INTRODUCTION:
An individual’s quality of life is greatly affected by the loss of one or more limb. To restore function, socket prosthetics are used; however, these devices have issues with the fit of the prosthetic and are inadequate for patients with short residual limbs. To help restore these patients to preamputation conditions, percutaneous, osseointegrated implants are being investigated to attach exoprostheses to the residual limb.

The aim of this research was to assess limb compensation in a 12 month amputation ovine model. This was accomplished by comparing vertical limb forces before and after amputation as well as stride length and stance phase as a percent gait cycle to determine if the sheep were limping.

METHODS:
Seventeen skeletally mature sheep underwent amputation at the distal metaphyseal flare of the Metacarpal III bone and were fit with a percutaneous, osseointegrated implant. A Morse taper at the distal end of the implant extended through the skin and attached to a Delrin/polyurethane exoprosthetic by means of a titanium adapter.

A commercially available pressure mat (Tekscan HR Mat, Tekscan, Inc., South Boston, MA) was used to measure the peak vertical forces (PVFs) from all four limbs. The size of the mat (width=0.45m, length=1.5m) allowed the sheep to ambulate across the transducer freely in an enclosed walkway, producing data from each limb for a complete gait cycle. A 3mm thick outdoor carpet was placed over the sensor to prevent the animals from slipping and to protect the sensor; however, this did not affect the resolution or the calibration, which was done before each test session.

PVFs and temporal-spatial parameters were recorded preoperatively and 3, 6, 9, and 12 months following amputation. For each trial, the sheep walked across the sensor at least five times while data were recorded and synchronized with digital video images (Figure 1). The PVFs were collected and compared to preamputation loads. Stride length and stance phase as a percent gait cycle were also determined for each limb and the amputated right forelimb was compared to the left forelimb to determine if the sheep were limping. Data are presented in means ± 95% confidence intervals. Statistical significance was determined using Paired t-Tests. This experiment has been approved by the local institutional animal care and use committees.

RESULTS:
To date, a total of 17 sheep have received preoperation data recordings and undergone surgery. There are currently 12 at the 3-month mark, 10 at the 6-month mark, 7 at the 9-month mark, and 3 at the 12-month mark.

The amputated forelimb was loaded less (P<0.05) for each month mark. There was a decreased load (P<0.05) from the 3-month to 12-month time point. All postoperative time points were compared to preamputation data by Paired t-Tests. This does confirm that the endoprostheses are being loaded.

DISCUSSION:
The sheep loaded their amputated limb 84% of their preamputation condition 3 months following amputation. By 12 months, the loading had decreased to 77%. The animals primarily compensated by applying more load to the left forelimb and left hindlimb. Although, there is not an increase in the amount the sheep are load bearing following surgery this does confirm that the endoprostheses are being loaded.

Comparing temporal-spatial parameters, no limp was observed postoperatively; however, preoperatively, a difference was noted for stance phase as a percent gait cycle. This can be attributed to the sheep being free range until one week before surgery. As such, the animals could have had a slightly erratic gait preoperatively before habituating to human contact. Since a limp was not observed postoperatively, it can be assumed that the implant did not cause the sheep any pain or discomfort. Further data will be compiled for the remainder of the animals to give a better understanding of the loading for the first 12 months following amputation. These data will be compared to bone mineral, structural, and remodeling parameters in future studies.

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