24th CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS

ISB 2013 BRAZIL

FUNCTIONAL EVALUATION OF FINGERS: PRELIMINARY RESULTS

[1]Jérôme Coupier, [1]Samir Hamoudi, [1]Olivier Snoeck, [1]Céline Mahieu, [1]Benoît Beyer, [1]Fédor Moiseev, [1]Victor Sholukha, [1]Patrick Salvia, [1]Véronique Feipel, [1]Marcel Rooze and [1]Serge Van Sint Jan
[1]Laboratory of Anatomy, Biomechanics and Organogenesis (LABO), Faculty of Medicine, Université Libre de Bruxelles, Belgium, http://homepages.ulb.ac.be/~labo.

SUMMARY

This paper presents a protocol for 3D functional evaluation of fingers.

A specific methodology has been developed to solve problems related to material limits, such as optoelectronic camera configuration in a gait laboratory environment, clusters shape and dimensions for small segments, precise initial processing for quality of data collection , post-processing for better visualization of clinical parameters. The protocol provides data related to subject specific kinematic of the hand (ranges of motion (ROMs), helical axes specifications, motion patterns…).

The protocol was applied in a group of twenty healthy volunteers. Results show good agreement with the literature. This protocol will be used in the future in patients with various finger disorders to allow rehabilitation quantification, deficit measurement, recovery objectification, etc…

INTRODUCTION

Kinematic evaluations are useful in the clinical field. Providing objective measurement of patient specific functional motion for different tasks can help clinicians to establish surgical guidelines, assess and follow up the outcome of surgery and/or rehabilitation, and evaluate functional capability.

Whereas it has been of current practice for a half century for gait [1], functional analysis of fingers appears to remain a challenge with many issues. Using an optoelectronic device, many approaches can be used such as the vectorial approach [6] or others methods [7]. Problems remain concerning marker concentration in a really small volume to acquire accurate 3D tracking of all finger segments.

We wanted to develop a protocol for functional analysis of all fingers in all planes of space.

METHODS

Instrumentation. A MXT40s VICON system including eight cameras (4M pixels, 100Hz) was used. A specific configuration of cameras positioning was developed for extra small volumes (maximum of 1000cm³). This includes a vertical camera, one horizontal, two low-angle and four high-angle cameras.

Cluster development. The complexity of the hand led us to use 80 markers divided in 20 clusters (Figure 1). Homemade clusters were designed with 3mm VICON markers with four markers per cluster. Cluster shapes were optimized to allow bilateral use.

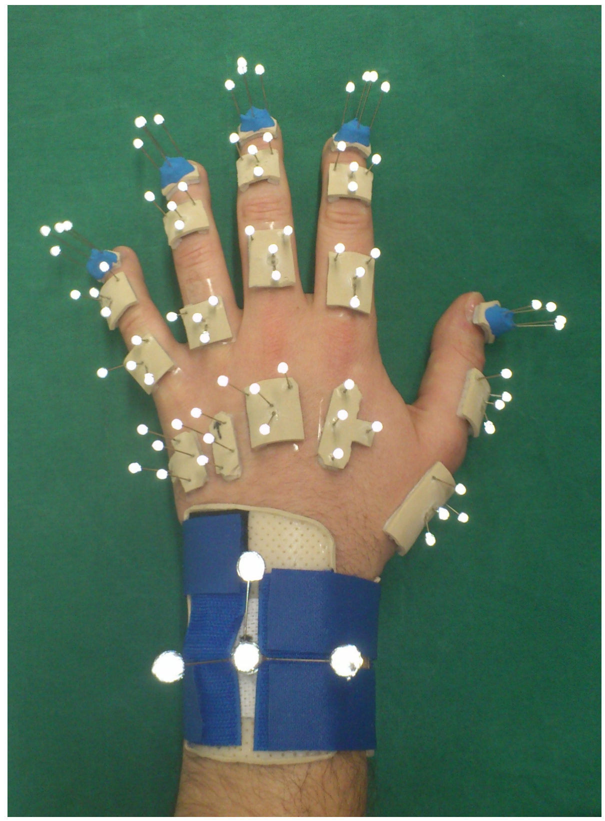

Figure 1: Left hand equipped with clusters and gantlet.

A specific gantlet for the wrist was developed to limit wrist motion and comprised the hand reference cluster.

Study sample. A sample of 20 healthy volunteers was recruited presenting no musculo-skeletal or mobility problem of the wrist or hand.

Evaluation protocol. Clusters were attached with hypoallergenic double-sided tape. Each hand was evaluated separately in a randomized order. Subject were invited to perform analytic motion (flexion / extension, abduction / adduction of long fingers and thumb separately) and functional tasks (pinch and hook grips). Each motion was performed three times at a relatively slow speed with standardized instructions. The procedure was repeated for the other hand. The time of the entire bilateral evaluation approximated one hour, which is acceptable for clinical functional analysis.

Data processing. After reconstruction, labeling (Figure 2) and filling gaps for each marker on each cluster , the C3D file extracted from VICON Nexus® software was then used in a homemade software lhpFusionBox [5] for biomechanical parameters analysis and visualization such as motion representation obtained using reference frames or helical axes.

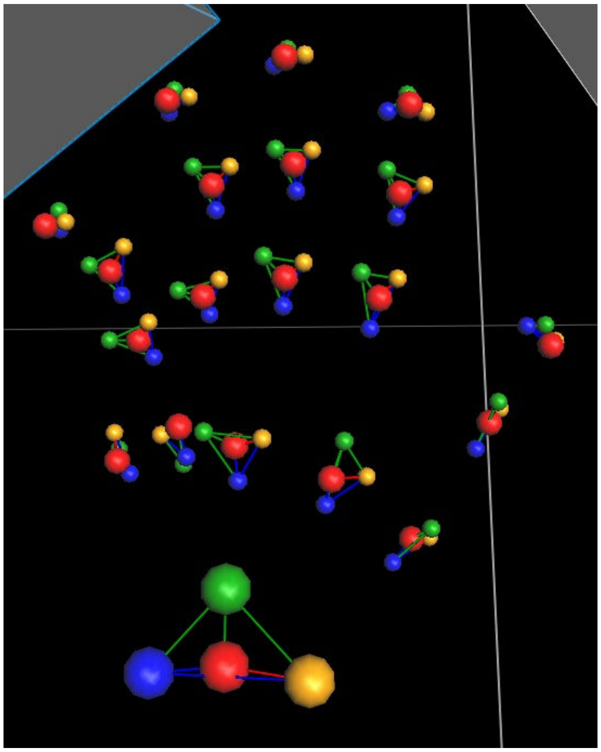

Figure 2: Example of reconstructed and labeled data.

Database creation. For each joint and each motion, ROMs were calculated and helical axes were characterized. Representations were obtained for description of motions patterns.

RESULTS AND DISCUSSION

The described protocol allowed to simultaneously collect 3D kinematics data of all finger joints in healthy volunteers. Functional ROMs were obtained (Table 1) and seem in agreement with the literature [2,3,4].

Helical axes characterization helps to describe subject specific joint mechanisms and to determine normal joint function. Patterns of motions seem in accordance with those found in literature. Advanced results will be presented at the conference.

Further investigation is in progress to test the reliability of the protocol in order to develop complete analysis of the fingers applied to patient health care.

CONCLUSIONS

A protocol for a complete motion analysis of the fingers for clinical applications was developed. Preliminary results were obtained in a group of volunteers to establish a healthy database.

ACKNOWLEDGEMENTS

Special thanks to Ms S. Telese Izzi, Mr H. Bajou and Mr JL. Sterckx for their technical assistance.

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Table 1: Example of ROMs obtained for a right hand during a long fingers Flexion / Extension task for each finger (F I to V), for each joint: Carpometacarpal joint (CM), Metacarpophalangeal joint (MCP), Proximal Interphalangeal joint (PIP), Distal Interphalangeal joint (DIP). ROMs following X- (abduction / adduction), Y- (rotations) and Z-axis (flexion / extension) respectively.

	FI			FII				FIII				FIV				FV			
	CM	MCP	PIP	CM	MCP	PIP	DIP	CM	MCP	PIP	DIP	CM	MCP	PIP	DIP	CM	MCP	PIP	DIP
X	12.8	10.2	26.4	13.2	20.5	15.1	27.0	11.9	14.6	10.3	7.4	10.6	21.4	38.6	27.9	13.7	13.5	32.9	22.3
Y	15.2	13.2	36.5	8.0	26.0	19.4	10.3	8.8	22.4	32.4	18.9	11.5	25.9	55.7	28.2	10.9	30.7	22.3	39.6
Z	28.3	17.4	99.7	17.4	75.5	104.7	73.2	16.4	87.4	102.6	73.1	14.6	82.0	111.0	86.8	10.0	87.4	93.4	79.4