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Clinical report

Dynamic splint using a super elastic wire for flexion contracture of the hand

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Abstract

We report a simple, small and effective dynamic splint using a super elastic wire (made of Ni-Ti alloy) for flexion contracture of the fingers and the hand. A dorsal outrigger dynamic splint with compound counterparts is commonly used for these contractures. However, the size of the splint is large and adjustment is complicated.

Our newly designed super elastic wire splint does not need a large forearm trough or an outrigger. The distance between the contracted finger and the super elastic wire is short, and the results in the compactness of this splint. Moreover, it is very easy to adjust the optimum traction force to the finger by a sliding finger cuff, without reshaping the splint.

We used this splint in four cases of flexion contracture of fingers. The extension lag of the proximal interphalangeal (PIP) joint before splinting was between 30° and 100°. As a result of splinting, improvement of the extension lag of the PIP joint was between 20° and 55° (mean 36.2°)

Introduction

Flexion contractures of the phalangeal joints of the fingers are often encountered in the daily practice of hand surgeons. To improve the range of motion of these joints, dynamic splinting has been proposed[1)2)]and also is used before surgical intervention, including tenolysis or other surgical contracture release.

Many dynamic splints have been designed for these finger flexion contractures[1)2)], and a compound extension splint with an outrigger is commonly used. This type of splint has an outrigger attached to a forearm trough or an outrigger with a lumbirical bar attached to a dorsal and a palmar metacarpal bar. The dynamic traction force is achieved with a finger cuff and an elastic band[1)].

However, this type of dynamic splint is large, the adjustment is complicated and the appearance is not particularly pleasing. To overcome these disadvantages, we designed a new dynamic extension splint with a super elastic wire.

Patients and Methods

The dynamic traction force of the new splint is provided by a "super elastic wire" made of Nickel-Titanium (Ni-Ti) alloy which has a straight shape memory (Actment Co, Ltd. Saitama, Japan). We used one or more than one super elastic wires of 0.4 or 0.6 mm in diameter, depending on the desired optimal traction force. If a contracture was marked, we used wires both 0.4 and 0.6 mm in diameter. Connection of the super elastic wire(s) is made to the dorsal metacarpal bar made by low temperature material (Aquaplast®) on the axis of the contracted finger. Insertion and fixation of the wire is facilitated by heating the tip of the wire. We cover the wire(s) with a vinyl tube (drip infusion tube) to prevent skin irritation and a pad is placed on the dorsal side of the PIP joint if needed. The con-

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tracted finger is in traction by a finger cuff in which the wire is placed.

Patients

Between April and December 2004, we used this splint in 4 cases of flexion contracture of fingers. All cases had previously been treated for flexor tendon repair including secondary repair and incomplete amputation, and failed to recover a normal range of movement of phalangeal joints. We told the patients to use the splint at night time, and if possible, also in the day time. The patients were 3 men and 1 teenage girl, with ages ranging from 17 to 57 years old. The extension lag of the PIP joint before splinting was between 30° and 100°.

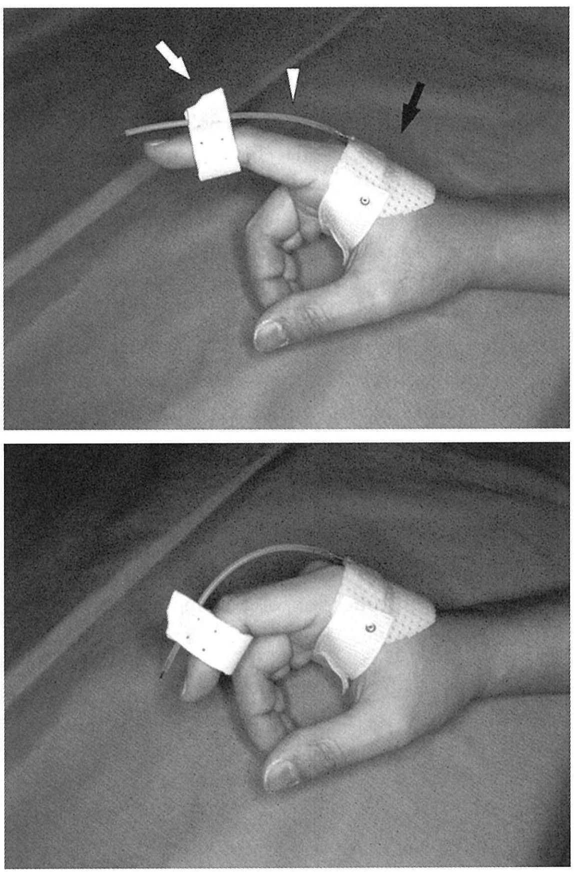

Fig. 1 The dynamic traction force of new splint is provided by the "super elastic wire (white arrow head)" made by Ni-Ti alloy. The super elastic wire is connected to the dorsal metacarpal bar (black arrow) made by low temperature material on the axis of the contracted finger. The wire is covered with a vinyl tube (drip infusion tube) to prevent skin irritation. The contracted finger is pulled by a finger cuff (white arrow) in which the wire is placed.
1-a : Finger extension
1-b : Finger flexion

Results

Dynamic splinting was performed without any trouble and the extension lag was improved in all cases. Improvement of the extension lag of the PIP joint was between 20° and 55° (mean 36.2°). Flexor tenolysis procedure was performed in two cases after dynamic splinting.

Discussion

Recently, Ni-Ti alloy possessing shape memory is used in various types of medical equipment, such as stents for blood vessels[3)], biliary duct[4)], and airway[5)] and its advantages are widely recognized. Takami et al.[6)] reported the application of a shape memory alloy to hand splinting. They used a plate alloy with shape memory which required prefabrication by heat treatment at 500℃. They also stated that cutting and drilling of the plate were difficult and that the high cost of the material was a drawback.

We used a Ni-Ti alloy super elastic wire containing 56.04% of Ni (0.3 mm diameter) or 55.99% of Ni (0.6 mm diameter), which has a straight shape memory. This wire is easily cut by a nipper or a wire cutter and it is relatively cheap (app. £8/meter in the Japanese market). We designed our dynamic splint by placing this wire on the axis of the contracted finger and utilized the elasticity as the traction force.

Our design of dynamic split has many advantages compared to the outrigger type dynamic splint which is also used in the similar cases of finger flexion contractures.

First, the distance between the finger and the outrigger is much longer than the distance between the finger and the wire. This results in the size of the splint becoming very large and it is not comfortable for patients when using the outrigger type splint. In particularly, the

Table 1

Age	Female/Male	Side of finger and type	Extension lag before splinting (degree)	Extension lag after splinting (degree)	Period of splinting (weeks)	Surgical procedure after splinting
31	M	Rt index, FDS&FDP rupture at Zone II	40	20	8 w	tenolysis
57	M	Rt ring, incomplete amputation at proximal phlanx	50	10	8 w	no
23	M	Lt little, FDP rupture at zone I	30	0	3 w	no
17	F	Lt ring, FDP re-rupture at zone II	100	45	12 w	tenolysis

outrigger must project distal to the finger when the splint is used for the PIP joint or DIP joint.

Secondly, from a mechanical point of view, our splint is more stable than the outrigger type splint. The longer attachment length of the outrigger resulted in a longer forearm trough necessary for the stability of the splint itself[1]. In contrast, because our splint uses a super elastic wire, it does not need a forearm trough or a bar, and only needs a metacarpal bar which does not immobilize the wrist proximally.

Third, as the passive range of motion of the joints begins to improve, the outrigger to which the traction device is attached must be adjusted to maintaining a 90° angle[1]. However, with our splint there is no need of making a revision : the optimal angle is maintained by sliding the finger cuff.

Prosser[2] reported that the treatment outcome of 20 subjects with PIP flexion contracture who were treated by a dynamic splinting program using either a Capener or low-profile outrigger. Each patient was instructed to wear the splint for 8 weeks. As a result, final extension lag averaged 21°, an improvement of 18°, compared to a mean improvement of 36.2° with our splint.

On the other hand, our newly designed splint does have a limitaion. It is very difficult to adjust different forces to the DIP and PIP joints, but we think that this circumstance is very rare.

In conclusion, our splint using a super elastic wire is very simple, compact, and effective for dynamic splinting of flexion contracture of the hand.

References

1) Fess EE, Gettle KS, Strickland JW : Hand Splinting ; Principles and methods. Mosby : 68-95, 180-193, 1981

2) Prosser R : Splinting in the management of proximal interphalangeal joint flexion contracture. J Hand Ther **9** : 378-386, 1996

3) Kandzari DE, Goldberg S, Schwartz RS, Chazin-Caldie M, Sketch MH, Jr : Clinical and angiographic efficacy of a self-expanding nitinol stent in saphenous vein graft atherosclerotic disease : the Stent Comparative Restenosis (SCORES) Saphenous Vein Graft Registry. Am Heart J **145** : 868-874, 2003

4) Goldin E, Beyar M, Safra T : A new self-expandable and removable metal stent for biliary obstruction—a preliminary report. Endoscopy **25** : 597-599, 1993

5) Tsugawa C, Nishijima E, Muraji T : A shape memory airway stent for tracheobronchomalacia in children : an experimental and clinical study. J Pediatr Surg **32** : 50-53, 1997

6) Takami M, Fukui K, Saitou S, Sugiyama I, Terayama K : Application of a shape memory alloy to hand splinting. Prosthet Orthot Int **16** : 57-63, 1992

指関節屈曲拘縮に対する超弾性ワイヤーを用いたダイナミックスプリント

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我々は指関節屈曲拘縮に対し、Ni-Ti 合金製の超弾性ワイヤーを用いた単純かつ小型のダイナミックスプリントを使用し、良好な結果を得たので報告する。

指関節屈曲拘縮に対しては副木を加工した背側アウトリガーを用いるのが一般的であった。しかしながら、スプリントのサイズは大きく、調節も複雑であった。我々が新しくデザインした超弾性ワイヤーを用いたスプリントは大きな前腕シャーレやアウトリガーを必要としない。拘縮指と超弾性ワイヤーとの距離が狭い為このスプリントは非常にコンパクトである。その上、スプリントを作り変えることなく、スライドする指カフを用いることで非常に容易に最適な牽引力へと調節することができる。我々は、このスプリントを指関節屈曲拘縮の 4 症例に用いた。スプリント使用前は 30〜100 度の伸展不全であったが、スプリント使用後は 20〜55 度 (平均 36.2 度) の改善を認めた。

〈キーワード〉 超弾性ワイヤー、ダイナミックスプリント、指関節屈曲拘縮