Introduction: With recent development of modern technology for easily converting CT images to computerized and physical models, researchers and clinicians have introduced patient- and site-specific drill templates for placement of pedicle screws and other bone screws. The use of a physical site-specific drill guide during surgery helps decrease the intraoperative pedicle screw trajectory error rate, as well as operating time and fluoroscopic exposure to the patient and medical staff. For optimal accuracy, the apposing three-dimensional model with embedded drill guide must conform to the intended bone uniformly and unambiguously. The purpose of this study was to measure and optimize the contact between three-dimensional models created to appose lumbar vertebrae, and to compare 4 template designs to determine the minimum bone contact area that still allows unambiguous positioning.

Methods: Axial computerized tomography (CT) images of a human cadaveric (Male, 39 years-old) L5 vertebra were obtained and 3D physical models that conformed to the area around the pedicle screw entry region were created using CT conversion software (ScanIP, Simpleware, Exeter, UK), computer aided design software (SolidWorks, Concord, MA) and a 3D printer (Spectrum Z510, ZCorporation 3D technologies, Burlington, MA). Four template shapes were devised and a series of four 3D models of each shape were created with varying offsets to measure their tangency. Offset was adjusted by altering conversion threshold and applying software filtering to subtract volume from the tool surface. The L5 soft tissue was removed to determine the closest intersection between bone and template surfaces of varying offsets. The best junction was measured by placing a fixed amount (2.0g - 4.0g) of plasticine between the tool and the bone, then manually pressing the tool and bone together with a consistent force. It was determined that the least amount of plasticine left on the formed conjuncture (Δ plasticine weight before and after tool articulation) demonstrated the most contact between the offset of the tool and the pedicle screw entry point on L5.

Results: Comparison of 20 3D models with 4 shapes and varying offsets (0.125mm - 0.750mm) revealed that the model with the most anatomically advantageous shape (Fig. 1C) achieved the highest plasticine displacement (mean±standard deviation 85±6%) at an offset of 0.125mm.

Conclusion: A unique method used for assessing tangency between 3D models intended to appose a cadaveric lumbar vertebra is described. Using this method, a patient-specific template shape that is appropriate for unilateral pedicle screw insertion and has optimal bone gripping properties was identified. Future research will incorporate this template design in experiments to assess ease and accuracy of template-assisted pedicle screw insertion.
Fig. 1. 4 Template shapes that were tested.