THE FUNCTIONAL RANGE OF MOTION OF THE FINGER JOINTS.

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Introduction

The ability to perform functional tasks is closely related to the available motion of the joints.[6] Despite the significant functional deficits, the literature on the functional range of motion of the finger joints is limited. Hume et al.[3] measured the range of motion of the finger joints while grasping 11 different objects. All subjects were male between 26-28 years.

Purpose: to define the functional range of motion (ROM) of the joints of the fingers.

Materials and Methods

1) We assessed the dominant hand of five male and five female asymptomatic volunteers, between the ages of 18 and 53 years.

2) The finger joints were measured with an electronic goniometer from the EVAL Computerised Evaluation System which has an accuracy better than 1° (Fig. 1).[1]

Figure 1. The EVAL electrogoniometer being used to measure the angle of the index MCP joint during grasp of a knife.

3) The active ROM of the MCP, PIP and DIP joints was measured in maximal flexion and extension. Passive extension of each joint was also measured.

4) The subjects completed the 20 tasks from the Sollerman Test of Hand Grip Function which assesses the eight main types of grip.[7] For each activity the pregrasp (Fig. 2) and grasp measurement (Fig. 3) were recorded. A total of over 5000 measurements were recorded.

Figure 2. The pregrasp position for holding an iron.

Figure 3. The grasp position for holding an iron.

5) Total active motion of the finger was defined as the sum of active motions for the three joints of the finger. The functional range of motion was defined as that utilised to complete 90% of the tasks (including both the pregrasp and grasp measurements).

6) Statistical analysis was performed using paired comparisons, repeated measures ANOVA (analysis of variance) tests to compare the differences between the measurements obtained.

Results

Active Range of Motion

1) The average active range of motion was MCP 109^0, PIP 108^0, and DIP 90^0. This accounts for 36%, 35% and 29% of the total active motion of the finger.

2) There was a progressive increase of active MCP and DIP joint motion from radial to ulnar due to an increase in active MCP joint extension and DIP joint flexion respectively. There was little variability in the active PIP joint motion.

Pregrasp

1) The pregrasp measurements were significantly more extended than the grasp measurements for all joints, reflecting the extension required for preparation of grasp.

2) The pregrasp posture to perform 90% of the functional activities utilised MCP 40%, PIP 34% and DIP 27% of the active joint motion.

3) The pregrasp postures were progressively more flexed from radial to ulnar side for all three joints (cascade of the hand).

4) The ulnar side of the hand utilised a greater arc of its active range of motion.

Grasp

1) The grasp posture to perform 90% of the functional activities utilised MCP 45%, PIP 54% and DIP 56% of the active joint motion .

2) When grasping large objects, (e.g. the cube) the MCP joint hyperextended beyond the active range to increase the span.

3) The index finger DIP joint hyperextended when holding a knife or a pen (Fig. 1). Hyperextension places the volar plate under tension, which locks the joint to allow a greater force to be applied to the tip of the finger (FDS and FDP).

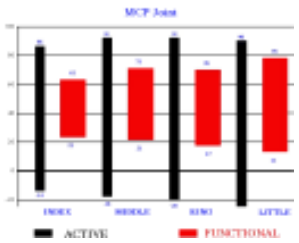
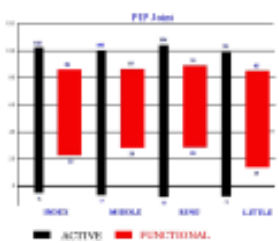


Figure 4.



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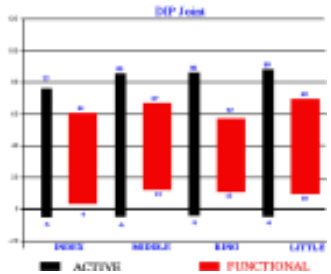

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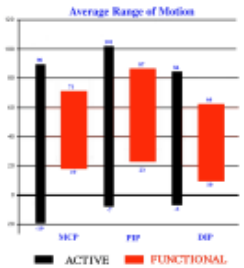

Figure 7.

Functional range of motion

1) The average functional ROM, MCP 19-71^0, PIP 23-87^0 and DIP 10-64^0 (fig.7). That is the volunteers performed 90% of the tasks, without extension of the PIP joint beyond 23^0. Therefore a fixed flexion deformity of this amount will not compromise the function of the hand when performing 90% of activities.

2) To perform 90% of the functional activities utilised MCP 48%, PIP 59% and DIP 60% of the active joint motion.

3) The functional ROM of the MCP joints was greater on the ulnar side of the hand.

4) The functional ROM of the PIP and DIP joints was greater on the border digits (Figs. 5& 6).

Discussion

Clinical Value of functional ROM

Directing rehabilitation The patient with a diseased or traumatised hand should have therapy directed at obtaining and maintaining the functional range of motion.

Indications for surgery Patients who have a fixed flexion deformity that encroaches upon the functional range of motion should be considered for surgery.

Assessment of outcome Outcome grading systems which include an assessment of the range of motion should be based on the functional requirements of the joint.

Pregrasp

Pregrasp is an important part of hand function and is clinically significant to a patient who can not extend the fingers in preparation to grasp (eg. FFD, boutonniere deformity or RA involving the MCP joints).

Different fingers

The index finger is important when performing precision movements with the thumb, such as manipulating small objects. The ulnar side of the hand is non-functional when performing these manoeuvres.
The ulnar side of the hand is important for power grip, grasping of large objects and for cupping of the hand. Flexor power to the ulnar side of the hand is provided by the strong long flexors and supported at the MCP joint by the bipennate lumbricals.[5] The little finger has the most passive, active and functional extension. MCP joint passive extension is important for increasing the span of the hand to grasp large objects. Greater active extension is provided by the two extensor tendons (MCP extension), and bipennate lumbricals (interphalangeal joint extension). The mobility of the little finger is increased by the saddle shaped CMC joint which increases the mobility of the fifth ray and adds rotation, to allow opposition.[5] It enables the ulnar side of the hand to 'cup' around an object (eg hammer) or extend when picking up a large cube or placing the hand flat on the table. The hypothenar musculature allows the mobile fifth ray to be manipulated with precision and controls opposition. The increased mobility, dexterity and opposition increase the function of the fifth ray and may represent the evolution of a "second thumb".

Different joints

The MCP joint is designed to increase the span of the hand. It has a relatively large active ROM, but a small functional ROM. In extension the collateral ligaments are lax and the unicondylar metacarpal head allows abduction and rotation, so that the MCP joint will adapt to the shape of the object in the process of grasp. As the MCP flexes to grasp, the collateral ligaments lock the MCP joint.

The PIP joint has the greatest functional ROM and is functionally important to the finger. It has a relatively large active ROM and large functional ROM which is flexed. The PIP joint is controlled by two long flexors and the extensor hood. The interosseous muscles provides controlled extension, while the lumbricals facilitate a unique interaction between the flexors and extensor hood.

The DIP joint has a relatively small active ROM and large functional ROM which is extended. It works in tandem with the PIP joint in performing precision movements via the intrinsic muscles, extensor hood and the oblique retinacular ligament.

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