Original Article

Effect of static wrist position on grip strength

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ABSTRACT

Background: Grip strength after wrist arthrodesis is reported to be significantly less than normal. One of the reasons suggested for this decrease in grip strength is that the arthrodesis was performed in a suboptimal position. However, there is no consensus on the ideal position of wrist fusion. There is a paucity of studies evaluating the effect of various fixed positions of the wrist on grip strength and therefore, there is no guide regarding the ideal position of wrist fusion. The authors' aim was to determine the grip strength in various fixed positions of the wrist and subsequently to find out in which position of wrist fusion the grip strength would be maximal. **Materials and Methods:** One hundred healthy adults participated in the study. For the purpose of this study, the authors constructed splints to hold the wrist in five different fixed positions: 45, 30 and 15 degrees of wrist extension, neutral and 30 degrees of wrist flexion. The grip strength in all the participants was measured bilaterally, first without a splint and then with each splint sequentially. **Results:** The average grip strength without the splint was 34.3 kg for right and 32.3 kg for the left hand. Grip strength decreased by 19–25% when the wrist was splinted. The maximum average grip strength with a splint on was recorded at 45 degrees of extension (27.9 kg for right and 26.3 kg for left side). There was a gradual increase in the grip strength with increase in wrist extension but the difference was not statistically significant ($P = 0.29$). The grip strength was significantly less in flexed position of the wrist ($P < 0.001$).

KEY WORDS

Grip strength; wrist position; wrist arthrodesis

INTRODUCTION

Arthrodesis is a well-established procedure in the management of many wrist and carpal disorders. It can provide significant relief of pain, correction of deformity and stabilization of the wrist joint. Despite its obvious benefits, it is unable to restore grip strength. Reported grip strength after successful wrist fusion has been demonstrated to only achieve 65–75% of the normal.[1-3] One reason stated for this decrease in the grip strength is suboptimal position of the fused wrist. However, a review of the current literature suggests that the optimal position for wrist arthrodesis remains controversial.[3-6]

The correlation between wrist position and grip strength has been studied in detail and this information has been applied to the ideal position of wrist arthrodesis. However, there are very few studies which have analyzed the effect of various

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fixed positions of flexion or extension of the wrist on the grip strength. Hence the effect of the wrist position on grip strength after wrist arthrodesis is not clear.

The purpose of present study was to investigate the effect of splinting on the grip strength when compared to the maximal grip strength in the self-selected position of the wrist and to find out the influence of the various static (fixed) wrist positions on grip strength.

MATERIALS AND METHODS

Hundred normal healthy adult volunteers working in our hospital participated in the study. The age of the participants ranged from 19 to 56 years (average 29 years). There were 60 males and 40 females. Ninety two of 100 were right-hand dominant and eight were left-hand dominant. For the purpose of this study we designed splints to hold the wrist in five different fixed positions of the wrist – 45, 30 and 15 degrees of wrist extension, neutral wrist position (0 degree wrist extension) and 30 degrees of wrist flexion [Figure 1]. The splints were made with thermoplastic material and an aluminium strip was incorporated over the dorsal aspect to prevent any deformation of the splint and change of wrist position while power gripping. The splint was contoured to attach to the dorsal aspect of the wrist and forearm in order to avoid interference with gripping. It was secured to the limb with one strap in the palm, one just proximal to the wrist and another in the proximal third of the forearm [Figure 2]. The strap in the palm was pliable and thin to minimize interference with grip and allow free rotation of the metacarpals. None of the patients felt the splint was uncomfortable for gripping, or painful.

Measuring grip strength

A Jamar dynamometer (Sammons Preston Inc., New York) was used to measure the grip strength for all the participants. All the participants were given a verbal explanation followed by a demonstration of how to perform maximum grip effort on the dynamometer. All measurements were taken in standardized position with the participant standing with their arm held in zero abduction flush against the body. The elbow was flexed to 90 degrees with the forearm in the neutral position and wrist in the position determined by the splint [Figure 2]. A single attempt of grip strength was recorded for each wrist position. Measurements were taken for both the left and right hand. Adequate recovery time (15 to 30 s) was given between the subsequent measurements to negate the fatigue factor.

Measurements with different wrist position

First measurement was done without the splint to detect the maximal grip strength in the self-selected (unconstrained) position of the wrist. The splints were then secured sequentially to the participants' wrist and grip strength at the first attempt was recorded. The process was then repeated on the opposite side.

Statistical analysis

The difference in the grip strength in various groups was statistically analyzed using the two-tailed student *t*-test and the significance was set at *P*-value less than 0.05.

RESULTS

The average grip strength in various wrist positions is shown in Figures 3 and 4. The average grip strength without splint was 34.3 kg at right hand and 32.3 kg at left hand. Grip strength

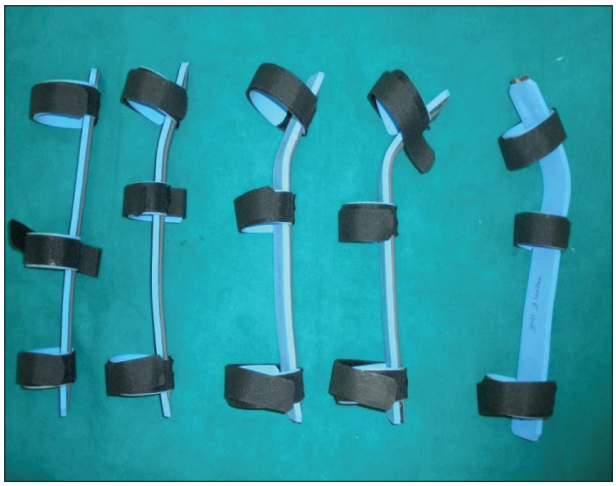

Figure 1: Splints designed to hold the wrist in different positions – 45 degrees wrist extension, 30 degrees wrist extension, 15 degrees wrist extension, neutral wrist position and 30 degrees wrist flexion

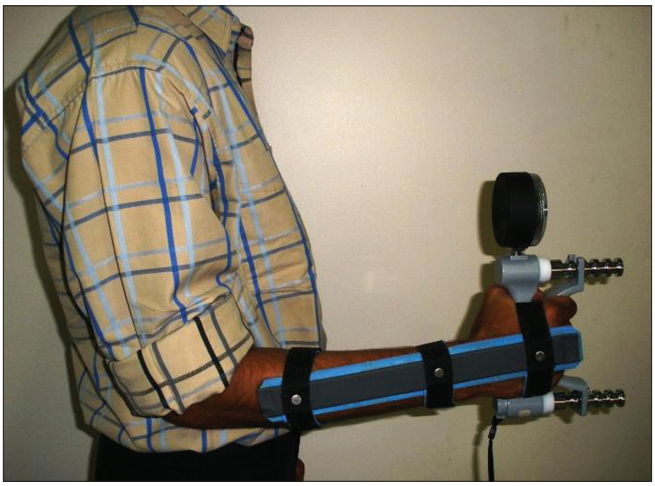

Figure 2: All measurements were taken in standardized position – standing with the arm held flush to the side of body, elbow flexed to 90 degrees, forearm in mid-prone position and wrist in the position determined by the splint

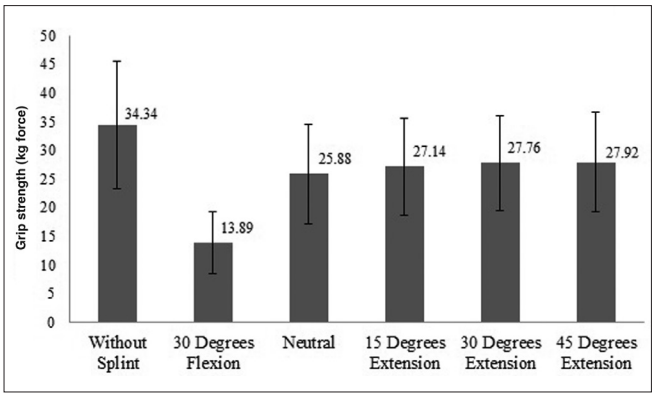

Figure 3: Change in grip strength with wrist position at right hand

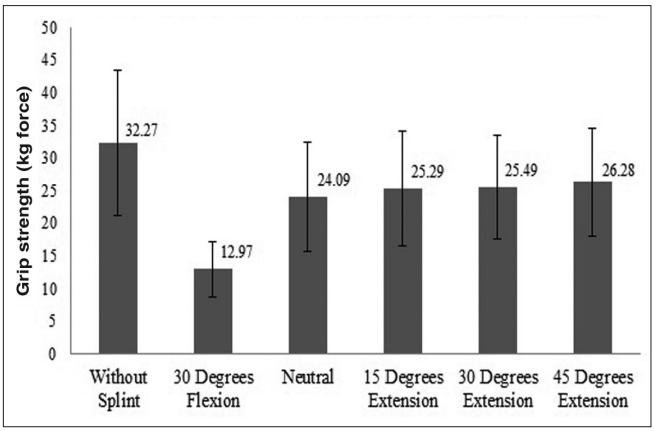

Figure 4: Change in grip strength with wrist position at left hand

reduced by about 19–25% when wrist was splinted, which is statistically significant ($P < 0.001$). Maximum average grip strength with the splint on was recorded when the wrist was held in 45 degrees of extension (27.9 kg on right side and 26.3 kg on left side). However, this maximum grip strength with the splint on was only 81% of the unconstrained grip strength without a splint. There was a gradual increase in the grip strength with increase in wrist extension (in the range analyzed in this study i.e. till 45 degrees) but the difference was not statistically significant ($P = 0.29$). Grip strength in wrist flexion was only 13.9 kg on right side and 13 kg on left side, which is approximately 60% less than the normal grip strength ($P < 0.001$). The restricted grip strength in flexed position of the wrist was only half of the restricted grip strength in extension.

DISCUSSION

Arthrodesis of the wrist is a commonly performed operation for traumatic and non-traumatic disorders of the wrist. Grip strength after wrist arthrodesis has been found to be significantly less than normal in various clinical studies. Wright and McMurthy[2] found grip strength to seldom reach the normal, Leighton and Petrie[7] found it to be 50 to 60% of the normal, Rayan[1] found it to be 78% of the normal. The main reasons for this decrease in grip strength are relative lengthening of the musculotendinous units because of bone removal and loss of movement in the radio-carpal and the inter-carpal joints, which normally allows for the optimal positioning of the wrist in dorso-palmar and ulno-radial plane (allowing ulnar deviation). Also it has been speculated that the reason for such a significant decrease in grip strength is that the wrist has been fused in a suboptimal position.[6] Subsequently the obvious question is, what is the *optimal* position to fuse the wrist in to maximize grip strength? There is no consensus on the ideal position of wrist arthrodesis.[3-5] Most authors recommend 0 to 30 degree of extension and 0 to 15 degree of ulnar deviation.[1-3,6]

The effect of wrist position on grip strength has been studied previously.[6] Grip strength was found maximum in the self-selected position of the wrist which was 35 degrees of extension and 7 degrees of ulnar deviation.[6] In any other position of the wrist the grip strength was decreased. The authors have aptly stated that their data does not describe the optimal position for wrist fusion but have suggested that the reduced grip strength after wrist arthrodesis may be because the fusion is done in neutral to 15 degrees of wrist extension.[6]

We believe that it is difficult to hold the wrist in specified angles while forcefully gripping the dynamometer and hence studies which report the variations in the grip strength with various wrist positions while leaving the wrist unsplinted would have significant measurement bias. The unconstrained grip strength is produced by an optimal balance between the various joints and the muscle tension that results in the maximum grip strength. If the wrist is splinted the grip strength is reduced. In our study the maximum grip strength of splinted wrist was 81% of the unconstrained grip strength of the same hand of the individual. Interestingly there was no significant difference in the grip strength with wrist in various positions of wrist extension tested in this study i.e. 0 to 45 degrees of extension ($P = 0.29$). The grip strength was significantly less in flexed position of the wrist ($P < 0.001$). The restricted grip strength in flexed position of the wrist was only half of the restricted grip strength in extension.

Netscher *et al*.[8] found it difficult to maintain a constant angle of wrist when performing measurement. Mathur *et al*.[9] used a simple device onto which the forearm and wrist could be strapped with Velcro. Pryce[10] used a special apparatus that had four straps to constrain the forearm to the table. In a table-bound device, the values may be affected by participants applying an isometric force by pulling the hand towards the body. In our study we used specially designed splint to hold

the wrist in various fixed position in dorso-palmar plane. We believe splinting the wrist and measuring grip strength in the standardized position would give more accurate values, which can be easily compared with the normal values.

From our results we believe that the ideal position of wrist arthrodesis depends on the functional demands of the individual and appearance. Clayton and Ferlic[1] recommended the wrist arthrodesis in 0 degrees in sagittal plane and 10 degrees ulnar deviation in frontal plane as they felt that with this wrist position the arc of pronation and supination best substitutes for flexion and extension of the wrist. Many of the patients are not happy with the appearance of the wrist in larger degrees of dorsiflexion. Fusion in larger degree of wrist extension may make it difficult for the patient to put his hand in the trouser pocket and also may make picking up of the small objects difficult. Also more dorsiflexion may make the use of the hand difficult for use in hygiene and toileting. Moreover, larger degrees of dorsiflexion have not found to give significantly larger grip strength in our study. We recommend fusing the wrist in 10–15 degrees of extension as this would give good appearance and shall allow good function of the hand.

Our study relates only to the position in the dorso-palmar plane and does not consider the position in the radio-ulnar plane, which is another significant determinant of grip strength.[6] We found it difficult to control the radio-ulnar position of the wrist with the splint, hence we did not include it in the study. Since the splint did not influence the radio-ulnar position of the wrist, we believe that change in radio-ulnar position remained similar in all the participants for a given splint position and the data presented reflected the true influence of wrist position in dorso-palmar position on grip strength.

Inference and implications

From the observations in this study, it appears that the position of wrist fusion between neutral and 45 degrees of extension does not significantly influence the grip strength. The decrease in the grip strength following the wrist fusion is not primarily because of the fusion done in suboptimal position. The main reasons for decreased grip strength are relative lengthening of the musculotendinous units and loss of movement in the radio-carpal and the inter-carpal joints, which normally allows for the optimal positioning of the wrist in dorso-palmar and ulno-radial plane.

CONCLUSION

Constrained grip strength is significantly reduced compared to grip strength in the unconstrained self-selected position of the wrist. The grip strength was significantly reduced in any degree of flexion of the wrist but there was no significant difference in the static grip strength between the neutral and 45 degrees of wrist extension. These results suggest that the position of wrist fusion between neutral and 45 degrees of extension does not significantly influence the grip strength. The ideal position of wrist arthrodesis can be tailored to the patient according to their individual needs.

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