ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

SURGICAL RECONSTRUCTION OF INTRINSIC MUSCLE FUNCTION IN TETRAPLEGIA: COMPARISON OF TECHNIQUES

[1,2]Ursina Arnet, [2]David Muzykewicz, [3,4]Jan Fridén and [2]Richard Lieber
[1]Swiss Paraplegic Research, Nottwil, Switzerland
[2]University of California, San Diego, USA
[3]Sahlgrenska University Hospital, Gothenburg, Sweden
[4]Swiss Paraplegic Centre, Nottwil, Switzerland
email: ursina.arnet@paraplegie.ch

SUMMARY
The aim of this study was to analyze the contribution of the intrinsics (INT) to a functional hand closing and to compare the results of two INT reconstruction techniques (Zancolli-Lasso and House procedures).
Kinematics of cadaveric hands during hand closing (FDP tendon pulled by a motor) were analyzed at following conditions: no activation of INT, high activation of INT and reconstruction of INT by Zancolli-Lasso or House technique.
The results showed that INT activation results in a more functional hand closing represented by a larger fingertip-to-palm distance. Both reconstruction techniques showed improved grasp capacity in comparison to the non-reconstructed hand. However, only the House procedure restored hand kinematics resembling those of an active INT hand.

INTRODUCTION
Regaining grasp function is an important goal for tetraplegic persons [1]. Finger flexion is traditionally restored by the transfer of extensor carpi radialis longus (ECRL) to flexor digitorum profundus (FDP). However, this transfer may result in a curling finger motion (interphalangeal flexion before metacarpophalangeal flexion), thus preventing the hand from grasping around large objects. This motion can be improved by also restoring intrinsic function. There are two main surgical techniques for intrinsic balancing: the Zancolli-Lasso [2] and House [3] procedures. The aim of this study was to analyze the contribution of the INT to a functional hand closing and to compare the results of the two INT reconstruction techniques.

METHODS
To analyze the contribution of the INT during hand closing, FDP tendons from 5 cadaveric hands were deformed by a motor while the INT were loaded with 0g (no INT activation) or 500g (high INT activation). To compare the two reconstruction procedures, the INT from 12 cadaveric hands were reconstructed either with the Zancolli-Lasso or the House procedure and were tested similarly.
Finger kinematics were quantified by video analysis. Kinematics were characterized by the angular change of the metacarpophalangeal joint (MCP) and the proximal (PIP) and distal (DIP) interphalangeal joints. Optimal grasp capacity was defined as the maximal fingertip-to-palm distance during hand closure.

RESULTS AND DISCUSSION
Varying the INT load changed the movement pattern of the fingers ($p<0.001$). With unloaded INT, maximal angular change occurred first in PIP, followed by DIP and MCP joints. With INT activation, the MCP joint moved first, followed by PIP and DIP. The latter resulted in a more functional grasping motion. Due to INT activation, fingertip movement followed a larger arc (Figure 1), resulting in a significantly greater fingertip-palm distance ($p<0.001$). The distance between the fingertip of the middle finger and the palm increased from 67±9mm to 89±4mm.

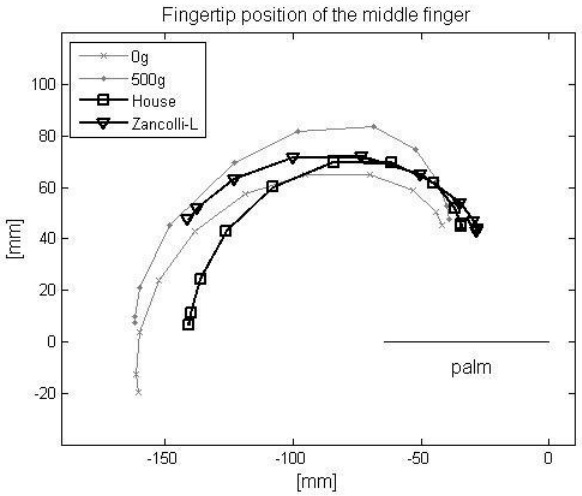

Figure 1: Fingertip position of the middle finger with different activation of the intrinsics (grey) and with two reconstruction procedures of the intrinsics (black).

Both reconstruction techniques showed improvement in fingertip-palm distance over the non-reconstructed hands (74±9mm for Zancolli-Lasso and 74±8mm for House

reconstruction, Figure 1), but there was no difference between the techniques (p=0.416). The kinematics between the procedures differed (p<0.001): with the House procedure the maximal angular change occurred first in the MCP and then the PIP and DIP joints (comparable to active INT), whereas with the Zancolli-Lasso procedure the maximal angular change occurred first in the PIP and DIP and then in the MCP joints (comparable to non-active INT). Since the Zancolli-Lasso procedure could not mimic finger kinematics of active INT, the improvement in fingertip-to-palm distance was mainly caused by the initial baseline MCP flexion of 40° resulting from the reconstruction.

CONCLUSIONS

Simultaneous activation of FDP and INT resulted in a more functional hand closing than did FDP activation alone. These results illustrate the importance of INT balancing during reconstruction of grasp in tetraplegic persons.

Both reconstruction techniques showed improved grasp capacity represented by a larger fingertip-to-palm distance in comparison to a non-reconstructed hand. However, only the House procedure restored hand kinematics resembling those of a hand with activated INT. This is because the House procedure provides for both MCP flexion and IP extension, whereas the Zancolli-Lasso procedure provides only MCP flexion. Additional negative factors related to the Zancolli-Lasso procedure exist, including a higher rate of loosening and palmar rather than dorsal incisions. For these reasons, we promote the use of the House procedure for reconstruction of INT function in tetraplegic patients.

REFERENCES

1. Hamou C, et al., *Hand Surg Am.* ***34***: 692-699, 2009.
2. Zancolli E, et al., *Clin Orthop Relat Res.* **112**: 101-113, 1975.
3. House JH, et al., *Hand Surg Am.* **10**:22-29, 1985.