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Elbow joint position sense after total elbow arthroplasty

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Background: Multiple human experiments have shown that articular lesions can have a negative effect on proprioception. The influence of total elbow arthroplasty on joint position sense has not been reported so far. The purpose of the study was to evaluate proprioception, defined as a joint position sense, after total elbow arthroplasty.

Methods: The study included 16 patients with unilateral semiconstrained linked total elbow arthroplasty and 21 healthy volunteers. The evaluation included measurement of active and passive reproduction of joint position sense of both elbows after surgery and the control groups. Reference angles included extension to 50° and 70° and flexion to 110°. We also assessed function of the elbow in arthroplasty group using the Mayo Elbow Performance Score, the Disability of the Arm, Shoulder and Hand score, and a visual analog scale for pain level.

Results: The average value of error of passive reproduction of joint position for elbows after arthroplasty was significantly inferior for all evaluated positions compared with the contralateral elbow and with the control group, respectively, at 110° flexion: 4.3°, 2.7°, and 3.2°; at 70° extension: 4.9°, 2.9°, and 2.7°; and at 50° extension: 6.3°, 3.8°, and 3.8°. The average value of error of active reproduction of joint position for the arthroplasty group was also significantly inferior, respectively, at 110° flexion: 3.5°, 1.9° and 2°; and at 50° extension: 4.4°, 3.3°, and 3°.

Conclusion: Proprioception in elbows that undergo total arthroplasty is significantly inferior compared with the contralateral site of the patient and in the healthy control group.

Level of evidence: Basic Science, Kinesiology.

Keywords: Joint position sense; proprioception; elbow; total elbow arthroplasty; osteoarthritis

Proprioception has been studied extensively throughout the past 2 decades. The first explorations were made more than a century ago with the pioneering work by Sherrington[36] in 1906, when the term proprioception was introduced and defined. A more modern definition was formulated by Goble as the ability of an individual to determine body segment positions and movements in space and was based on sensory signals provided to the brain from muscle, joint, and skin receptors.[13-16] In general, proprioception refers to the perception of joint position and movement and is part of neuromuscular control of the body parts (joints). Afferent information coming from the receptors localized in capsule, ligaments, tendons, muscles, and skin is further processed in the central nervous system on different levels (spinal cord, brain stem, cortex, and cerebellum). The

The University of Medical Sciences in Poznan Ethical Committee approved this project (approval number 573/11).

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final response is reflex activation of stabilizing muscles in effort to obtain proper joint balance and stability.

Joint position sense (JPS) has been one of the attributes of joint proprioception.[32] JPS has been studied mostly with the potentially unstable knee and shoulder. Numerous human experiments have shown that articular lesions can have a negative effect on proprioception.[10,22,27,40,42] Others have proposed that inferior proprioceptive abilities contribute to abnormal loading and an increased risk of injury.[3] Control of the non–weight-bearing elbow joint may also be specifically important for fine and precision tasks of the upper limb.[18,21,22]

Proprioception of the elbow has not yet been extensively studied. To our best knowledge, no study has investigated elbow proprioception after total elbow arthroplasty (TEA). Only a few reports about proprioception after other joint replacements have been published.[3,20] TEA is currently a reliable surgical option for patients with a broad variety of indications, including painful arthritis and comminuted distal humeral fractures.[7,34,35] Although pain relief and an improved function is a significant and predictable advantage, the failure rates remain relatively high.

The function of the implant generally relies on the laxity of components, dynamic muscle support, and prosthetic alignment.[1] The surgical approach is extensive, and damage to the soft tissues might be an issue. The capsule needs to be excised and muscle attachments around the elbow released. In theory, that has to affect elbow proprioception and neuromuscular control. The purpose of the study was to evaluate proprioception, defined as a JPS, after TEA.

Materials and methods

This was a retrospective case-control study. Data included patients with unilateral semiconstrained linked TEA with a minimum 2-year follow-up time after having been operated on in our institution between 2002 and 2012. Of 26 patients evaluated, 16 (10 women and 6 men) agreed to participate in the study and have been followed up retrospectively. All study participants signed appropriate consent.

The patients were an average age of 59.25 years (range, 38-84 years). The indication for surgery was rheumatoid arthritis in 9 patients, osteoarthritis in 2, and post-traumatic arthritis in 5. The right elbow was operated on in 9 patients and the left in 7, and the Bryan-Morrey triceps-sparing approach was used in all cases. The average follow-up time was 39.9 months (range, 24-84 months).

The control group for proprioception measurements consisted of 21 healthy volunteers who were an average age of 26 years (range, 20-30 years). There medical records showed no evidence of elbow problems or any neurologic disorders.

Evaluation was performed at the follow-up visit and included proprioception evaluation by measurement of the JPS of both elbows in TEA and in the control group. The TEA group was further evaluated for range of motion (ROM), pain level according to the visual analog scale (VAS), Mayo Elbow Performance Score (MEPS), and the Disability of the Arm, Shoulder and Hand (DASH) score.

Proprioception evaluation

Proprioceptive abilities were evaluated by the measurement of JPS. For that purpose, reproduction of the joint position (RJP), both active (ARJP) and passive (PRJP), was analyzed. The general idea is that patients reproduce actively and passively a presented reference joint position. The angles of reference and RJPs were measured with the high-accuracy electronic goniometer. The absolute value of difference of reference and reproduced angles was analyzed as a measure of proprioceptive abilities. The difference has been called the error of ARJP (EARJP) or PRJP (EPRJP), depending on active or passive reproduction.

We used the Propriometer, a specific device developed previously in our institution (Progress Company, Ostrów Wielkopolski, Poland).[28,31] This electronic goniometer, with an accuracy of 0.1°, consists of a transducer (based on the Earth's magnetic field), a PC panel, and a remote. The personal computer (PC) panel is connected to the PC and is controlled with specific software that allows a proper recording and calculation of measurements.

To obtain a stable and undisturbed motion of the elbow, the patient was seated in a Biodex chair (Biodex Medical Systems, Inc, Shirley, NY, USA), and the upper limb was fixed into a hinged frame. For passive evaluation, the device moved the elbow in a continuous passive motion with constant speed of 2° per second. The transducer was placed on the Biodex moving frame, parallel to the forearm (Fig. 1, *A*).

For active evaluation, the transducer was placed on the forearm and the arm was placed parallel to the floor, resting on the Biodex frame (Fig. 1, *B* and *C*). The forearm was free, not supported, and fully controlled by the examinee.

For both modes, the person being examined held the remote in the opposite hand. The patient's eyes were covered, and the room was silent. Reference positions (50°, 70°, or 110°) were presented passively and confirmed by pressing the remote button once the position was achieved and memorized. The reference angle was recorded in the PC unit. The forearm was repositioned to the starting angle of 90° flexion. The patient's task was to reproduce the same position, extend it to 50° or 70°, or flex it to 110°. Once the patient achieved the position, then he or she pressed the button again to confirm it. The reproduced angle was recorded to the program and the error of reproduction of the joint position calculated. For active reproduction, the patient used his or her muscles to move the forearm to the desired position. For passive reproduction, the frame moved to allow passive elbow motion.

Five repetitions were performed for every reference position for the active and passive mode. An average of 5 measurements was calculated to get the final average error for each actively (EARJP) and passively (EPRJP) reproduced reference position.

Both elbows were evaluated for every study participant: affected and nonaffected elbows for the TEA group and both elbows for the control group. Preliminary calculations of the errors of the control group did not reveal significant differences in any measures when dominant and nondominant sites were compared. Therefore, results of both elbows were combined into one control group for further comparisons.

The protocol that was developed for this study was based on our previous experience with shoulder proprioception assessment.[28,31] Current study methodology was modified for the evaluation of the elbow joint.