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ABSTRACT:

Analysis of a Redesigned Non-Conventional Humeral Tumor Prosthesis Using Finite Element Methods

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Humeral neoplasms represent one of the most common types of primary bone tumors and significantly affect the biomechanics of the shoulder complex [1]. In many cases, treatment options include limb amputation or limb-salvage surgery through bone grafts or endoprosthetic reconstruction combined with chemotherapy or radiotherapy [2]. At the National Institute of Rehabilitation (INR), approximately 20 patients per year are treated for this condition using a modular prosthetic system developed by the Bone Tumor Service [1].

The RIMAG non-conventional humeral prosthesis is manufactured from Ti-6Al-4V and consists of a humeral stem assembled with modular heads, a spacer, an adjustable sleeve that allows modification of the resection length, and fixation screws. Although limb-salvage surgery preserves adjacent joints, the absence of humeral stabilizing muscles compromises the stability of the glenohumeral joint, increasing the risk of shoulder dislocation during elbow motion [3].

To evaluate this biomechanical behavior, a virtual biomechanical analysis was performed comparing two design versions of the RIMAG prosthesis using the finite element method [4]. A virtual anatomical model of a healthy male shoulder was developed, incorporating the three most common humeral resection levels reported in clinical practice. A total of 21 biomechanical scenarios were simulated including elbow flexion, internal rotation, and external rotation of the arm.

Results showed that the original prosthesis design presented greater lateral deviation from the humeral axis and a higher tendency toward glenohumeral dislocation. In contrast, the redesigned prosthesis demonstrated improved alignment with humeral anatomy and reduced displacement values, suggesting improved biomechanical stability of the shoulder complex.

Keywords: Humeral prosthesis, Bone tumors, Shoulder biomechanics, Finite element method.

References:

1. Linares L, Domínguez V, Araujo V, Delgadillo E, León S. Treatment and reconstruction of humeral bone tumors using a non-conventional RIMAG prosthesis. Acta Ortopédica Mexicana. 2014;28(1):3-11.
2. González L. Bases para el diseño de prótesis de hombro. Master’s Thesis, Mechanical Engineering Department, CENIDET, 2012.
3. Valencia R. Biomechanical analysis of a non-conventional shoulder tumor prosthesis using the finite element method. Bachelor Thesis, UNAM, 2006.