A BIOMECHANICAL EVALUATION OF CORTICAL ONLAY ALLOGRAFT STRUTS IN THE TREATMENT OF PERIPROSTHETIC FEMORAL FRACTURES

*Haddad, F S (A-Charnley & BOA/Wishbone trusts, Norman Capener Fwsph); *DeHaan, M N; *Bradly, O; *Masri, B A (A-Bagby Fdn); *Garbuz, D S; *Goertzen, D J; *Oxland, T R (A-Bagby Fdn); *Duncan, C P

++Department of Orthopaedics, UBC, Vancouver, BC, Canada. 3114-910 W. 10th Ave. Vancouver, BC Canada V5Z 4E3, (604) 875-5475, Fax: (604) 875-4677, toxland@interchange.ubc.ca

INTRODUCTION
Cortical onlay allograft struts have been increasingly employed in periprosthetic femoral fractures involving a well-fixed femoral stem. Allograft struts can act as biological bone plates that stabilise a periprosthetic fracture and ultimately strengthen the bone. Strut fixation also avoids problems seen in other fixation methods associated with the use of screws around a prosthesis. However, there is no standard of practice regarding which fixation variables, such as cable number or strut length, should be selected for optimal fixation results. This study was designed to determine the effect of strut length, strut number and configuration, cable number, cable tension and the effect of cables versus wires on three-dimensional motion at the site of a periprosthetic femoral fracture.

METHODS
Sixteen fresh human cadaveric femora were dissected of soft tissue and used in this study. Ten femurs were cut to form cortical struts, and six femora were potted individually in dental stone (Tru-Stone, Hereaus Kulzer, South Bend, IN, USA). A transverse osteotomy was performed on each of the six femurs to simulate a fracture at the level of the tip of a femoral prosthesis. Femoral stems were not inserted into any of the femora to avoid the introduction of additional unwanted variables. In total, ten femur-strut constructs were tested, each including a unique set of struts from a single femur. A standard construct was defined as the use of two 20 cm struts in the anterior and lateral position, held against the femur by three high tension cables above and three below the fracture site. The standard construct was retested within each variable group. The following fixation variables were assessed:
1) The number of cables above and below the fracture site (two, three and four);
2) Cable tension (high = 450 N, and low = 290 N);
3) Cable (Howmedica, Rutherford, NJ, USA) fixation as compared to Luque wire (Zimmer, Warsaw, IN, USA) fixation;
4) Strut number and position: i) Combined anterior and lateral struts; ii) Combined medial and lateral struts; iii) A single anterior strut; iv) A single lateral strut;
5) Strut length (20 cm, 16 cm and 12 cm).

Cranial-caudal and anterior-posterior (AP) loads were applied to the head of the femur using a custom designed loading jig affixed to a biaxial servohydraulic materials testing machine (Instron 8874, Canton, MA). The goal of the loading design was to approximate physiological loading of the femoral head for normal gait, as measured in patient telemetric studies [1][2]. The specimens were loaded in force control sinusoidally in the cranial-caudal direction for one hundred cycles at a frequency of one Hz and simultaneously loaded in the AP direction to +/-0.15 times body weight at a frequency of one half Hz. The femurs were mounted with a twelve degree angle of adduction such that the applied force was to +/-0.15 times body weight at a frequency of one half Hz. The femurs were mounted with a twelve degree angle of adduction such that the applied force was to +/-0.15 times body weight at a frequency of one half Hz. The femurs were mounted with a twelve degree angle of adduction such that the applied force was to +/-0.15 times body weight at a frequency of one half Hz. However, there is no standard of practice regarding which fixation variables, such as cable number or strut length, should be selected for optimal fixation results. This study was designed to determine the effect of strut length, strut number and configuration, cable number, cable tension and the effect of cables versus wires on three-dimensional motion at the site of a periprosthetic femoral fracture.

High cable tension showed a general trend towards less motion in all motion directions when compared with low tension, with the only significant decrease being in ML translation (p<0.05). There was a clear trend towards increased motion with the use of wires rather than cables for all motion degrees of freedom. The differences were significant in axial rotation (p<0.05), AP bending (p<0.05) and axial translation (p<0.01). We observed strut fractures in four cases (3 anterior and 1 lateral strut) when a single strut alone was used to stabilize the fracture. There was a strongly significant decrease in fracture motion for all motion degrees of freedom if two struts were used rather than one (p<0.01) (Figure 1). There was no significant difference between the two single-strut configurations. There was also no significant difference between the two two-strut configurations. Decreasing the strut length from 20 cm to 12 cm led to a significant decrease in axial rotation (p<0.05). However, there was no clear trend in all the other directions of motion.

DISCUSSION
Our data show a strong improvement in fracture stability with the use of two struts rather than a single strut alone. However, no difference was detected for the two strut constructs between the medial and anterior strut in combination with a lateral strut. This means that the extra soft tissue stripping and devascularization inherent in placing a medial strut instead of an anterior strut provides no benefit in terms of fixation stability. Multifilament cables provide more fracture stability than wires. The reason for this may be that higher tensions can be reached when tightening cables versus wires. The different surface characteristics of the cable and wire may also affect stability of the fixation. Increasing cable tension gave greater stability although this may not fully translate to the clinical situation because the cable may garrote or fracture the strut. The lack of clarity in the strut length results may be due to the effect of strut fit. We did not quantify strut fit, but as struts are shortened, their fit and therefore contact area with the femur changes. Improved strut fit may explain the decreased motion seen in axial rotation when shortening struts from 20 cm to 12 cm. We also did not quantify strut shape or contact area, although both seem to be very important to the stability of the construct. Our data favour the use of two struts held with cables with the emphasis on the number of cables rather than the length of the struts.

REFERENCES

ACKNOWLEDGEMENTS
We are grateful to the George W. Bagby Research Foundation at UBC, Howmedica for providing cables and tensioners, Zimmer for providing Luque wires and tighteners, and to the John Charnley and BOA/Wishbone trusts and the Norman Capener Travelling Fellowship (FSH).