Reproducibility Analysis of Classifications for Fractures of the Proximal Humerus when assisted by Additive Manufacturing (3D Models)

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INTRODUCTION:
Classifications used for proximal humerus fractures have poor interobserver and intraobserver reliability, even when using computerized tomography (CT) and digital three dimensional (3D) reconstruction. Therefore, our aim is to verify, using the Kappa Coefficient, if the reliability of the proximal humerus fracture classifications (Neer, AO, Hertel) increases when 3D printed models (3DPHF) are used in the assessment. Nonetheless, to determine if the treatment indication changes between the two methods (CT scan alone vs. CT scan plus the 3DPHF).
METHODS: We assessed, retrospectively, charts, x-rays, and CT scans of 30 patients. Six evaluators with different levels of expertise (shoulder and elbows specialists - senior group, shoulder and elbow fellows - fellow group, and orthopaedic surgeons with no specialization in shoulder and elbow surgery - general group) classified the fractures and proposed a treatment based on the digital CT scans and printed model. After 8 weeks, the evaluation was repeated. The evaluation consisted of a questionnaire with images of the classifications in order to standardize the assessment, the evaluators classified the fractures according to the Neer, Hertel and AO classification. Also, they were asked to choose a treatment among 1) Nonsurgical treatment, 2) Open reduction and internal fixation (ORIF) with Proximal Humerus Locked Plating, 3) ORIF with Proximal Humerus Locked Plating and structural bone graft, 4) Shoulder Hemiarthroplasty, 5) Total Anatomic Shoulder Arthroplasty, 6) Reverse Shoulder Arthroplasty, or 7) ORIF with Cancelous Screws and/or sutures.
RESULTS: We included 30 patients with an average 55,9 years old (24-88). Sixteen subjects were female (53,3%) and 14 were male (46,7%). There was no difference in sex distribution between the groups. The Kappa Coefficient in each group is summarized in Table 1. The Kappa Coefficient in the fellow's group was: Neer k:0,417 (CT) and k: 0,620 (3DPHF); Hertel k:0,379 (CT) and k: 0,524 (3DPHF); AO k:0,512 (CT) and k:0,603 (3DPHF). In the general group, the Kappa Coefficient was: Neer k:0,378 (CT) and k:0,510 (3DPHF); Hertel k:0,398 (CT) and k:0,416 (3DPHF); AO k:0,550 (CT) and k:0,500 (3DPHF). In the Senior group, the Kappa Coefficient was: Neer k:0,675 (CT) and k:0,704 (3DPHF); Hertel k:0,678 (CT) and k:0,721 (3DPHF); AO k:0,622 (CT) and k: 0,729 (3DPHF). We observed that the agreement increased in every group (except general in the AO classification) after the evaluation of the printed model, and the highest intraobserver agreement was found in the senior group. It was observed that the change in treatment indication occurred more frequently among the complex fractures (3 and 4-part in the Neer classification), specially in the general group. In simple fractures (1 and 2 part) there was no change in the proposed treatment that was considered statistically significant.

Table 1. Intraobserver agreement
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Classification	Evaluators	Groups	Kappa	P-value
NEER	Fellow	CT	0,417	<0,001
		3DPHF	0,620	
	Senior	CT	0,675	<0,001
		3DPHF	0,704	
	General	CT	0,378	<0,001
		3DPHF	0,510	
HERTEL	Fellow	CT	0,379	<0,001
		3DPHF	0,524	
	Senior	CT	0,678	<0,001
		3DPHF	0,721	
	General	CT	0,398	<0,001
		3DPHF	0,416	
AO	Fellow	CT	0,512	<0,001
		3DPHF	0,603	
	Senior	CT	0,622	<0,001
		3DPHF	0,729	
	General	CT	0,550	<0,001
		3DPHF	0,500	