Early Active Vector Adjustable Skin Traction (EAVAST) for complex and unstable phalangeal fractures

A non-invasive treatment for complex unstable finger fractures.

By Karin Boer-Vreeke, Jason Fairclough, Jason Lam & Janou Bardoel

Introduction

Comminuted intra-articular fractures at the base of the middle phalanx have been termed pilon fractures.[1] Fractures with more than 50% of the articular surface involved, with or without dorsal subluxation, are difficult to treat and often result in a poor functional outcome. The aim of treatment is to restore active stability and an anatomical position of the joint, with the least invasive treatment possible.[2] Giddens' recent review of outcomes of metacarpal and phalangeal fractures suggests that non-operative treatment is indicated in cases where less than 1/3 of the articular surface is involved without dorsal displacement.[3] He notes that a key factor in determining outcomes is that the joint retains an ability to palmarly glide when flexed, and not simply pivot.[3] Kiefhaber states that acceptable outcomes depend on achieving and maintaining a well-aligned, well-reduced joint, re-establishing normal joint kinematics and restoring motion. Importantly, he also notes that anatomic articular surface reduction is desirable but not necessary for a good outcome.[4]

The EAVAST technique combines longitudinal skin traction, early active movement and the use of bolsters and straps

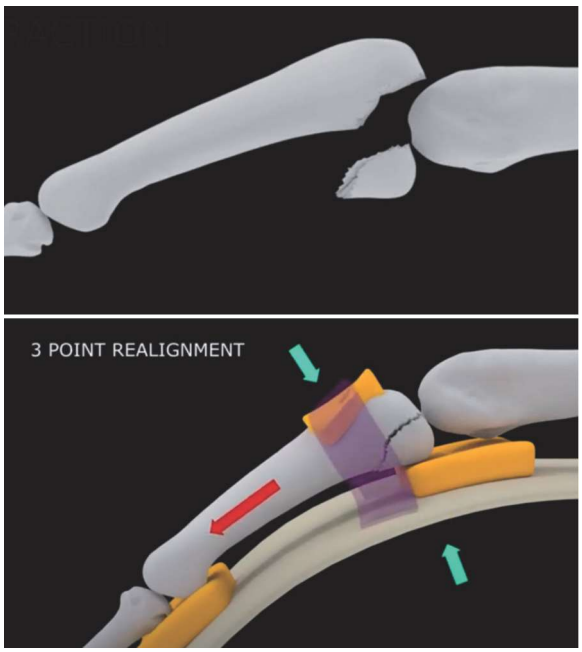
Abstract

Finger fractures are a common presentation to emergency departments. Complicated fractures are often treated surgically, using plates, screws or k-wires, however, the disruption of the soft tissue often leads to complications such as adhesions, limited range of motion or infections. Early Active Vector Adjustable Skin Traction (EAVAST) is an alternative, non-invasive method for treating complex unstable finger fractures without the possible risks of surgery. The treatment involves utilizing skin traction to facilitate ligamentotaxis and early active mobilization. This may lead to less complications, better range of motion and early return to normal daily life activities.

Current surgical treatments for unstable finger fractures include fixation with K-wires, screw fixation, plate fixation or hemi-hamate reconstruction.[5] A known risk with surgical methods is the increased disruption of soft tissues and complications such as limitations in motion (59%), cold intolerance (37%), numbness (12%), work impairment caused by the operation (16%), stiffness, pain and infection.[6]
Although an operation may achieve an anatomical reconstruction of the joint surface, due to soft tissue damage, gliding and joint space may be compromised. There is growing interest in less invasive, non-operative techniques for treating finger fractures. Traction is one such technique and can be applied through pins (skeletal traction) [7-9], the skin[10] or nail.[11] Traction employs the principle of ligamentotaxis by applying a longitudinal force that tightens the soft tissue envelope to assist fracture reduction. It is often combined with early active motion and palmar translation corrections as described by Schenk.[12] A modern evolution of traction is Early Active Vector Adjustable Skin Traction (EAVAST) described by Dowd et al.[13] and extension block splinting as described by Hamer and Quinton.[14] The aim of this article is to introduce the EAVAST method to Dutch hand therapists and hand surgeons and to demonstrate our experience with it on unstable fractures that would otherwise have been surgically managed.

About the EAVAST method

The EAVAST technique combines longitudinal skin traction, early active movement and the use of bolsters and straps to facilitate glide/translation or the adjustment of torque in sagittal or transverse planes. Traction force applied is typically strong at 500 grams to assist fracture reduction and maintain realignment.



Figures 1 and 2 *Three-point realignment method using bolsters and a palmar translation strap can be used to correct a dorsally subluxed PIPJ fracture-dislocation*

Only one study is reported on the EAVAST method. Dowd et al.[13] compared outcomes between surgery and the EAVAST method in a retrospective cohort analysis (n=181) in Australia. Results showed faster and better recovery of motion. Total Active Movement (TAM) was 25 degrees more in the EAVAST group ($p<0.001$) and less complications were reported compared to surgery.

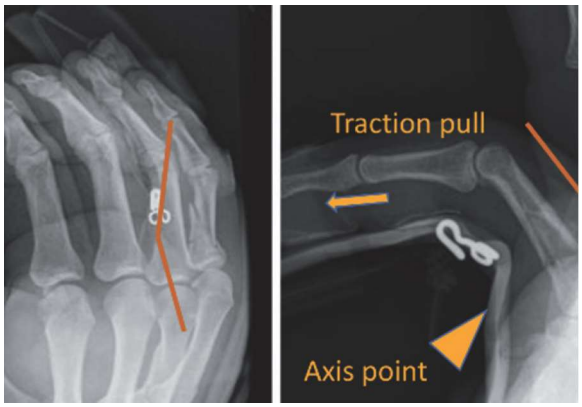


Figure 3 *A cantilever is set up by creating a flexion bend in the splint at the point of the fracture, and then applying a flexion force under traction to rotate the distal fragment volarly through a torque force. It is commonly used to correct volar apex proximal phalanx shaft fractures*

While functional outcomes were positive, there were also limitations. The initial use of rigid zinc-oxide tape induced allergic reaction in some patients, there was loss of tension due to sweating under the tape and lower compliance due to odor and the inability for patients to change their tape or wash their finger. This led to the development of a porous hypoallergic tape method and design, the Butterfly Skin Traction, by author Jason Fairclough. The EAVAST method was presented and demonstrated at workshops in Berlin IFSSH Conference 2019.

Figure 4 *The use of bolsters and a compression strap in combination with traction can be applied to oblique and shortened shaft fractures to restore axial length and compress fractures. Coban can be used to bind the medium density foam bolsters allowing gentle fracture compression*

Key aspects of EAVAST are shown below:
1) Longitudinal Traction of typically 500grams;
2) Transverse vector adjustment with bolsters and straps, and/or adjustment of splint position into flexion to alter the orientation of the force vector (figures 1 and 2);
3) Cantilever effects – to adjust angle of fractures through use of splint position and straps (figure 3);
4) Fracture compression through foam blocks and elastic straps (figure 4);
5) Early motion under traction to prevent or correct malrotation and prevent stiffness.
After attending one of the EAVAST workshops, the therapists of the Hand and Wrist Centre The Hague started to use the EAVAST method in close collaboration with the hand & wrist surgery department of the Haaglanden Medical Centre. The following case studies show the application of the EAVAST method to four patients that would otherwise have had surgery and we will discuss our experience with the method. The protocol used was EAVAST splinting for six weeks; the patient was instructed to remove the splint five times a day, apply the traction manually and perform gentle active flexion/extension of the whole finger whilst under traction. During the splinting period patients were able to wash their hand and clean the splint.

Case report 1

A thirty-two-year-old right-handed male had an accident during work in the flower industry where he fell on his left hand. His fourth digit was dislocated dorsally resulting in an intra-articular fracture of the Proximal Inter Phalangeal (PIP) joint with a large fragment comprising 2/3 of the joint surface (figure 5).

The EAVAST traction splint (figure 6) was applied with strong traction and flexion of 30°. Fracture alignment was confirmed by x-ray and he was discharged with the EAVAST protocol. X-ray at 6 weeks showed good fracture union. The splint was removed and the patient was instructed to perform light activities of daily living and gentle active and passive mobilisation exercises with the injured finger. On review at 3 months, the patient had a full active range of motion and was ready to resume his work. He reported no pain at final discharge.

Case report 2

A fifteen-year-old male, right-handed trainee manual worker attended emergency after falling on his right hand. An intra-articular fracture of the PIP joint was seen of his fourth digit. The decision was made to apply EAVAST.

Figure 5 *Lateral view of initial x-ray before applying EAVAST of case 1*

Figure 6 *Example of the EAVAST splint for one finger*

Figure 7 *Lateral view of x-ray taken 4 days after applying EAVAST of case 2*

Figure 8 *Lateral view of initial x-ray before applying EAVAST of case 3*

The alignment was checked after four days of traction, due to the fact the x-ray was taken after the weekend (figure 7). Afterwards the traction was adjusted from 30° to 10° of flexion in the PIP joint. This improved the alignment of the fracture even more, confirmed by CT scanning and the patient was discharged with the EAVAST protocol and reviewed at 6 weeks. His fracture was well consolidated and he was able to bend his finger to touch his palm and reported no pain. Unfortunately, he did not follow up on treatment, missed his next appointment and did not respond to telephone calls. There are no long term follow up data for this patient.

Figure 9 *Lateral view of x-ray with EAVAST traction of case 3*

Case report 3

A forty-two-year-old left-handed male IT consultant fell from his bike on an uneven road and attended the emergency on a Saturday. He sustained a fracture of the 5th metacarpal and an intra-articular fracture with dorsal dislocation of the PIP joint of his third digit of his left hand (figure 8). A plaster was applied and the patient was scheduled for surgical review by the hand surgeon on Monday where, upon review, it was decided to apply EAVAST as traction device to restore joint congruency. Considerable improvement was made in fracture alignment and reduction of the step in the joint. However, the X-ray showed there was still a slight dorsal dislocation in the joint, causing the joint to pivot and not glide (figure 9). The patient was scheduled for surgery which could be done five days later. The hand surgeon decided to insert two K-wires in 45° flexion of the PIP joint, as dorsal block pinning method described by Viegas (figure 10).[15]
Three days after the operation the EAVAST traction splint was reapplied to enable the patient to exercise PIP and distal inter-phalangeal (DIP) joint flexion, and to maintain joint spacing. The patient was discharged with the EAVAST protocol and reviewed at 6 weeks post-trauma. The fracture was consolidated and the k-wires were removed.

Due to the dorsal block pinning in 45° flexion there was limited extension in the PIP joint and the patient was given a relative motion splint to block metacarpophalangeal (MCP) hyperextension and stimulate PIP extension in a gentle and active way during activities of daily living. He wore a night splint for PIP extension and did active and passive exercises for flexion and extension. Nine months post-trauma the patient had full range of motion and reported no limitations in daily life activities. He had resumed playing padel tennis and only reported some mild discomfort with heavy gripping.

Figure 10 *Lateral view of surgical screening after dorsal block pinning of case 3*

Figure 11 *Lateral view of surgical screening after dorsal block pinning of case 3*

Good functional outcomes and radiological reductions were demonstreated with the EAVAST method

Case report 4

A seventeen-year-old right-handed male high-school student fell on his right thumb playing football with his friends. He attended the hospital ten days after injury, thinking it was only a sprain of his thumb. An initial X-ray was taken, showing a comminuted, intra-articular fracture with dorsal angulation of the proximal phalanx (figure 11) and EAVAST splint was applied (figure 12).
X-rays made after 4 days of traction showed better alignment and the traction was continued for four weeks with the EAVAST protocol.
Six weeks post-trauma there was full consolidation with a slight dorsal angulation. The splint was removed and the patient was instructed to use his thumb only for light daily life activities and perform gentle active and passive mobilization exercises. He was instructed to generally build up strength and durability. Three months post-trauma the patient had a full range of motion, Kapandji score of 10, full grip strength, no pain and was able to perform in sports and school as before trauma.

Discussion of the challenges encountered using EAVAST

Case 1 and 2 were pilon fractures without dorsal dislocation. They demonstrated good functional outcomes and radiological reductions with the EAVAST method. In similar cases in the past we used skeletal traction with a k-wire placed distal from the fracture, with the same functional outcomes. Using the EAVAST method seems more (cost) effective, as there is no operation required, and it reduces the risks of a surgical procedure.
The pilon fracture with dorsal dislocation in case 3 was a more challenging treatment. The EAVAST method achieved good palmar fracture translation, fracture reduction and reduction of step. However, the longitudinal traction force alone proved insufficient to reduce the dorsal dislocation and surgery was provided to achieve further palmar translation and assist joint gliding. Surgery was a closed procedure performed with K-wires so

Figure 12 *Example of the EAVAST splint for a thumb*

damage to soft tissues was minimal, however it can still result in prolonged stiffness of the finger. We chose to use EAVAST in postoperative management with the splint utilised for early active mobilization and maintaining the joint space to mitigate some of the risks of surgery such as postoperative stiffness. We cannot prove this made any difference to the result. Maybe the same result would have been achieved if it had just been k-wired and a relative motion splint was used afterwards, or if it had not been k-wired at all.

Case 4 was also challenging as it was significantly delayed at presentation to the hospital. The fracture had already undergone healing, including formation of a fibro-cartilaginous bridge making reduction of the malunion more difficult. The stiffness of the tissue increases with healing, meaning that greater force is needed for reduction. The large cross-sectional area of the thumb makes applying the right direction and leverage needed for reduction difficult. However, the use of EAVAST resulted in an acceptable union with only a slight residual dorsal angulation and the patient regained full mobility and function within 3 months.

Conclusions

EAVAST is a versatile technique in the hand surgeons' and hand therapists' repertoire. In selected cases, it can provide good functional outcomes if used as a primary method for treating complex finger fractures and can also be used as an adjunct to surgery. It should not be considered the simple application of longitudinal force, rather the art is in its application to address angular deformation and subluxations. The technique requires close collaboration between the hand surgeon and hand therapists and also informed consent from the patient as compliance with the exercise program is vital to its success.

In our experience, EAVAST is an attractive proposition to patients as it is non-invasive and carries fewer risks than surgery. It is well tolerated by patients and all four patients were satisfied with the treatment method. Three regained full range of motion and resumed their normal daily life activities within 3-9 months. With one patient, unfortunately, there was no follow up.

We hope hand therapists and hand surgeons will consider using the EAVAST method as an alternative for surgical treatment in unstable finger fractures.

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Conflict of interest

Jason Fairclough is the Founder of Kangaroo Medtek Pty Ltd which is developing the Butterfly Traction System and he has a pecuniary interest in this company.

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