Prediction Of Biomechanical Stability According To Types Of Hook Plate And Different Procedure Methods In The Acromioclavicular Dislocation

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INTRODUCTION: Surgical method for acromioclavicular joint dislocation, fixation using a hook plate is representative, and has the advantage of being minimally invasive and excellent in restoring the anatomical position of the bone after surgery[1-2]. However, using the thick hook plate causes surgical problems such as damage to the surrounding soft tissue and the appearance of the implant on the skin. For this reason, thin hook plates are often used but it is not well known about the ideal implant specifications and surgical methods, and there are few biomechanical studies on this[3].Therefore, in this study, Surgical stability of the clavicle and acromion model according to the thickness of the hook plate, the diameter of the screw, the insertion position and number of implants is predicted using finite element(FE) analysis.

METHODS: A three-dimensional(3D) clavicle and acromion model was constructed using computed tomography(CT) data of the right shoulder from a normal 33-year-old male with the slice thickness of 1-mm. The hook plate(E=110GPa, v=0.3) was inserted above the clavicle, ensuring a contact between the upper hook and the lower acromion. Three proximal locking screws(E=110GPa, v=0.3) were inserted into the upper proximal part of the clavicle. Ten different types of finite elements models were performed. Type A(t3.78mm, Ø3.5mm screw, Depuy Synthes Inc.) and B(t2.5mm, Ø2.7mm screw, GS Medical Corp.) referred to the group of hook plates with different thicknesses and distal locking screws with different diameters. Subtype A, B and C referred to the group of which distal locking screws were inserted posterior, medial and anterior(Ø3.5mm screw 1ea: Type 1-A, Type 1-B; Ø3.5mm screw 2ea: Type 1-AB; Ø2.7mm screw 1ea: Type 2-A, Type 2-B, Type 2-C; Ø2.7mm screw 2ea: Type 2-AB, Type 2-AC, Type 2-BC; Ø2.7mm screw 3ea: Type 2-ABC)(Fig 1). A 'Tied contact' with no movement assumed complete fusion between screw-bone and screw-plate, a 'General contact' with a friction coefficient(μ) of 0.3 assumed slight slippage between bone and plate[4]. Considering the posture of holding a 0.5kg mug, a muscle force of 14.9N was loaded to the position of the clavicle where the sternocleidomastoid muscle was attached[5](Fig 2). The distal acromion was fixed in all direction, the proximal clavicle was fixed to allow rotation. To analyze the risk of subacromial erosion and fracture risk of hook according to the plate thickness and the number of screw insertions, the peak von mises stress(PVMS) occuring the acromion was comparatively analyzed in each finite element model.

RESULTS SECTION: As a result, low subacromial erosion and fracture risk of hook plate were confirmed in many screws and thin plates(Type 2-ABC), and PVMS increased as the hook plate was thin, the number of distal locking screws decreased and positioned posterior to anterior. In PVMS of the acromion, other types(Type 1-A: 23.7%; Type 1-B: 5.0MPa, 31.6%; Type 1-AB: 4.1MPa, 7.9%; Type 2-A: 5.4MPa, 42.1%; Type 2-B: 6.0MPa, 57.9%; Type 2-C: 6.3MPa, 65.8%; Type 2-AB: 4.2MPa, 10.5%; Type 2-AC: 4.3MPa, 13.2%; Type 2-BC: 4.7MPa, 23.7%) showed an increase of about 30.7% compared to Type 2-ABC(3.8MPa)(Fig 3a). Hook plate showed a similar trend, the other types(Type 1-A: 8.1MPa, 14.1%; Type 1-B: 8.3MPa, 16.9%; Type 1-AB: 7.2MPa, 1.4% Type 2-A: 9.6MPa, 35.2% Type 2-B: 10.1MPa, 42.3%; Type 2-C: 10.7MPa, 50.7%; Type 2-AB: 7.7MPa, 8.5%; Type 2-AC: 8.1MPa, 14.1%; Type 2-BC: 8.7MPa, 22.5%) also confirmed an increase of about 23.9% compared to Type 2-ABC(7.1MPa)(Fig 3b).

DISCUSSION: This study predicts that the use of thin hook plates and an increased number of small-diameter screws will reduce subacromial erosion and plate damage. While further clinical research is needed, the use of thin plates and small-diameter screws is considered a good approach to reduce the occurrence of Subacromial erosion.

SIGNIFICANCE/CLINICAL RELEVANCE: This study predicts that the use of thin hook plates and an increased number of small-diameter screws will reduce subacromial erosion and plate damage. While further clinical research is needed, the use of thin plates and small-diameter screws is considered a good approach to reduce the occurrence of Subacromial erosion.

Reference: [1] D. Francesco et al., 2012, [2] Chen et al., 2014, [3] Chang et al., 2019, [4] Hung et al., 2017. [5] L. Jiantao et al., 2021

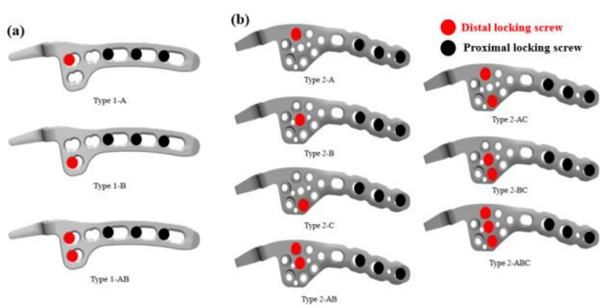

Figure 1. Model variables, (a) Type 1, (b) Type 2

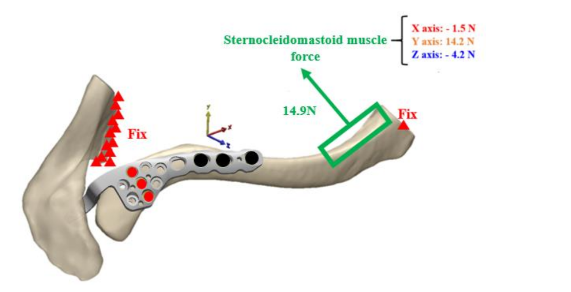

Figure 2. Loading & Boundary conditions(Sternocleidomastoid muscle force)

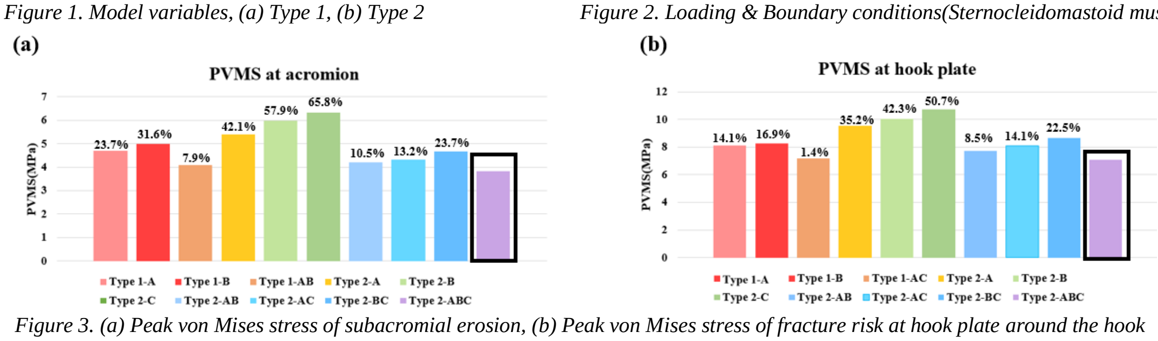

Figure 3. (a) Peak von Mises stress of subacromial erosion, (b) Peak von Mises stress of fracture risk at hook plate around the hook