AN IN VITRO MECHANICAL COMPARISON OF
TPLO PLATES

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Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE OR ARTS
May 2010

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ACKNOWLEDGMENTS

The author would like to thank Drs. Kenneth E. Bartels, Mark C. Rochat, Jerry W. Ritchey, Kristyn D. Broaddus, Mark Payton, and Demir Coker for their assistance, guidance, and mentorship.

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CHAPTER I

INTRODUCTION

Cranial cruciate ligament disease is the most common etiology of pelvic limb lameness in the dog (1). Surgical management of the disease is recommended to provide stifle stabilization and subsequent improvement of overall limb function. Of the many techniques which have been described for stabilization of cranial cruciate ligament deficient stifles, the tibia plateau leveling osteotomy (TPLO) has gained significant popularity since its introduction in 1993 (2). The TPLO procedure makes no attempt at reproducing the passive constraints of the stifle, and is unique when compared to many other stifle stabilization techniques because the focus is placed upon altering stifle biomechanics to provide a stable stifle joint during the weight bearing phase of locomotion whereby cranial tibial thrust and cranial tibial translation are eliminated (2, 3). This is accomplished by creating a curved osteotomy in the proximal tibia followed by rotation of the proximo-caudal tibia to level the tibial plateau and eliminate cranial tibial thrust (2, 3).

Currently, a variety of plating designs from different manufacturers have become available for use in the TPLO procedure. Stable fixation of the osteotomy is critical to avoid delays in healing and the potential for implant failure. Three prior reports have examined postoperative complications associated with the TPLO procedure (4-6). Common complications encountered with the procedure include but are not limited to the following: tibial tuberosity fracture, tibial fracture, fibular fracture, osteomyelitis, infection of the incision, swelling or edema, wound dehiscence, patella fracture, hematoma, patella tendon swelling, and broken or loose screws (4-6). Pacchiana et al. identified loose implants and broken screws in 6 of 67 procedures which had complications ≥15 days after surgery (5). In total, this accounted for 1.5% of all complications observed in this study. Priddy et al. examined 193 cases in which complication rates associated with broken screws and loose screws were found to be 2.1 and 1.0 percent respectively (6). Finally, Stauffer et al. found complication rates of broken screws to be <1% in the perioperative period, and the complication rate associated with screw loosening to be 1% in respect to long term complications (4). Interestingly, plate breakage has not been reported as a complication.

The introduction of locking plate technology has added another dimension to the implant fixation aspects of TPLO surgery. Usefulness of such technology could prevent or minimize construct micromotion leading to screw loosening or breakage. Knowledge of the capacity of plates and screws to withstand compressive and bending forces would provide useful information for selecting implants that would be less prone to failure and avoiding the resulting complications such as collapse or displacement of the osteotomy, and loss of the proper tibial plateau angle.

Another consideration when selecting implants for secure fixation of a TPLO are the additional biomechanical challenges associated with performing a TPLO in obese, hyperactive, and large and giant breed dogs. In these scenarios, the TPLO surgery, regardless of how ideally performed, may have undesirable results if insufficient stability is afforded by the currently available TPLO implants. Currently, there are few comparative biomechanical studies of the currently marketed TPLO plate designs in the literature (7). It would be beneficial to identify an implant which could provide adequate stabilization and allow for appropriate healing in situations in which implants would experience excessive loads.

The purpose of this study was to investigate the mechanical performance of four different TPLO plate designs in axial compressive load to failure, four point bending load to failure, and cyclic axial compressive loading. The null hypothesis is that all constructs will perform similarly during cyclic axial compressive loading and experience similar loads at failure in single cycle axial compressive loading and four-point bending load to failure tests.

CHAPTER II

MATERIALS AND METHODS

Construct design

Seventy two osteotomy gap constructs were assembled by use of 60mm x 40mm x 68mm blocks of solid rigid polyurethane foam (1522-03 Sawbones, Pacific Research Laboratories, Inc., Vashon, WA, USA) for the base component to simulate the proximal portion of the tibial diaphysis in the clinical setting and 60mm x 40mm x 58mm blocks for the upper component to simulate the tibial plateau in the clinical setting. The density of all solid rigid foam used was 20 pounds per cubic foot or 0.32 grams per cubic centimeter. The gap for all constructs was created by use of a custom shim placed between the 2 blocks. The shim allowed for the creation of a standardized 3mm gap for each construct. The shim was held in place between the two blocks using a C-clamp during application of all plates. The gap model was used to create an extreme scenario requiring the constructs to function in a buttress fashion. While this gap model is a "worst case" scenario that would be unlikely in the clinical setting, it was chosen as a means to provide the clearest mechanical comparison among the plates tested.

The osteotomy gaps were stabilized with 3.5mm versions of the following plates: a standard TPLO plate (SP) (Slocum Enterprises, Inc., Eugene, OR, USA), a low profile TPLO plate (Lop) (Securos, Inc., Fiskdale, MA, USA), a locking TPLO plate (LocP) (New Generation Devices, Franklin Lakes, NJ, USA), and a broad locking TPLO plate (bLocP) (New Generation Devices, Franklin Lakes, NJ, USA). All bone plates were made of wrought 316L stainless steel. All plates were centrally placed, with the long axis of the plate parallel to the long axis of the blocks. The plates were secured using 3.5 mm self tapping cortical screws 40 mm in length (New Generation Devices, Franklin Lakes, NJ), with the exceptions described below. All the holes for the cortical screw were drilled into the polyurethane foam using 2.5 mm drill bits and the screws were placed using standard AO technique and in neutral fashion. All constructs using the LocP and 3.5 mm bLocP designs were secured with locking 3.5 mm self tapping cortical screws (New Generation Devices, Franklin Lakes, NJ) placed in the screw holes on either side of the gap. This resulted in placement of locking screws in the number 3 and 4 holes for the LocP and holes number 4 and 5 for the bLocP constructs. The locking screws holes were drilled by use of the locking drill guide for the LocP and bLocP (New Generation Devices, Franklin Lakes, NJ) and a 2.5 mm drill bit. The locking screws were handed-tightened without the use of a torque limiting device. New materials were used for the creation of each construct.

Mechanical Testing

All testing was performed by use of a servohydraulic uniaxial testing machine with a 5kN load cell (MTS Systems Corporation, Eden Prairie, TX) and a load controller (Fastrack

8800D controller, Instron corporation, Norwood, MA) in gap closing axial compressive load to failure and fatigue cycling. Each construct was mounted into the testing device using a customized loading platform to allow for rotation in all planes during loading. The customized loading platform was comprised of a 60mm x 40mm x 6.5mm steel plate with a machined small round depression 10mm in diameter located in the center of the plate. The platform was designed to fit precisely with the top of each construct so that the compressive load was applied in exactly the same manner for in each construct. The loads were therefore applied to the constructs such that all compressive loading was applied 20mm from the medial aspect of the construct, or the surface in which the plate was placed, and parallel to the long axis of each plate. This was placed atop all constructs during testing. A 12.75mm diameter steel ball bearing was placed in the depression of the steel plate as the specimen was loaded into the materials testing machine. The materials testing machine was fitted with a corresponding 30mm thick steel cylinder 60mm in diameter with a 10mm diameter machined depression in the center of the cylinder for communication with the steel ball bearing. The bearing and machined depressions were lubricated prior to testing each construct. The customized loading platform was developed to eliminate variability in loading of each construct, and to facilitate rotation of the proximal portion of the construct in any direction during axial loading. For load to failure testing in axial compression, six constructs of each plate type underwent loading applied at a continuous rate of 2mm/min until failure or closing of the gap (See Figure 1).

Figure 1: View of a LocP construct positioned and loaded in the material testing system prior to axial compressive load to failure testing. Note the customized loading platform atop the construct.

Failure was defined as plastic deformation of the implant, gap closing on the side opposite the plate, screw pullout, screw bending, screw breakage, or significant foam compression around and between screws. For gap closing to occur, a 4.1 degree bend in the plate would be experienced by all plates on each construct.

A second group of six constructs of each plate type were tested in a four-point bending load to failure model. The constructs were manually placed on the support rollers for each construct. The distance between the support rollers was 120 mm. The distance between the load rollers was 40 mm. The constructs were positioned such that the load was applied to all constructs on the surface opposite that of the plate and screws. Failure was defined as above. Again, loads were applied to all at a constant 2mm/min rate while collecting data for statistical analysis.

A third group was tested to perform fatigue analysis in cyclic axial loading. The objective of this manner of testing was to compare the four types of plate constructs with regard to their respective fatigue resistance. This was based on the supposed normal loading of a pelvic limb by calculation of 20% of the body weight of a dog weighing approximately 77kg during the convalescent period. The constructs were loaded to 0.15 kN at a cyclic rate of 20 Hz with the amplitude of 0.1 kN for one million cycles or until implant failure occurred as previously described. Following the fatigue analysis of these constructs, all of these constructs were loaded in axial compression to failure. Loading of the constructs was performed as described above. Load data from the load cell and position of the actuator was collected for ten points for each cycle beginning with the initial loading cycle. In the ten points collected minimum and maximum position was recorded. The data collection continued to the runout limit of the test (one million cycles), or failure of the construct as previously described. A logarithmic plotting of position and load for all cycles to the runout limit was performed by use of commercial software (MATLAB Version 7.6, The MathWorks, Inc., Natick, MA). This graphical representation created an S-N diagram (fatigue strength versus cycle life or number) with an overlaid M-N diagram (maximal moment versus cycle number) for each cycle of each construct tested. Data for cycle number one, one hundred, one thousand, ten thousand, one hundred thousand, and one million were obtained for further statistical analysis. This was performed to provide a representative evaluation of all constructs in low-cycle fatigue (less than 10^3 cycles) as well as high-cycle fatigue (10^6 cycles or greater).

Statistical Analysis

Statistical analyses were conducted with the use of commercial software (PC SAS Version 9.1, SAS Institute, Cary, NC). The response variables examined for all constructs included mean stiffness, loads at failure, mean displacement minimum, and mean displacement maximum. Analysis of variance procedures were used to assess the effects of plate type and the cycle number. A two-factor factorial in a completely randomized design model was assumed and calculated with PROC MIXED. The simple effects of plate type compared within cycle number were assessed with a SLICE option in an LSMEANS statement. If the overall simple effects of plate type were judged significant at the 0.05 level with the SLICE option, then pair-wise t-tests were computed. Means and standard errors of each of the response variables were calculated and the results of the pair-wise comparisons presented with letters denoting the significant ($p<0.05$) differences.

CHAPTER III

RESULTS

Axial Compressive Load to Failure

The LocP constructs sustained a significantly higher mean load at failure when compared to the other constructs tested (See Table 1 below).

Plate	Mean Maximum Load (in kN) with +/-SE	Mean Stiffness (as kN/mm) with +/- SE	Post Fatigue Mean Maximum Load (in kN) with +/-SE	Post Fatigue Mean Stiffness (as kN/mm) with +/- SE
SP	0.291 ^{b} +/- 0.02	3.432 ^{a} +/- 0.08	0.243 ^{a} +/- 0.03	2.313 ^{a} +/- 0.24
LoP	0.221 ^{b} +/- 0.01	3.304 ^{a} +/- 0.12	0.205 ^{a} +/- 0.02	2.776 ^{a} +/- 0.28
LocP	0.370 ^{a} +/- 0.01	3.222 ^{a} +/- 0.10	0.413 ^{a} +/- 0.02	2.941 ^{a} +/- 0.10
bLocP	0.422 ^{a} +/- 0.04	3.473 ^{a} +/- 0.08	0.374 ^{a} +/- 0.01	2.747 ^{a} +/- 0.23

Table 1: Single cycle compressive load to failure. Mean maximum loads at failure and stiffness of each construct tested in axial compressive loading to failure are depicted. Loads are in kN and stiffness is depicted as kN/mm. The differences are demonstrated by the letters. Similar letters in the same column indicate no statistical difference. SE is the ± standard error for measurements in the column prior.

Yet, there were not any significant differences amongst all constructs in mean construct stiffness in the acute axial compressive load to failure. Failure occurred as plastic deformation of the plate and gap closing in all specimens. It should be noted that, although axial compression was applied to the constructs, the plates failed by bending. Screw pullout, screw loosening, or screw breakage did not occur.

Four Point Bending Load to Failure

The bLocP construct had a significantly higher mean stiffness (3.023 ± 0.08 kN/mm) than all the other constructs tested ($P \leq 0.003$) (Table 2 below).

Plate	Mean Maximum Load (in kN) with +/- SE	Mean Stiffness (kN/mm) with +/- SE
SP	0.840^{b} +/- 0.05	2.487^{b} +/- 0.12
LoP	0.530^{c} +/- 0.05	2.397^{b} +/- 0.08
LocP	0.830^{b} +/- 0.06	2.564^{b} +/- 0.14
bLocP	1.170^{a} +/- 0.11	3.023^{a} +/- 0.08

Table 2: Single cycle four point bending acute load to failure

Mean loads at failure and mean stiffness of constructs for each plate type in tested four point bending. Loads are in kN and stiffness is depicted as kN/mm. The differences are demonstrated by the letters. Similar letters in the same column indicate no statistical difference. SE is the ± standard error for measurements in the column prior.

The mean load at failure for each construct design is summarized in table 2 above. The bLocP experienced a significantly larger mean maximum load (1.170 kN ± 0.11) at failure and the LoPs experienced a significantly smaller mean maximum load (0.530 kN ± 0.05) at failure. The LocP (0.830 kN ± 0.06) and the SP (0.840 kN ±0.05) constructs were not significantly different. All constructs exhibited plastic deformation after gap closing without any evidence of screw pullout, screw loosening, or screw breakage.

Cyclic Axial Compressive Loading

The mean stiffness (kN/mm) of the bLocP (0.658 ± 0.02) and SP (0.649 ± 0.01) constructs were not significantly different throughout all cycles as summarized in table 3 below.

Cycle	Plate Type	Mean Stiffness (in kN/mm) with +/- SE
1	SP	**0.650**^{a} +/- **0.03**
1	LoP	**0.373**^{b} +/- **0.03**
1	LocP	**0.524**^{a} +/- **0.06**
1	bLocP	**0.647**^{a} +/- **0.04**
100	SP	**0.647**^{a} +/- **0.03**
100	LoP	**0.365**^{b} +/- **0.01**
100	LocP	**0.531**^{a} +/- **0.06**
100	bLocP	**0.648**^{a} +/- **0.04**
1000	SP	**0.639**^{a} +/- **0.04**
1000	LoP	**0.432**^{b} +/- **0.08**
1000	LocP	**0.532**^{ab} +/- **0.06**
1000	bLocP	**0.653**^{a} +/- **0.04**
10000	SP	**0.649**^{a} +/- **0.03**
10000	LoP	**0.349**^{b} +/- **0.10**
10000	LocP	**0.533**^{a} +/- **0.06**
10000	bLocP	**0.647**^{a} +/- **0.04**
100000	SP	**0.663**^{a} +/- **0.03**
100000	LoP	**0.423**^{b} +/- **0.14**
100000	LocP	**0.545**^{ab} +/- **0.06**
100000	bLocP	**0.666**^{a} +/- **0.04**
1000000	SP	**0.641**^{a} +/- **0.02**
1000000	LoP	**0.362**^{b} +/- **0.15**
1000000	LocP	**0.478**^{b} +/- **0.10**
1000000	bLocP	**0.695**^{a} +/- **0.06**

Table 3: Cyclic loading in resistance to failure testing. Mean stiffness for each plate type tested in cyclic axial compression. The first column denotes the number of cycles. The second is the plate design. The third column is the mean stiffness with letters denoting the differences between plates for the same number of cycles. The final column is ± standard error.

The LocP (0.525 ± 0.03) and LoP constructs (0.383 ± 0.04) exhibited lower mean stiffness than the bLocP and SP constructs. The LoP had a significantly lower stiffness than all other constructs for cycle number one, 10^2 cycles, and 10^4 cycles. At 10^3 and 10^5 cycles, the differences between the LoP and LocP constructs were not significant. At 10^6 cycles, stiffness of the bLocP and the SP constructs were significantly greater than the other two constructs. None of the construct had any sign of screw loosening or breakage. Four LoP constructs, one bLocP, and one LocP failed due to gap closing prior to one million cycles. In these particular constructs, S-N diagrams and M-N plotting demonstrated implausible extremes with regard to loads and position at the point of gap closure. Although the plates were not evaluated microscopically, grossly visible evidence of plastic deformation of all plates was present in constructs that had not reached one million cycles of fatigue testing.

Post-Cycling Axial Compressive Load to Failure

The stiffness or load at failure during an axial compressive load to failure following fatigue testing of plate-screw-foam constructs were not significantly different to the similar constructs which underwent acute axial compressive loading alone.

All plate-screw-foam constructs failed through gap closing. No evidence of screw failure was observed. Plastic deformation was present in all plate-screw-foam constructs in the portion of the plate spanning the construct gap.

CHAPTER IV

DISCUSSION

Load to Failure Testing

Testing in single cycle axial compressive load to failure demonstrated higher mean maximal loads at failure for the LocP and bLocP constructs. However, when comparisons were made with regard to mean stiffness, there were not any significant differences between constructs. The significantly higher loads experienced by the bLocP construct may be likely attributable to the area moment of inertia (AMI) of the plate type used in these constructs (Table 4). Additionally, the locking screws used in the LocP and the bLocP will function to dissipate the load applied to the constructs across the entire plate-screw portion of the construct due to the locking interface between the screw head and plate hole (13). The locking capabilities of the LocP construct would theoretically have provided a mechanical advantage in this manner of testing. This was not apparently realized in the findings contained in this study. The bLocP construct demonstrated significantly higher loads at failure in four-point bending as well. Another notable observation was that the LoP construct experienced significantly lower mean loads at failure in four-point bending compared to the other three groups. These differences are not surprising given that the LoP is thinner than the other plates and has a lower AMI for out of plane bending; therefore it would be expected to be weaker in comparison to the other plates. This fact was likely contributing to the lower mean loads at failure for the LoP constructs. Therefore, due to the geometry of the LoP in comparison to the other plates tested, it may be inferred that due to this difference in the AMI inherent to this plate design, the differences could be expected. It should be noted that despite the differences which may be a result of this particular construct design and bone modeling material, the results are similar to another study using cadaveric canine tibias (7).

Cyclic Axial Compressive Loading

The cyclic axial compressive loading of all plates offered important information relative to fatigue responses and cycle life of each plate-screw-foam construct. When comparing mean stiffness of all constructs over one million cycles, construct mean stiffness in order of greatest to least was: bLocP and SP >> LOCP >> LoP. The bLocP and the SP constructs demonstrated greatest stiffness over one million cycles and resisted cyclic loading similarly. Therefore it is only these two constructs which were statistically similar throughout all cycles. This, in part, supports the original null hypothesis. Additionally, the SP, LocP, and the bLocP all demonstrated similar stiffness to 10^5 cycles. This, in part, supports the null hypothesis that all plate-screw-foam constructs will perform similarly up until 10^5 cycles of loading. The exact clinical relevance of this information provided in this study remains unknown as there is no ideal fatigue or cycle life of any bone plate because many variables contribute to uncomplicated osteosynthesis following a TPLO procedure (8). Although limb mechanics and stresses experienced by the implants may be similar in many dogs following TPLO surgery, other factors such as concurrent orthopedic disease, obesity, animal personality and owner compliance may have a profound impact on osteotomy healing and/or construct failure. Therefore, careful consideration of these factors, including use of a plate and screws that are less susceptible to mechanical failure, is prudent in more complicated cases.

Again, in the locking constructs an increase in stiffness is possibly explained through the use of the locking plate-screw technology. As for the observations associated with the SP, the AMI of the SP is nearest that of the bLocP, and therefore this may explain the similarity in performance when comparing these two constructs.

Interestingly, four of the six LoP constructs tested did not reach one million cycles of fatigue testing before gap closure was observed. In part this could be potentially attributed to the placement of the all plates onto the foam block without contouring. This leads to a unique situation for the LoP which has a semitubular design. With screw placement, the underside of the plate did not sit entirely flush with the surface of the foam block. This may have lead to an inherently weaker construct and consequently lead to gap closing prior to the millionth cycle. An additional concern when choosing implants is implant stiffness. Uncomplicated healing of the TPLO will be most likely if adequate stiffness is maintained during the healing period. The stiffness of the bLocP and the SP constructs were not significantly different during the fatigue testing that approximated load situations similar to a 77 kg dog during a slow, controlled walk. This degree of stiffness should also be considered when debating the need for double plating of large and giant breed dogs. The need for double plating TPLO may be not always be necessary for a few large breed dogs, given a single bLocP or SP construct was able to avoid failure until loaded to limits greater than those typically experienced by dogs weighing as much as 77 kg. This has to be considered with caution as the results of the study herein were performed with a synthetic material and in an extremely controlled loading environment.

Study Limitations

Limitations of this study are those experienced by all *in vitro* testing. First, the main limitation of the study is the 3mm gap model. This was an extreme which would be very unlikely in the clinical situation. Although the gap model allowed for ease of mechanical comparison between plate types, it unfortunately does little to approximate the clinical experience. Secondly, variation in construct assembly and positioning of the construct within the MTS could have occurred despite efforts to eliminate variability. The actuator arm was marked to provide for accurate positioning of the construct. In addition, construction of the custom platform was to allow for rotation during compressive testing, maintain uniform plate-screw-foam construct compression, and potentially allow for some self correction of the constructs during testing if rotation occurred. Nevertheless, small variances might still occur, and it is these limitations that may potentially account for the gap closures in constructs during fatigue testing prior to one million cycles. Also, there is unfortunately no means of accounting for *in vivo* factors such as bone resorption along the osteotomy, callus formation, bilateral cruciate disease, and a large variety of other clinical and physiological factors which may influence healing along the osteotomy site. These potential variations are simply impossible to reproduce using the constructs and testing methods utilized by this study.

The plates used in this study were not contoured and were applied to the foam blocks just as they were received from the respective manufacturers. This is ultimately one of the most significant limitations of the study, as the use of any one of these plates requires some degree of plate contouring to approximate the medial aspect of the proximal tibia during a TPLO surgery. It is reasonable to believe that each plate design will undergo significantly different stresses following plate contouring (9). It is also reasonable to expect that due to anatomical variation, contouring of each plate will be somewhat different for each case clinically. Therefore, the response to cyclic loading within similar plate designs will likely be different for each case.

The polyurethane foam block used for creation of the construct was of a density similar to that of canine cancellous bone (10). Although, the use of foam in place of bone was a limitation of the study, there were distinct advantages to the testing of the construct using foam of this density. As described in an earlier study the polyurethane foam has been demonstrated to be an excellent canine cancellous bone model which may decrease data variability and improve statistical power during mechanical testing (10, 11). The foam for the distal aspect of the model was of the same density. Comparable cortical foam was not utilized in attempts to provide an inexpensive construct whilst limiting variability of the entire construct. In addition the foam was cut into rectangular segments to again minimize data variability that has been noted even in rapid prototyping modeling methods (12). The foam withstood all testing without any gross evidence of cracking or even severe indentation of the foam blocks. However the possibility of compression or mircrofracture within the foam block does exist. This must be taken into consideration when situations of plate-screw-foam constructs failed in unexpected fashion, failed without evidence of permanent plate deformation, or when no clear evidence of screw failure was evident. In the cyclic testing of the constructs, the potential for this microcompression and microfracture within the foam block itself may have not been evident. Unfortunately, sectioning and microscopic evaluation of the foam and the plate-screw-foam construct in situ was not performed. This problem may have altered the results of this study, but all constructs were created similarly so the impact of diffuse compression of the foam blocks would have impacted on all constructs in a similar manner.

Another area, in which this impact could have been realized, would be behavior of the screws utilized for the creation of the constructs. The LocP and the bLocP constructs were all created with the use of locking screws which should allow for a more rigid construct with resistance to failure (13-15). Theoretically, the implants with locking screws would possibly maintain greater stiffness. Although in single cycle compressive loading higher mean loads of failure were realized, a disparity in the mean stiffness of the constructs with locking screw technology was observed. Without plate contouring, and the SP, LocP, and bLocP being mounted in a flush manner to the foam blocks when preparing the constructs it may be theorized that these plate designs would definitely respond differently in comparison to the LoP. The differences in the constructs in the testing methods performed did not clearly demonstrate a significant advantage to those implants with locking screw technology. Therefore, one may speculate that no clear evidence suggesting a benefit to locking screws may be a result of the degradation of the screw foam interface during the cyclic testing of the constructs. Additionally, when considering the LoP, microscopic changes along the area of contact between the plate margins and foam may have occurred contributing to the results in this study. Finally, despite the considerations above, extrapolation of information provided in this study to a clinical scenario must be performed with caution as the construct as tested is the plate, screw, and foam construct which may be significantly different than that of the plate, screw, and bone in the clinical case. Again, the clinical scenario may result in a considerable difference as a result of plate contouring and cortical bone contact between the plate and proximal tibia.

In addition to the construct limitations, torsional testing of the plates to provide additional information for each plate design also may have been useful. Considering that some torsional stresses in the cranial cruciate ligament deficient stifle likely exist, one must consider that torsional stability at the osteotomy is necessary during healing. Finally, controlled prospective studies involving the use of each of the plate designs would be needed to establish the true clinical advantages and disadvantages of each plate design.

In summary, the bLocP and SP constructs demonstrated the greatest mean stiffness in cyclic axial compression through 10^6 cycles and the bLocP construct demonstrated greatest stiffness in four point bending. No statistical difference was present among constructs in axial compression. Additional in vitro and in vivo testing will be necessary to provide a complete assessment of the mechanical and biological properties of these and other TPLO plate types. The information from this and other studies may then allow for a complete consideration of all advantages when selecting implants for stabilization of tibial plateau leveling osteotomies.

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Title of Study: AN IN VITRO MECHANICAL COMPARISON OF TPLO PLATES

Pages in Study: 23 Candidate for the Degree of Master of Science

Major Field: Veterinary Biomedical Sciences

Scope and Method of Study: In vitro biomechanical study

Findings and Conclusions:

An in vitro mechanical study was performed to compare the fatigue properties and loads to failure of four plate designs used to stabilize the tibial plateau leveling osteotomy (TPLO). Seventy-two gapped osteotomy models were created using 3.5mm versions of the following plates: a standard TPLO plate (SP), a low profile TPLO plate (LoP), a locking TPLO plate (LocP), and a broad locking TPLO plate (bLocP). The eighteen constructs for each plate design were sub-divided into three identical groups of six. Six constructs were mounted in a materials testing device and subjected to cyclic compressive loading until failure was observed or one million cycles were achieved. Additionally, six constructs of each plate design were tested in compressive axial loading and six others in four-point bending in a load to failure manner. To provide residual strength comparisons, the six constructs undergoing cyclic fatigue compression testing were also tested in axial compressive loading. There were not any significant differences in stiffness between plates tested in axial compressive loading. However, mean loads at failure were higher for the LocP and bLocP constructs. The bLocP had a significantly higher mean stiffness and mean load at failure compared to the other constructs tested in four point bending.

ADVISER’S APPROVAL: Kenneth E. Bartels