Deformity correction and internal fixation during surgical treatment of Charcot Arthropathy (CA) requires strong implants capable of ensuring long-term stability and function of the foot. The purpose of this study was to determine the construct shear strength of the newly developed VLP Locking Osteopenia Screw (Smith & Nephew, Inc., Memphis, TN, USA), as compared to the VLP Locking Cortical Screw (Smith & Nephew, Inc.) in a PERI-LOC VLP One-Third Locking Tubular Plate (Smith & Nephew, Inc.). A foam bone analog was cut and placed into a testing device to simulate supported and unsupported fracture conditions. The simulated fracture was reduced with a PERI-LOC VLP plate and either the osteopenia or cortical locking screws and then loaded until failure. Testing results demonstrated that construct shear strength was approximately 1.7 times higher for the osteopenia screw construct (p<0.05). This evidence suggests that performance of the VLP Locking Osteopenia Screw can be expected to exceed that of the VLP Locking Cortical Screw under similar loading conditions.

Introduction
Charcot Arthropathy (CA) is a diabetic foot complication that can result in trauma fractures and ambulatory loss for the patient [1]. Untreated, this pathology can significantly increase the risk of infection and amputation, and can result in upwards of 37% percent patient mortality [2-4]. In the latter stages of CA development, surgical intervention may be required to effectively address soft-tissue damage and pronounced bone deformity [5, 6]. While there is limited evidence supporting the use of any specific surgical technique, any internal fixation implant should demonstrate acceptable fixation strength to enable long-term construct stability and tissue healing [7-9].
In this study, a shear static load was applied to a low density foam bone analog to simulate a patient with dorsal plating, coupled with compromised bone quality. The utilized loading pattern was designed to be similar to what would be expected when stepping off a curb or into a hole which produces a static shear load. In addition, this study compares the shear strength of a construct with one of two fixation methods. A construct with VLP™ Locking Osteopenia Screws (Smith & Nephew, Inc., Memphis, TN, USA) was compared to a construct consisting of VLP Locking Cortical Screws (Smith & Nephew, Inc.) in a PERI-LOC® VLP One-Third Locking Tubular Plate (Smith & Nephew, Inc.). The intent of this test was to determine if the osteopenia locking screw showed an increased resistance to screw pull-out compared to the cortical locking screw, while locked into a plate subjected to a shear static load.

Materials and Methods

Two types of screws were evaluated in this study: 3.5mm VLP Locking Cortical Screws and 5.0mm VLP Locking Osteopenia Screws (Figure 1). A rectangular low density foam block with a radius on one edge was used to simulate neuropathic bone similar to that presented in CA patients. A simulated fracture was generated in the block by a transverse cut made perpendicular to the long axis of the block. The foam block was then cut in half parallel to the curved edge allowing for loading on a flat surface on the back of the bone analog, thus simulating plantar loading of the foot. Each construct was comprised of a plate, three screws and two pieces of 10 lb/ft³ (160.1 kg/cm³) foam (General Plastics, Tacoma, WA). The simulated fracture was reduced with a plate and either the cortical or the osteopenia locking screws.

Per the surgical technique, all screws had the same predrill diameter. Each plate received one screw located in the supported bone analog and two screws located in the unsupported bone analog (Figure 2). This orientation was intended to replicate dorsal plating of the bones in the foot. All screws were inserted perpendicular to the plate and locked into the plate at the same torque value. A quasi-static axial load (Alliance RF 150 Screw Machine, Model 4501035, MTS Systems Corporation, Eden Prairie, MN) was applied to the unsupported bone analog until failure of the construct. The load was applied with a flat indenter with a minimum offset (< 1mm) to the fracture line. Load and displacement values were recorded during each test. Construct shear strength was defined as the maximum load measured from the load vs. displacement graph. Five constructs comprising of each type of screws were tested. Failure of the construct was defined as a 10% drop in load. The shear strength of the two constructs was evaluated using a Student's t-test with a significance level of p < 0.05.

Results

Test results are reported in Figure 3. The failure mode of screw fixation loss in the unsupported bone analog was seen in all samples tested. This pull-out effect is illustrated in Figure 4. The average construct shear strength value of the 5.0mm...
The Shear Strength of the VLP Locking Osteopenia Screw versus the VLP Locking Cortical Screw in a PERI-LOC™ VLP One-Third Locking Tubular Plate Construct

VLP™ Locking Cortical Screw constructs was 1.7 times higher than that of the 3.5mm Cortical VLP Locking Screw constructs. The difference in observed shear strength values was found to be statistically significant (p<0.05).

Figure 3: Construct shear strength test results for VLP Locking Osteopenia and Cortical Screws

![Graph showing shear strength test results for VLP Locking Osteopenia and Cortical Screws](image)

**Discussion and Conclusion**

Failure of fracture or fusion reduction is typically caused by a loss of screw fixation strength [10]. This is particularly true when addressing advanced foot deformity in neuropathic CA patients with poor bone quality [11]. The key design features affecting fixation strength include screw diameter, thread shape, and the depth of thread engagement [10-13]. The result of the current study demonstrates that the average shear strength of the 5.0mm VLP Locking Osteopenia Screw constructs was higher than that of the 3.5mm VLP Locking Cortical Screw constructs, and this difference was statistically significant (p<0.05). This increased performance is primarily due to the design of the osteopenia screw. First, a typical cortical screw has a minor diameter of approximately 2.7mm and a major diameter of 3.5mm. However, the VLP Osteopenia Locking Screw couples a 5.0mm major diameter with the same minor diameter. This larger thread profile improves pull-out strength and stripping torque. The current evidence suggests that with this feature, performance of the VLP Locking Osteopenia Screw can be expected to exceed that of the VLP Locking Cortical Screw under similar loading conditions.

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