appear to be most critical. We hypothesized that the developed fracture prediction tool would be able to identify the fracture risk from these critical lesions. The aim of this study was to analyse porcine femurs affected by simulated AVN lesions to understand loading on subsequent failure of bone as well as the assessment of geometric and material parameters on fracture risk.
Methods: A computational tool was created which predicted the stress and strain of the bone structure under loading and its susceptibility to geometric and material properties. Beam theory was used to calculate the maximum loading force at which the bone was likely to fracture. The forces acting on the upper femur were simplified and merged to a single static joint contact force pointing to the centre of the femoral head. Geometric and material properties such as Young's modulus were derived from non-invasive three dimensional computed tomography images (QCT) using a material model. Fifteen porcine femurs were compression tested until failure, where apart from the control samples each femur had an artificial lesion at one of two different positions within the femoral head, lateral and medial to the fovea. The predicted fracture load and location was compared with experimental results.
Results: The predicted fracture load and site correlated well with the experimental data. When analysing fracture at the neck, the predicted fracture loads for the lesion affected femurs were lower throughout. Lesions within the subchondral area had a huge impact on the stability. This trend has been seen in the computational as well as in the experimental data. The predicted fracture load was up to 50% lower within the femoral heads which had a lesion lateral to the fovea. Experimentally as well as computationally there was no difference between the control samples and the heads affected by a lesion medial to the fovea.
Discussion: This in-vitro study demonstrated that fracture prediction based on beam theory is a viable tool to predict fracture. The tool correctly identified the femoral neck and points at the head as fracture sites. The lesion position plays an important role and lesions lateral to the fovea in the weight bearing area are more severe. Slippage of the epiphyseal plate decreased the stability of the porcine femurs indeterminably and made an exact calculation of the fracture load more difficult.
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STAND UP AND SIT DOWN ASSISTANCE PROVIDED BY CUHK-EXO EXOSKELETON

Bing Chen [a,b], Chun Hao [b], Xuan Zhao [b], Lai Yin Qin [c], Kai Ming Chan [a], Sheung Wai Law [a], Ling Qin [a], Wei Hsin Liao [b]
[a]*Department of Orthopaedics and Traumatology, The Chinese University of Hong Kong, Hong Kong, China*
[b]*Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Hong Kong, China*
[c]*Division of Biomedical Engineering, The Chinese University of Hong Kong, Hong Kong, China*

Introduction: The number of people with mobility disorder caused by stroke, spinal cord injury or other related diseases is increasing [1]. To improve the quality of life of these people, devices that can assist them to regain the ability of mobility are in great demand. Stand up and sit down (STS) motion is the first step for paralyzed patients to regain the ability to walk around from their wheelchairs, which is significantly important. In addition, STS training is important for paralyzed patients because it can activate their circulatory and respiratory systems, alleviate spasticity, and increase the bone mineral density of their lower body.
Subjects and Methods: A lower extremity exoskeleton (CUHK-EXO) was developed to assist paralyzed patients with performing essential daily life motions, such as STS, walking, walking upstairs and downstairs. The whole system of the CUHK-EXO was designed with the considerations of ergonomics, user-friendly interface, safety and comfort. Kinematics model of the human-exoskeleton system (HES) was established, and the center of pressure (COP) on the ground and center of gravity (COG) of the whole system calculated. A reference motion pattern of the STS motion was also designed based on discussion with clinical doctors with regard to stability and comfort. In addition, a preliminary test was conducted with optical motion analysis system to obtain reference trajectories of hip and knee joints of the CUHK-EXO. Based on the change in COP position, an algorithm of reference trajectories online modification of the exoskeleton according to the wearer's own effort in the STS motion was proposed and implemented in the control of CUHK-EXO. The effectiveness of the whole system was evaluated by STS testing. Due to safety considerations, before clinical testing, the STS test was first conducted with a healthy subject simulating paralyzed patients.
Results: Based on STS testing, ground reaction forces (GRFs) applied to the HES feet and crutches were obtained. With the measured GRFs, the HES actual COP position was calculated, and the COP deviation between the actual COP and predefined reference COP was obtained. With the COP deviation, the modification angle φ for the exoskeleton knee joints was generated, and the predefined reference trajectory of the knee joint was updated online.
Discussion and Conclusion: With the testing results, we found that if the COP deviation of the HES exceeds the threshold, then we get into an area where the system has the possibility of becoming unstable. The modification angle φ was calculated and added to the predefined reference trajectory of the knee joint. Then, the COP deviation returned to within the threshold to ensure the stability and comfort of the wearer during STS assistance. Thus, we can conclude that the CUHK-EXO can provide stable and comfortable STS assistance for paralyzed patients according to their motion intention and motion conditions.
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HUMERAL COMPONENT VERSION IN REVERSE SHOULDER ARTHROPLASTY AFFECTS IMPINGEMENT IN ACTIVITIES OF DAILY LIVING

Xiang Chen, Andreas Kontaxis, Dan Choi, Julien Berhouet, Timothy Wright, David Dines, Russel Warren, Lawrence Gulotta
Hospital for Special Surgery, USA

Introduction: Impingement, the major functional setback of reverse shoulder arthroplasty (RSA), has been correlated with both implant design and surgical techniques. Studies have suggested the favorable effect of humeral component retroversion on reducing scapular impingement (contact of the humeral cup with the scapular inferior border) and increasing external rotation and abduction range of motion (ROM). However, limited data exist to show how humeral version affects impingement in activities of daily living (ADLs) and whether other impingement sites (besides the glenoid inferior border) may affect the functional outcome. We investigated the effect of humeral component version on the mechanism of impingement during ADLs.
Materials and Methods: A single surgeon performed virtual RSA on 30 arthritic shoulders that were reconstructed from pre-operative CT scans. For each subject, the humeral component was placed into 5 versions (-40°, -20°, 0°, 20°, and 40°; (+) anteversion, (−) retroversion), while maintaining the height and 45° neck/shaft humeral resection. Incidence of both intra-articular impingement (contact of the scapula's inferior border with the humeral prosthesis) and extra-articular impingement (acromion and/or coracoid contact to the humerus) was measured for a kinematic dataset that included 10 ADLs and 3 standard ROM (abduction, forward flexion, scaption) activities determined from 10 healthy subjects. The risk of impingement during the ADLs was assessed as the collective frequency of impingement across a cycle of motion. Frequent impingement sites on the scapula were also identified. For the standard activities, average ROM for each humeral version was calculated.
Results: For the ADLs, 0° retroversion showed the least amount of impingement. In contrast, 40° retroversion resulted in the largest ROM for the standard activities ($94.5\pm20.6^\circ$ in abduction, $108.3\pm8.6^\circ$ in forward flexion, and $89.1\pm13.0^\circ$ in scaption). The most frequent site of impingement changed with the degree of version; retroverted fixation increased the extra-articular impingement, where the anteverted alignment increased the contact between the inferior scapula border and the humeral cup.
Discussion: Our results showed that humeral version can significantly affect the impingement in RSA. Maximizing ROM in standard activities may not reduce the risk of impingement during ADLs. Our data indicate that 0° of humeral version should be preferred to reduce the overall impingement. However, the results are based on a small number of ADLs, and future studies should expand on a larger kinematic data set. It has also been shown that retroversion can increase tension on teres minor, which can result in increased active external rotation post-operatively.
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A NOVEL SCREW HEAD DESIGN OF PEDICLE SCREW FOR REDUCING THE CORRECTION LOSS IN PATIENTS WITH THORACOLUMBAR VERTEBRAL FRACTURES: A BIOMECHANICAL STUDY

Bin Ye, Ming Yan, Huiyang Zhu, Wei Duan, Xueyu Hu, Zhengxu Ye, Zhuojing Luo
Department of Orthopaedics, Xijing Hospital, Fourth Military Medical University, No. 169 West Changle Road, Xian, Shaanxi Province, China

Background: Correction loss is a common phenomenon in patients with thoracolumbar vertebral fractures (TLVF) who undergo posterior pedicle screw fixation. The incidence varies with the kinds of fixation instrumentation used. There is higher incidence in polyaxial pedicle screws (PAPS) group than in fixed-axis pedicle screws (FAPS). Monoplanar pedicle screws (MPPS), which is mobile in the axial plane but fixed in the sagittal plane, may be a better fixation instrumentation for TLVF.
Subjects and Methods: 30 porcine spinal units (L2–L4) were used for the static and dynamic tests, which were randomized into 6 groups (A1, A2, A3, B1, B2 and B3). Static test was performed in A1, A2, and A3. In this test, FAPS, MPPS and PAPS were performed in A1, A2 and A3 respectively. The ultimate load was noted after tested. Additionally, dynamic test was performed in B1, B2 and B3, used FAPS, MPPS and PAPS respectively. Correction loss (head-shank angle (HSA) shift and anterior vertebral body height (AVBH) shift) was obtained and analyzed in each mode.

Discussion and Conclusion: In static test, FAPS and MPPS groups had significantly higher ultimate load than PAPS group ($p < 0.05$) and FAPS group had a little higher ultimate load than MPPS group ($p < 0.05$). In dynamic test, correction loss was minimal in FAPS group, medium in MPPS group and maximal in PAPS group. However, the differences were statistically significant in all comparisons but no in the comparison of FAPS and MPPS groups ($p > 0.05$). In conclusion, the findings from the current study suggest that MPPS can significantly increase the stiffness in axial direction, compared to PAPS, and reduce the risks of correction loss. For TLVF, MPPS is a better optional instrumentation for minimally invasive surgery.

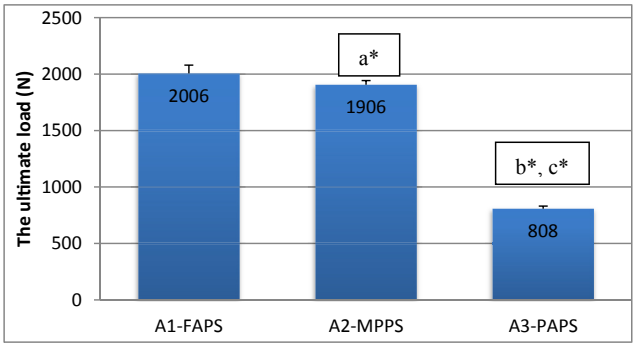

Figure 1 Static testing results.

Table 1 Dynamic testing results

Group	No. of tested spinal units	No. of IF	HSA shift (°)	AVBH shift (mm)
B1-FAPS	5	0	1.2±0.23	4.4±2.07
B2-MPPS	5	0	1.4±0.32[a]	6.8±2.38[d]
B3-PAPS	5	0	2.9±0.23[b*,c*]	11.6±1.82 [e*,f*]

IF = implant failure; HSA = head-shank angle; AVBH = anterior vertebral body height.
[a] Represents no significant difference from group B1 ($p = 0.255$).
[b*] Represents a significant difference from group B1 ($p < 0.001$).
[c*] Represents a significant difference from group B2 ($p < 0.001$).
[d] Represents no significant difference from group B1 ($p = 0.097$).
[e*] Represents a significant difference from group B1 ($p < 0.001$).
[f*] Represents a significant difference from group B2 ($p = 0.004$).

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