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In vitro comparison of biomechanical characteristics of sagittal split osteotomy fixation techniques

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Abstract. The aim of the present study was to compare the biomechanical stability of 10 different fixation methods used in sagittal split osteotomy. Twenty-five fresh sheep mandibles were stripped of all soft tissues and sectioned at the midline. A sagittal split osteotomy with 5 mm advancement was performed on each hemimandible. The hemimandibles were randomly divided into 10 groups of 5, and then fixed with 5 different bicortical screws, 4 different miniplates with or without bicortical screws, and 1 resorbable screw configuration. All specimens were mounted on a specially designed 3-point biomechanical test model and compression loads were applied using the Lloyd LRX testing machine until 3 mm displacement was reached. Load/displacement data were gathered and compared using the Mann–Whitney *U*-test with Bonferroni correction ($P < 0.01$). The 3 bicortical screws in an inverted backward-L pattern provided the most biomechanical stability of the screw patterns tested. The miniplate fixed obliquely with 2 bicortical screws in the proximal segment provided the most biomechanical stability of the miniplate groups.

Key words: sagittal split osteotomy; rigid fixation; biomechanical stability.

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Skeletal relapse is the most common complication after sagittal split osteotomy (SSO)[5,7,15]. Authors agree that stability at the osteotomy site is greater with rigid fixation than wire fixation[7,18,28]. The advantages and disadvantages of using bicortical screws and miniplates for fixation after an SSO procedure have been well documented[29,20,22]. There are numerous studies[1,3,4,6,9,11,22] comparing the *in vitro* biomechanical performance of SSO fixation techniques, but it is still not certain which technique is the most effective.

With biomechanical test models, the main problem is how to imitate the human masticatory muscles when examining the stability of rigid fixation techniques. For this purpose, a 2-point biomechanical test model (a cantilevered beam model) has been used[1,19]. More recently, a 3-point biomechanical test model was developed as the best to imitate the masticatory muscles, but there is only 1 study published so far using such a model[3]. The aim of the present study was to compare the biomechanical stability of 10 different fixation methods following SSO using a custom-made 3-point biomechanical test model.

Materials and methods

Twenty-five fresh sheep mandibles (from animals with a mean weight of 40 kg, fed with the same diet, collected from the same abattoir and slaughtered in the same way) were used in this study. The mandibles were stripped of their soft tissues and divided along the anterior midline between the central incisors. The specimens were kept moist and refrigerated at −15°C until all testing was completed. The coronoid processes were removed from all hemimandibles because they caused problems in placement on the biomechanical test model and changed the biomechanical test results by absorbing the forces applied in the preliminary tests. A sagittal split osteotomy with 5 mm advancement was performed on each hemimandible. A medial osteotomy extending from the mandibular foramen to the mandibular inferior border was performed, and this osteotomy was joined with a buccal vertical osteteomy through the mandibular inferior border, differing from human sagittal split procedures. Impacted molar teeth in the osteotomy site were extracted and irregular bone processes at the bony interface were removed. The hemimandibles were randomly divided into 10 groups of 5 and fixed using 10 different techniques. These fixation groups consisted of 1 bicortical screw (group A) (Fig. 1A), 2 bicortical screws in a vertical pattern (group B) (Fig. 1B), 2 bicortical screws in a linear pattern (group C) (Fig. 1C), 3 bicortical screws in an inverted backward-L pattern (group D) (Fig. 1D), 3 bicortical screws in an inverted-L pattern (group E) (Fig. 1E), miniplate placed horizontally with 4 monocortical screws (group F) (Fig. 1F), miniplate placed obliquely with 2 bicortical screws in the proximal segment (group G) (Fig. 1G), the same as group F but with miniplate placed obliquely (group H) (Fig. 1H), the same as group G but with 1 additional bicortical screw at the inferior border (group I) (Fig. 1I), and 3 resorbable bicortical screws in an inverted backward-L pattern (group J) (Fig. 1J). All screw grooves were drilled with a machine to prevent vibration. Diameters and lengths of screws were 2.0 mm and 17 mm for titanium bicortical screws, 2.0 mm and 5 mm for titanium monocortical screws (Elektron Medikal Tic. A.ş., Ankara, Turkey), and 2.8 mm and 16 mm for resorbable bicortical screws (Inion ltd, Lääkärinkatu, Tampare, Finland), respectively.

Each of the hemimandibles was placed on the 3-point biomechanical test model

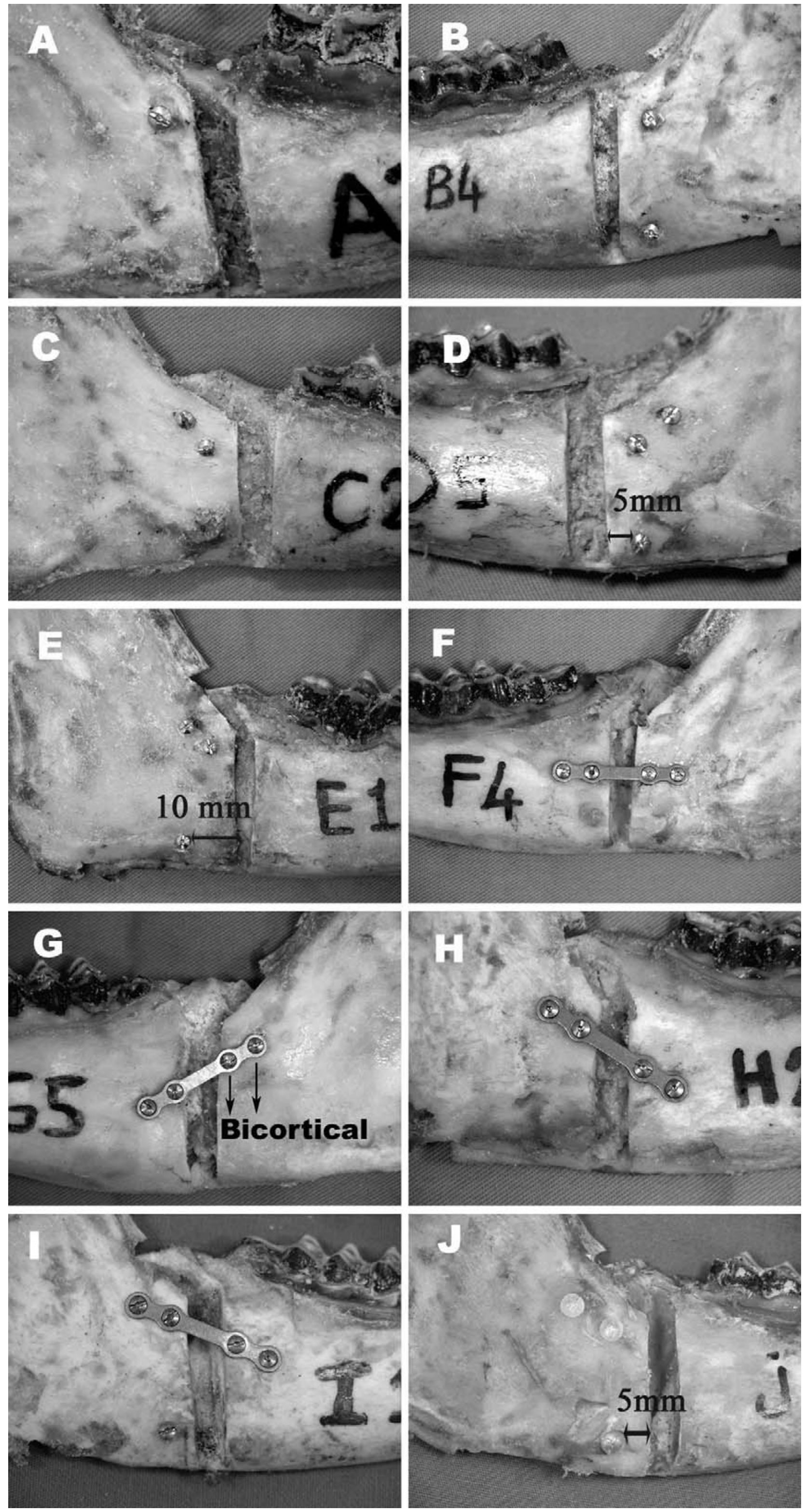

Fig. 1. (A) 1 bicortical screw. (B) Two bicortical screws in a vertical pattern. (C) Two bicortical screws in a linear pattern. (D) Three bicortical screws in an inverted backward-L pattern. (E) Three bicortical screws in an inverted-L pattern. (F) Miniplate placed horizontally fixed with 4 monocortical screws. (G) Miniplate placed obliquely fixed with 2 bicortical screws in proximal segment, 2 monocortical screws in distal segment. (H) Miniplate placed obliquely fixed with 4 monocortical screws. (I) Miniplate placed obliquely fixed with 2 bicortical screws in proximal segment and 1 bicortical screw at inferior border. (J) Three resorbable bicortical screws in an inverted backward-L pattern.