was conducted in 52 (20%) cases. Information regarding meniscal treatment was missing in one case. A total of 116 (45%) TPLOs were performed on the right stifle, and 140 (55%) TPLOs were performed on the left stifle (Table 1). All arthrotomies performed were mini-arthrotomies, as previously described.[15] All tibial osteotomies were performed with the tibia positioned laterally on the operation table, with popliteal muscle elevation and gauze packing. A TPLO jig was placed in all TPLOs performed by ACVS residents. All TPLOs were stabilized with a commercially available plate and screw system using the manufacturer-recommended technique (DePuy Synthes, Raynham, MA).[16] All skin incisions were closed by an FS or primary operating resident using an intradermal suture pattern.

TABLE 1 Demographic and surgical characteristics of 256 subjects by the four surgeon groups. Continuous variables are reported as mean ± SD. Categorical variables are reported as number (%).

Variable	YR-1 ($n = 45$)	YR-2 ($n = 64$)	YR-3 ($n = 73$)	FS ($n = 74$)
Age (years)[a]	5.3 ± 2.8	6.4 ± 2.7	6.2 ± 2.9	6.2 ± 2.9
Sex (M/F/MN/FN)	2/3/15/25 (1/1/6/10)	4/2/15/43 (1/1/6/17)	2/3/22/46 (1/1/9/18)	1/0/34/39 (0/0/13/15)
Weight (kg)	37.1 ± 21.8	33.5 ± 10.7	31.6 ± 10.9	33.7 ± 11.4
BCS[b] (4/5/6/7/8/9)	3/7/12/12/6/2 (1/3/5/5/2/1)	2/11/19/17/13/0 (1/5/8/7/5/0)	2/18/20/19/12/1 (1/8/8/8/5/0)	4/17/13/18/11/1 (2/7/5/8/5/0)
ASA (1/2)	35/10 (14/4)	55/9 (21/4)	62/11 (24/4)	66/8 (26/3)
Procedure (arthrotomy/ arthroscopy)	17/28 (7/11)	25/39 (10/15)	30/43 (12/17)	37/37 (14/14)
Meniscal tear treatment[c] (yes/no)	41/4 (16/2)	54/9 (21/4)	60/13 (23/5)	48/26 (19/10)
Side (right/left)	22/23 (9/9)	31/33 (12/13)	32/41 (12/16)	31/43 (12/17)

Abbreviations: ASA, American Society of Anesthesiologists physical status classification; BCS, body condition score; F, female; FN, female neutered; FS, faculty surgeon; M, male; MN, male neutered; YR, year of residency.
[a]Age was missing for two cases.
[b]BCS was missing for 16 cases.
[c]Meniscal tear treatment was missing for one case.

3.3 | Effect of ACVS resident participation and procedure on surgery duration

There was no interaction between resident participation and procedure ($p = .446$). Main effects analysis showed that the resident participation and procedure have effects on surgery duration (resident participation, $p < .001$; procedure, $p < .001$). Surgery duration was 1.42 times (95% CI: 1.35–1.50; $p < .001$) longer in TPLO with arthroscopy (GLSM = 147 min; 95% CI: 141–152) than in TPLO with arthrotomy (GLSM = 103 min; 95% CI: 99–107). TPLO in which an ACVS resident participated (GLSM = 153 min; 95% CI: 148–158) required 1.54 times (95% CI: 1.46–1.64; $p < .001$) more time than TPLO in which an ACVS resident did not participate (GLSM = 99 min; 95% CI: 94–104) (Table 2).

The fitted function of the LRM was: Surgery duration (min) = exp (4.418 + 0.353*arthroscopy +0.434*resident participation).

3.4 | Effect of the year in training and procedure on surgery duration

No interaction between the effects of the stage in training and the procedure was identified ($p = .070$). Both surgeon and procedure had effects on surgery duration (surgeon, $p < .001$; procedure, $p < .001$). The pairwise comparisons revealed that surgery duration was 1.42 times (95% CI: 1.35–1.50; $p < .001$) longer in TPLO with arthroscopy (GLSM = 165 min; 95% CI: 159–171) than in TPLO with arthrotomy (GLSM = 116 min; 95% CI: 112–121). Surgery duration among YR-1 (GLSM = 170 min; 95% CI: 160–180), YR-2 (GLSM = 148 min; 95% CI: 141–156), and YR-3 (GLSM = 147 min; 95% CI: 140–155) was longer than FS (GLSM = 99 min; 95% CI: 94–104) (YR-1 vs. FS: GLSMR = 1.71; 95% CI: 1.55–1.90; $p < .001$, YR-2 vs. FS: GLSMR = 1.49; 95% CI: 1.36–1.64; $p < .001$, YR-3 vs. FS: GLSMR = 1.49; 95% CI: 1.36–1.63; $p < .001$). Also, surgery duration among YR-1 was longer than among YR-2 and YR-3 (YR-1 vs. YR-2: GLSMR = 1.15; 95% CI: 1.03–1.27; $p = .004$, YR-1 vs. YR-3: GLSMR = 1.15; 95% CI: 1.04–1.28; $p = .002$). Surgery duration did not differ between YR-2 and YR-3 (GLSMR = 1.00; 95% CI: 0.92–1.10; $p = 0.999$) (Table 2).

The fitted function of the LRM was: Surgery duration (min) = exp (4.419 + 0.351*arthroscopy +0.539*YR-1 + 0.402*YR-2 + 0.398*YR-3).

3.5 | Effect of surgeon on arthroscopy duration and tibial osteotomy duration

Of the 147 cases that received TPLO with stifle arthroscopy, 106 cases had records about arthroscopy duration and tibial osteotomy duration and were included in a one-way ANOVA analysis that revealed a difference in arthroscopy duration between at least two surgeon groups ($p < .001$). The multiple comparisons found that arthroscopy duration was longer in YR-1 (GLSM = 69 min; 95% CI: 60–80), YR-2 (GLSM = 75 min; 95% CI: 66–85), and

TABLE 2 Surgery duration estimated from linear regression models.

Procedure	Surgeon (*n*)	Mean duration ± SD (min)	Estimated duration (min)	Surgeon (*n*)	Mean duration ± SD (min)	Estimated duration (min)
TPLO with arthroscopy	Resident (110)	188 ± 43	182	YR-1 (28)	216 ± 45	202
				YR-2 (39)	183 ± 35	176
				YR-3 (43)	175 ± 42	176
	FS (37)	117 ± 18	118			
TPLO with arthrotomy	Resident (72)	130 ± 29	128	YR-1 (17)	134 ± 19	142
				YR-2 (25)	123 ± 24	124
				YR-3 (30)	133 ± 36	124
	FS (37)	86 ± 17	83			

Abbreviations: FS, faculty surgeon; TPLO, tibial plateau leveling osteotomy; YR, year of residency.

YR-3 (GLSM = 76 min; 95% CI: 67–86) than in FS (GLSM = 42 min; 95% CI: 36–49) (YR-1 vs. FS: GLSMR = 1.65; 95% CI: 1.26–2.16; $p < .001$, YR-2 vs. FS: GLSMR = 1.79; 95% CI: 1.39–2.32; $p < .001$, YR-3 vs. FS: GLSMR = 1.82; 95% CI: 1.40–2.35; $p < .001$). Arthroscopy duration did not differ between YR-1, YR-2, and YR-3 (YR-1 vs. YR-2: GLSMR = 0.92; 95% CI: 0.72–1.12; $p = .807$, YR-1 vs. YR-3: GLSMR = 0.91; 95% CI: 0.71–1.16; $p = .740$, YR-2 vs. YR-3: GLSMR = 0.99; 95% CI: 0.78–1.25; $p = .999$). A one-way ANOVA revealed a difference in tibial osteotomy duration between at least two surgeon groups ($p < .001$). The multiple comparisons found that tibial osteotomy duration was longer in YR-1 (GLSM = 133 min; 95% CI: 120–147), YR-2 (GLSM = 102 min; 95% CI: 93–112), and YR-3 (GLSM = 95 min; 95% CI: 86–103) than in FS (GLSM = 74 min; 95% CI: 67–83) (YR-1 vs. FS: GLSMR = 1.79; 95% CI: 1.47–2.18; $p < .001$, YR-2 vs. FS: GLSMR = 1.38; 95% CI: 1.14–1.66; $p < .001$, YR-3 vs. FS: GLSMR = 1.27; 95% CI: 1.06–1.53; $p = .006$). Also, tibial osteotomy duration was longer in YR-1 than in YR-2 and YR-3 (YR-1 vs. YR-2: GLSMR = 1.30; 95% CI: 1.09–1.56; $p = .001$, YR-1 vs. YR-3: GLSMR = 1.41; 95% CI: 1.18–1.68; $p < .001$). However, tibial osteotomy duration did not differ between YR-2 and YR-3 (GLSMR = 1.08; 95% CI: 0.91–1.28; $p = .616$). The breakdown of arthrotomy and tibial osteotomy duration was not available in cases that underwent TPLO with stifle arthrotomy.

3.6 | Linear mixed effects model

Of the 256 cases, 238 were included in a linear mixed effects model (LMM) analysis. A total of 18 cases with missing data in one of the independent variables were removed from the LMM analysis. A $\log_e$-transformation was applied to surgery duration. The LMM of $\log_e$-transformed surgery duration with the lowest AIC included procedure, surgeon, meniscal tear treatment, stifle side, and weight as fixed effects and individual FS and residents as random effects. There was no interaction between the fixed effects (procedure*surgeon: $p = .248$, procedure*meniscal treatment: $p = .986$, procedure*stifle side: $p = .544$, procedure*weight: $p = .835$, surgeon*meniscal treatment: $p = .312$, surgeon*stifle side: $p = .695$, surgeon*weight: $p = .922$, meniscal treatment*stifle side: $p = .098$, meniscal treatment*weight: $p = .578$, stifle side*weight: $p = .288$).

The fitted function of the LMM was: Surgery duration (min) = exp (4.280 + 0.459*YR-1 + 0.339*YR-2 + 0.344*YR-3 + 0.301*arthroscopy +0.097*meniscal tear treatment +0.055*right stifle +0.003*weight).

The predicted surgery duration in YR-1, YR-2, and YR-3 was 1.58 times (95% CI: 1.33–1.89; $p < .001$), 1.40 times (95% CI: 1.18–1.67; $p < .001$), and 1.41 times (95% CI: 1.19–1.68; $p < .001$) longer than in FS, respectively. The predicted surgery duration for TPLO with arthroscopy was 1.35 times (95% CI: 1.26–1.44; $p < .001$) longer than TPLO with arthrotomy. For the cases that received meniscal tear treatment, the predicted surgery duration increased 1.10 times (95% CI: 1.04–1.17; $p = .002$) compared with the cases that did not receive meniscal tear treatment. Also, the predicted surgery duration in TPLO performed on the right stifle was 1.06 times (95% CI: 1.01–1.11; $p = .019$) longer than in TPLO performed on the left stifle. The predicted surgery duration increased by 1.03 times (95% CI: 1.01–1.04; $p = .003$) for every 10 kg increase in weight (Table 3).

4 | DISCUSSION

This study demonstrated that surgery duration was 54% longer when TPLO surgery was done by a resident

TABLE 3 Linear mixed effects model of $\log_e$-transformed surgery duration.

Variable	Coefficient (95% CI)[a]	*p*-value
Intercept	4.280 (3.986–4.574)	< .001
Surgeon		
YR-1	0.459 (0.283–0.635)	< .001
YR-2	0.339 (0.167–0.511)	< .001
YR-3	0.344 (0.171–0.516)	< .001
FS	Reference group	
Procedure		
TPLO with arthroscopy	0.301 (0.235–0.369)	< .001
TPLO with arthrotomy	Reference group	
Meniscal tear treatment		
Yes	0.097 (0.037–0.156)	.002
No	Reference group	
Side		
Right	0.055 (0.009–0.102)	.019
Left	Reference group	
Weight	0.003 (0.001–0.004)	.003

Abbreviations: CI, confidence interval; FS, faculty surgeon; TPLO, tibial plateau leveling osteotomy; YR, year of residency.
[a]Coefficients and 95% CI for the $\log_e$-transformed surgical duration.

compared to an FS. Comparing surgery duration between the years of residency training, YR-1 required 15% more time than YR-2 and YR-3 to complete TPLO. However, surgery duration did not differ between YR-2 and YR-3. Considering arthroscopy duration and tibial osteotomy duration separately, tibial osteotomy duration among YR-1 was 30% and 41% longer than YR-2 and YR-3 but did not differ between YR-2 and YR-3. Arthroscopy duration did not differ between YR-1, YR-2, and YR-3.

The difference in surgery duration between ACVS residents and FS was 54 min, ranging from 71 min for YR-1 to 48 min for YR-3. These findings suggested that residents in training required more time to complete TPLO, which was consistent with the results in an open carpal tunnel release and laparoscopic appendectomy in human medicine. The prolonged surgery duration was reported to be associated with increased surgical cost and complication rate.[13–14,17] At our institution, the charge for anesthesia is currently $50 for each 15 min of added duration. Therefore, the difference in TPLO surgery duration between ACVS residents and FS may represent a potential increase of $200 in cost to owners. Additionally, the potential decrease in operating room turnover and an increase in the need for staff support hours, can have important implications for hospital administration.

This study found that YR-1 required 15% more time than YR-2 and YR-3 to perform TPLO, suggesting that TPLO surgery duration significantly decreased through the first year of residency training. This change in surgery duration is similar to a previous study evaluating surgery duration in hemilaminectomy performed by veterinary residents, in which the mean exposure to hemilaminectomy per resident over the training period was 30.7 cases, and the most significant decrease in surgery duration occurred in the first 10 cases.[10] The decrease in surgery duration may be due to improvement in surgical skills and a decreased need for faculties to provide active help during surgery. A previous study from human medicine assessing surgical competency using the Global Index for Technical Skills reported that the mean scores for the postgraduate year-1 (PGY-1) residents significantly improved by PGY-2. Based on that study, the categories with the lowest scores among PGY-1 residents were “flow of operation” and “time and motion”, and these two categories remained the lowest average score in the resident's final year (PGY-5).[18] While the difference in skill level and required competency across training programs precludes direct comparison, these studies may provide insights into the potential areas of improvement to achieve a shorter surgery duration.

The change in tibial osteotomy duration over the three-year residency training was consistent with the trend observed in TPLO surgery duration, whereas no significant change was observed in arthroscopy duration between YR-1, YR-2, and YR-3. These results suggest that the decrease in TPLO surgery duration was attributed to the decrease in tibial osteotomy duration, and stifle arthroscopy may require more experience to improve procedural efficiency. However, there were unrecorded factors that could affect surgery duration. At our institution, the degree of FS intervention in TPLO differs by the year of residency training. Senior residents perform more parts of the procedure than YR-1 and YR-2 without needing the instruction of FS, which could require additional time to perform TPLO. Additionally, surgery duration is just one metric investigated in the study and cannot provide a comprehensive understanding of the residents' surgical proficiency, such as surgical skills, communication, decision-making, and outcome. Therefore, it is possible that the nonsignificant difference in TPLO duration between YR-2 and YR-3 and that in arthroscopy duration between YR-1, YR-2, and YR-3 did not reflect the proficiency in TPLO.

Performing arthroscopy requires various skills, including the knowledge of anatomy, instruments, and specific procedures, equipment handling, bimanual dexterity, depth perception, and the flow of operation. In human medicine, several types of global rating scales have been introduced and used as evaluation tools in the competency assessment of arthroscopic procedures.[19–21] Future studies should evaluate various proficiency metrics, in addition to surgery duration, using objective assessment tools to evaluate how the surgical performance of ACVS residents changes throughout their program.

In the current study, the TPLO performed on the right stifle took 6% longer than the TPLO performed on the left stifle. One possible explanation for the difference is the influence of the surgeon's dominant hand. FSs and ACVS residents in this study were all right-handed. Therefore, it is possible that the right-handed surgeons required more time for right stifle TPLO than left stifle TPLO. The difference in dexterity and instrument handling between the dominant hand and the nondominant hand might contribute to the prolonged surgery duration in the right stifle TPLO. However, since left-handed surgeons were not included in this study, it is unclear whether there was a significant interaction between the stifle side and the surgeon's dominant hand.

The study had several limitations. It only included four FS and 10 ACVS residents from a single institution, so the results may lack generalizability to other institutions that have different teaching systems. At our institution, all FSs had more than 5 years of experience performing arthroscopy and TPLO, and the residents took on the responsibility as a primary surgeon under the direct supervision of an FS. Prior operating room experience, including surgical internship, was not investigated, as all the residents during the study period joined our residency program directly from a postgraduate internship program. The surgery duration was compared between each year of residency training, and the change in surgery duration over time of each ACVS resident was not investigated because of the small number of TPLOs that each resident performed in the study period. Also, due to the nature of the retrospective study, our study failed to consider the influence of student participation and the level of FS intervention during TPLOs, which were possible confounders.

In conclusion, TPLO performed by an ACVS resident required 54% more time compared to an FS. TPLO surgery duration significantly decreased after the first year of residency training but did not decrease further afterward. Stifle arthroscopy duration did not decrease throughout the residency training. The results of this study will add to our understanding of the time required for resident training in TPLO, aiding with effective resource allocation, planning of curricula, and cost management associated with resident training. Future studies should consider the interaction dynamic within the operating room and various performance metrics using objective assessment tools to assess how the surgical skills of residents change as their residency program proceeds and help improve resident training.

AUTHOR CONTRIBUTIONS

Niida A, BVSc: Identified suitable medical records, recorded and compiled data, conducted statistical analysis, interpreted data, and drafted and revised the manuscript. Chou P-Y, BVM, MVM, MS, DACVS (Small Animal): Contributed to concept and designed the study, data collection and interpretation, and draft and revised the manuscript. Filliquist B, DVM, MAS, DACVS (Small Animal), DECVS: Contributed to the design of the study, data interpretation and provided scientific, in-line editing of the manuscript. Marcellin-Little DJ, DEDV, DACVS, DECVS, DACVSMR: Contributed to the design of the study, data interpretation and provided scientific in-line editing of the manuscript. Kapatkin AS, DVM, MAS, DACVS: Contributed to the design of the study, data interpretation, and provided scientific in-line editing of the manuscript. Kass PH, DVM, MPVM, MS, PhD: Contributed to data interpretation and statistical analysis and provided scientific in-line editing of the manuscript. All authors provided a critical review of the manuscript and endorsed the final version. All authors are aware of their respective contributions and have confidence in the integrity of all contributions.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest related to this report.

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How to cite this article: Niida A, Chou P-Y, Filliquist B, Marcellin-Little DJ, Kapatkin AS, Kass PH. The impact of surgery resident training on the duration of tibial plateau leveling osteotomy surgery. *Veterinary Surgery*. 2024;1-8. doi:10.1111/vsu.14113