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How do C6/C7 tetraplegic patients grasp balls of different sizes and weights? Impact of surgical musculo-tendinous transfers

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Abstract
Study design: Prospective control cohort study. Objectives: To develop a new test to analyse qualitatively grasping strategies in C6/C7 tetraplegic patients, and to quantify the effect of musculo-tendinous transfers. Setting: France. Methods: Twelve C6/C7 tetraplegic adults (17 arms; 31.3±7.9 years) and 17 healthy subjects (30.9±9.4 years) completed the study. We assessed participants' ability to grasp, move and release standardized balls of variable sizes and weights. Outcome measures: Failures, movement duration (MD), grip patterns, forearm orientation during transport. Results: In patients as well as in controls, the number of digits involved in prehension increased proportionally to the size and weight of the ball. C6 non-operated tetraplegic patients failed 38.2% of the tasks. They frequently used supine transport (51.4% of successful tasks). MD was longer, with a large distribution of values. The presence of active elbow extension poorly influenced the amount of failure nor grip configuration, but significantly reduced MD and supine transport (34%). Patients who were evaluated after hand surgery showed a trend towards improved MD and more frequent completion (failure 30%), especially for middle-sized and middle-weighted balls. Grip patterns were deeply modified, and all transports were made in pronation. Conclusion: The 'Tetra Ball Test' evidences the characteristics of grasping in tetraplegic patients and those influenced by surgery. It may be useful in understanding effects of surgical procedures. This preliminary study must be completed to evaluate the quantitative responsiveness and reproducibility of this test and to develop instrumented electronic balls to optimise it. © 2007 International Spinal Cord Society All rights reserved.

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Prehension; Prehension assessment; Spinal cord injury; Tendon transfer surgery; Tetraplegia

References
• Maynard Jr, F.M.
  International standards for neurological and functional classification of spinal cord injury. American spinal injury association

• Yarkony, G.M.
  Benefits of rehabilitation for traumatic spinal cord injury. Multivariate analysis in 711 patients
Harvey, L.A., Batty, J., Jones, R., Crosbie, J.  
**Hand function of C6 and C7 tetraplegics 1-16 years following injury**  

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**Kinematics of prehension and pointing movements in C6 quadriplegic patients**  

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**SCIM - spinal cord independence measure: A new disability scale for patients with spinal cord lesions**  

Landi, A., Mulcahey, M.J., Caserta, G., Della Rosa, N.  
**Tetraplegia: Update on assessment**  

Cesari, P., Newell, K.M.  
**The scaling of human grip configurations**  

McDowell, C.L., Moberg, E.A., House, J.H.  
**The second international conference on surgical rehabilitation of the upper limb in tetraplegia (quadruplegia)**  

Zancolli, E.A.  
2nd edn. JB Lippincott: Philadelphia, and

**Synergistic control of stimulated pronosupination with the stimulated grasp of persons with tetraplegia**  

Koshland, G.F., Galloway, J.C., Farley, B.  
**Novel muscle patterns for reaching after cervical spinal cord injury: A case for motor redundancy**  
Upper limb surgery for tetraplegia: A 10-year re-review of hand function

Remy-Neris, O., Milcamps, J., Chikhi-Keromest, R., Thevenon, A., Bouttens, D., Bouilland, S.
Improved kinematics of unrestrained arm raising in C5-C6 tetraplegic subjects
after deltoid to triceps transfer

Perreault, E.J., Crago, P.E., Kirsch, R.F.
Postural arm control following cervical spinal cord injury

Hoffmann, G., Laffont, I., Hanneton, S., Roby-Brami, A.
How to extend the elbow with a weak or paralysed triceps? Control of arm
kinematics for aiming in C6 C7 quadriplegic patients

Ejeskar, A., Dahlgren, A., Friden, J.
Clinical and radiographic evaluation of surgical reconstruction of finger flexion in
tetraplegia

Tetraplegia Hand Activity Questionnaire (THAQ): The development, assessment of
arm-hand function-related activities in tetraplegic patients with a spinal cord
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Wuolle, K.S.
Development of a quantitative hand grasp and release test for patients with
tetraplegia using a hand neuroprosthesis

Teissier, J., Fattal, C., Egon, G.
Strategy for improving hand opening in the tetraplegic upper limb

Coulet, B., Allieu, Y., Chammas, M.
Injured metamere and functional surgery of the tetraplegic upper limb

Jeannerod, M.
(1988) The Neural and Behavioural Organisation of Goal-Directed Movements,
Clarendon Press: Oxford

Santello, M., Flanders, M., Soechting, J.F.
Postural hand synergies for tool use

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