Chapter

Orthotic Treatment Overview of Carpal Tunnel Syndrome

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Abstract

Carpal tunnel syndrome or median compressive neuropathy at the wrist is the condition of median nerve compression. Most of the CTSs are idiopathic and are provoked by repetitive grasping and manipulating activities, and the exposure can be cumulative. Orthotic splinting is prescribed both pre- and postsurgical but essentially in pre-surgical situation. The importance of wrist orthotic splints in non-operative treatment for carpal tunnel syndrome is a known scenario. Also evidentially it has a standard of care despite having varying rates of success. The aim and objective of orthotic splinting is to immobilize the wrist to stop flexion and maintain low range of wrist motion which help to decrease inflammation. CTS splint may be applied to dorsal side or in volar for maintaining wrist in a neutral position. The general recommendation is to wear a wrist immobilization orthotic splint as night splint. Splint kinematics and kinetics for biomechanical analyzing principles are essential to understand the principles involved in the various standard design, construction, and fitting of CTS splint. Application of orthotic biomechanics is for possessing a specific understanding of orthotic splinting function as per clinical orthotic assessment.

Keywords: carpal tunnel syndrome, orthotic splints, CTS biomechanics, CTS orthotic splint biomechanics

1. Introduction

Compression of the median nerve at the wrist is the most common upper extremity compressive neuropathy known as carpal tunnel syndrome [1–4]. It affects as much as 3% of the population at any one time. Still CTS remains a clinical syndrome, and as many as 15% of patients in some series have clinical evidence. Although surgical relieved for the median nerve compression my processed in the presence of normal severe electro diagnostic results [2, 3].

CTS decreases the cross-sectional area of the carpal tunnel that produces increased carpal tunnel canal volume content which may result in increased pressure in the carpal canal. Secondarily intracarpal tunnel pressure may be affected by external pressure to the palm [3].

The value of nonsurgical treatment protocol for mild CTS is a standard option. Conservative management is generally not an ideal option for moderate-to-severe CTS, especially in patients who have signs of muscle atrophy or significant sensory impairment. Non-surgery management options that have been described for CTS include orthosis use, nonsteroidal anti-inflammatory drugs, injection of the carpal tunnel with a corticosteroid, tendon-nerve gliding exercises, iontophoresis, ultrasound, and daily activity site modifications. The importance of CTS orthotic splints is well known in non-operative scenario. The American Academy of Neurology recommends a noninvasive orthotic treatment for the light and moderate CTS pathology. CTS orthotic treatment protocol remains the standard of care even though varying rates of success have been reported in the literature [5–7].

The objective of CTS splinting is immobilizing the wrist motion that decreases inflammation. Increased pressure in the carpal tunnel has been demonstrated with either wrist flexion or extension; therefore splinting of the wrist in a neutral position is recommended. Mild CTS symptoms of short duration are recommended with night splinting. Day and night splinting is recommended when there is mild-to-moderate symptoms during the day or with minimal activity. Also postoperative CTS splinting protects healing structures while allowing the predefined wrist motion.

Other significant objective of CTS splinting is ranging from pain relief and protection to prevention and correction of the wrist deformity.

Clinical orthotic assessment in terms of anatomic, kinesiology, neurology, and functional effects is important for prescribing CTS splint.

CTS and CTS splint's kinetics and kinematics analyses play a key role to understand the principles involved in the various standard design, construction, and fitting of CTS splint.

2. Orthotic assessment for CTS

Orthotic assessment includes the use of a variety of clinical qualitative and quantitative evaluation methods and instruments whose subsequent data is integrated to produce a clearly defined picture of CTS and its patho-biomechanics.

Points are essential for orthotic prescription.

- Demographic data and individual client factors (age, motivation, intelligence, vocation/avocation, clinic proximity).
- Chief complaint (type of pain during hand and wrist activity in static or dynamic condition).
- Previous orthotic treatment history (type of orthotic splint, function, and pressure system).
- Other treatment plans (postoperative, what are other medical conditions).
- Manual muscle testing (minimum gravity control muscle power for wrist patho-kinetics).
- Active range of motion (check the wrist patho-kinematics).
- Passive range of motion (check the wrist patho-kinematics).
- Upper extremity reflexes (check wrist pathophysiology).
- Skin condition (orthotic splint material).
- Body temperature (orthotic splint material and design).
- Perspiration (providing hole over orthotic splint).

- Soft tissue condition (check pressure tolerance capacity. Creep, stress-relaxation, stress rate sensitivity, etc.).
- Pain scale (VAS scale, which type of pain and how to grade pain according to splint pressure system applied).
- Clinical test related to CTS (diagnosis of abnormal motion and pain).
- X-ray finding (structure of carpal tunnel and any other involvement).
- Swelling (orthotic splint material for low-grade swelling).
- EMG test (muscle activity profile, resting potential, neuromuscular junction condition, neuromuscular integration for wrist joint kinetic and kinematic condonation).
- NCV-test (median nerve activity profile, resting potential, neuromuscular junction condition, neuromuscular integration for wrist joint kinetic and kinematic condonation).
- Coordination (central nervous to peripheral nerve activity through wrist joint kinematics for various activity of daily living).
- Dexterity (power and precision grip strength).
- Asking price (appropriate to individual client factors and third-party payers).
- Period of time splint is to be used (temporary, semipermanent, permanent).
- Minimalism (no irrelevant parts, splint is applicable and pertinent to the need).
- Optimum function (splint allows usage and performance without unnecessary reduction of motion).
- Optimal sensation (splint permits as much sensory input as possible).
- Efficient fabrication (no extraneous parts or procedures, such as the use of reinforcement parts instead of curving contour, bonding instead of uninterrupted coalescing of components, straps instead of contiguous fit, inappropriate use of padding).
- Application and removal (appropriate to individual client factors).
- Client suggestions (requested adaptations that would not alter or jeopardize splint function).
- Influencing primary and secondary joints (motion allowed or restricted appropriately; components accomplish intended functions).
- Attaining purpose (immobilize, mobilize, restrict motion, or transmit torque).
- Effect on joints not included in splint; kinetic effects (avoids application of contraindicated forces to no splinted joints).

- Anatomical variables (surface of application appropriate, healing structures protected as necessary, external hardware considered).
- Exercise routine (permits efficient execution of prescribed therapeutic exercises).
- Patient education.

Orthotic assessment is essential for the splinting design program and instructions for the wearing times and exercise regimen, donning and doffing, and precautions.

3. CTS-ASHT orthotic splint nomenclature

American Society of Hand Therapists, ASHT (SCS) (1989), developed a universal splint nomenclature. It is based on splint function rather than splint design.

CTS splint classification also follows this classification. SCS components consist of identification of articular/nonarticular, location, direction, purpose (immobilization, mobilization, restriction, torque transmission), type, and the total number of joints. All splints have inherent mechanical characteristics that combine to a series of predictable patterns [1–3].

3.1 Articular/nonarticular orthotic splint

The principal division is given below (**Tables 1**–**6**).

Articular splints for CTS follow three-point/four-point or two-point pressure systems to affect the wrist joint by immobilizing, mobilizing, restricting, or transmitting torque. Nonarticular splints for CTS mainly obey the two-point pressure forces to stabilize or immobilize the wrist joint.

ESCS splint classification system (ESCS) for CTS splint groupings of primary and secondary joints, when a primary joint is linked with its potential secondary joint partners, a predictable linear pattern (**Table 2**).

3.1.1 Examples

Joints = [elbow level] = type 1

Total joints = [wrist + elbow = 2 joints] = (2)

Articular/nonarticular orthotic splint	
Articular	Those that affect articular structures
Nonarticular	Those that affect an anatomic segment or structure but do not affect joint motion or cross a joint

Table 1.
Principal classification of orthotic splint.

Primary joints	**Secondary joints**			**Total joint involvement/splint**
Wrist joint	DIP	PIP	MP	Design and tramline of CTS splint (0 type, 1 type, 2 type, etc.)

Table 2.
CTS orthotic splint classification.

Force (KP)	Wrist flexion (degree)	Wrist extension (degree)
0–10	0–5	0–5
10–20	5–10	5–10
20–30	10–15	10–15
30–40	15–20	15–20

In force (KP) the resultant tendon force was 0–10, 10–20, 20–30, and 30–40. Wrist flexion (degree) had 0–5, 5–10, 10–15, and 15–20. Wrist extension (degree) had 0–50, 5–10, 10–15, and 15–20.

Table 3.
Resultant tendon force on wrist sagittal plane motion.

Study	Patients with CTS		
	Neutral position (mmHg)	Flexion (mmHg)	Extension (mmHg)
Gelberman et al. (1981)	32 ± 4.27	94 ± 12.53	110 ± 14.66
Werener et al. (1983)	31 ± 4.13	75 ± 10	105 ± 14
Szabo and Chidgey (1989)	10 ± 1.33	32 ± 4.27	51 ± 6.80
Okutsu et al. (1989)	43 ± 5.73	192 ± 25.60	222 ± 29.60
Luchetti et al. (1989)	26 ± 3.47	—	—
Rojviroj et al. (1990)	12 ± 1.60	27 ± 3.60	33 ± 4.40
Graham et al. (1991)	20 ± 2.67	—	—

Table 4.
Reviewed report for wrist pressure in normal position, flexion position, and extension position.

Wrist position (sagittal and frontal planes) with minimum pressure (mmHg) in CTS splint		
	Minimum pressure	Wrist motion
CTS	19 ± 1.5	Flexion 2 ± 0.7 ulnar deviation 1 ± 0.4
Normal/CTS splint	8 ± 0.75	Extension 2 ± 0.7 ulnar deviation 2 ± 1

Table 5.
Minimum wrist pressure for CTS and wrist motion.

Carpal tunnel pressure (mmHg) data for subjects performing a repetitive material handling Task with and without a wrist splint							
Pre activity baseline		During activity		Post activity baseline		During activity	
Without splint	With splint	Without splint	With splint	Without splint	With splint	First minute of activity	Last minute of activity
6	5	13	12	6	5	12	13

Table 6.
Pressure of flexible wrist splint on carpal tunnel during repetitive hand activity.

4. Orthotic treatments for CTS

Orthotic splinting for CTS still remains the standard option [8–10]. CTS splint is mainly prescribed before surgery including muscle atrophy or continuous sensory impairment. Patients who present with mild symptoms will have the best option to conservative splinting.

Hence orthotic CTS splint is prescribed for mild-to-moderate and postoperative conditions.

Numerous customized design orthotic splints are commercially available. On the other hand, custom-fit CTS orthosis may be made for individual patients for minimizing external pressure over the median nerve.

Customized volar or dorsal orthotic splints are provided with neutral position over wrist joint. Dorsal-based splint Carpal Lock CTS splint applied for restricting kinematic external pressure over the carpal tunnel with thin straps over the palm leave the palmar surface free. It is indicated for mild CTS patient.

The general principle for orthotic splint application which maintains the wrist in a neutral position is that pressure on the median nerve as it passes through the carpal tunnel is amplified in positions of wrist flexion and extension (Gelberman 1984). Neutral wrist joint position (loose pack position) is the clinical condition for orthotic splinting to hold the wrist even when the patient is asleep and likely to flex their wrist without being able to correct themselves. The wrist angle in CTS splint and altering the shape of the carpal tunnel are moving the lumbricals distally out of the carpal tunnel to decrease pressure on the median nerve (Manente et al. 2001).

Manente et al. (2001) expressed a compared report for night CTS splint (4 weeks) with no treatment group. Premoselli et al. (2006) performed a quasi-randomized trial that compared a CTS splint worn at night for 6 months with no treatment group. Both studies concluded that orthotic splinting has a significant impact on CTS.

4.1 Static CTS wrist hand orthosis

WHO is the standard design option used in CTS. Wrist joint is one of the key elements for upper extremity splinting. Fine tune position of wrist splint maintains powerful extrinsic tendon, finger, and hand digital posture and motion. Static is indicated to make the wrist static and restrict sagittal and coronal plane motions.

Many plastics and metallic standard CTS-WHO splint are designed for orthotic treatment by various universities and institutes as the Institute in Chicago, the Institute for Rehabilitation and Research in Houston, and the Institute of Rehabilitation Medicine at New York University.

4.2 CTS immobilization splints

Wrist immobilization orthotic splint for CTS aimed to allow healing of injured or inflamed wrist. This splint can restrict sagittal and coronal plane motions. The correct application can provide significant result in mild-to-moderate CTS. For increasing mechanical advantage, two-thirds the length of the forearm extension may be added in CTS splint.

4.2.1 CTS immobilization splint type 0

- Here the primary joint of a type 0 wrist immobilization splint is the wrist itself.

- There are no secondary joints included in a type 0 wrist splint. Neutral wrist position is also used frequently, and, in this instance, the splint is called a wrist neutral immobilization splint, type 0.

4.2.2 CTS immobilization splint type 1

- Type 1 wrist immobilization splint indicates the presence of one secondary joint level included in the splint in addition to the primary joint, the wrist.
- The secondary joint most often included in a wrist immobilization splint, type 1 (2), is the thumb CMC joint, which is held motionless by a carefully fitted first metacarpal bar component.
- Type 1 wrist immobilization splints that include the thumb CMC may be used to help control and/or decrease wrist pain.
- Because mechanical purchase on the first metacarpal is challenging, complete immobilization of the CMC joint is difficult to achieve with a type 1 wrist immobilization splint.

4.2.3 CTS immobilization splint type 2

- Type 2 wrist immobilization splints incorporate two secondary joint levels in addition to the wrist the primary joint. Secondary joint(s) may be situated either proximal or distal to the wrist depending on the specific purpose of the splint.
- For example, splints may include both the thumb CMC and MP as distally located secondary joint levels, or they may include the forearm and elbow as proximal secondary level joints.
- Type 2 wrist immobilization splints that incorporate the thumb are sometimes used to provide additional stabilization for partial fusions or fractures on the radial side of the wrist including scaphoid fractures or radial wrist ligament injuries where thumb IP joint motion is permitted.

4.3 CTS mobilization splints

Generally prescribe for the postoperative CTS patients.

- Supple wrists that lack active motion.
- Stiff wrists with the limited passive range of motion. For the most part, flaccid wrists lacking full or partial active motion require simple mobilization splints that facilitate and improve hand function. Occasionally, more complicated splinting utilizing torque transmission may be required to substitute for absent movement in supple wrists. Types of CTS splints are type 0, type 1, and type 3.

4.4 CTS restriction splints

Restriction CTS orthotic splints are prescribed to acute mild CTS patients for daytime use for restricting or where defined arcs of active wrist motion are required. Prescribe for the pre- and postoperative CTS patients.

Wrist sagittal and coronal plane motion restriction is controlled by inflexible materials like thermoplastic, metal, etc. Less rigid materials like neoprene, leather, vinyl, and tape are used for some allowing some degree of wrist range of motion. CTS restriction splints are type 0 and type 2.

4.4.1 CTS restriction splints type 0

- Type 0 wrist restriction splints control motion at one primary joint the wrist. There are no secondary joints included in type 0 restriction splints.

- Restriction splints may be designed and fit to allow full or limited wrist extension/flexion while preventing radial and ulnar deviation or vice versa, or they may simply limit motion in one direction while allowing increments of motion in other directions.

- Wrist circumduction restriction splints allow varying degrees of overall wrist mobility while providing external support for sports, work, and/or avocational activities.

- These splints are constructed in softer materials including tape neoprene or fabric.

4.4.2 CTS restriction splints type 2

- Type 2 wrist restriction splints limit gradations of wrist motion and are used with a variety of diagnoses. They are often worn during sports or work activities.

- Generally, these splints allow normal motion while limiting extreme motion in extension and/or flexion or in radial and/or ulnar deviation.

- One of the most commonly used type 2 wrist restriction splints includes the thumb CMC and MP as secondary joints.

4.5 CTS torque transmission splints

These are usually prescribed in postoperative CTS patients. Dynamic splinting is not recommended for CTS patients. Postoperative CTS patients may be prescribed who are having patho-kinematics in the transverse plane (wrist rotation). Also it is used for the therapeutic approach for contracture release for CTS.

4.5.1 CTS torque transmission splints type 3 and type 4

- Torque transmission splints affecting the wrist joint may have three or four secondary joint levels incorporated and are categorized as type 3 or type 4, respectively.

- These splints function longitudinally by controlling finger joint motion to transmit torque to the wrist joint proximally so that extrinsic muscle power is focused exclusively on the wrist joint.

4.5.2 CTS dynamic splinting application

Berner et al. (2008) studied with dynamic splint application for a modality that treats CTS using low-load, prolonged duration stretch to reduce contracture, which contributes to median nerve compression. Dynamic splinting reduced experimental patients' symptoms and improved electrodiagnostic parameters [11] (**Figures 1–7**).

Figure 1.
CTS volar splint.

Figure 2.
CTS dorsal splint.

Figure 3.
CTS wrist hand orthosis with thumb extension.

Figure 4.
CTS carpal lock splint.

Figure 5.
CTS thumb spica.

Figure 6.
CTS thumb spica.

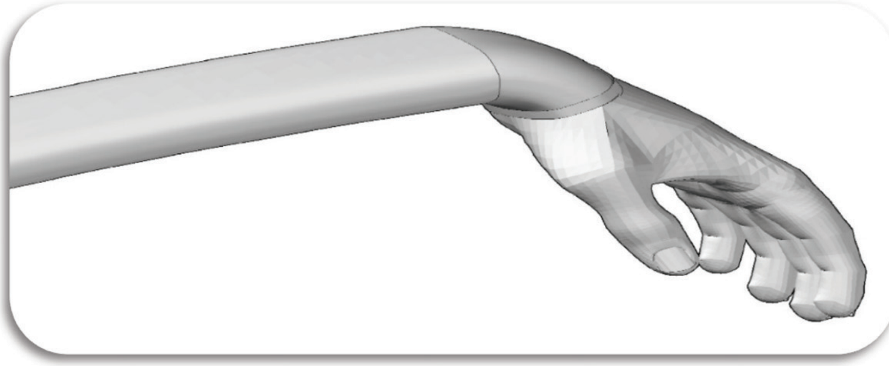

Figure 7.
Three-dimensional model of CTS hand.

5. Orthotic clinical checkout guidelines for CTS orthotic splinting

Given the diagnostic requirements the splint has been fitted appropriately to adapt to the following:

- Anatomical structure (bony prominences, arches, dual obliquity, skin creases).
- Ligamentous stress (immobilization, mobilization, restriction, or torque transmission forces correctly applied to avoid damage or attenuation).
- Joint alignment (anatomical axes aligned with splint articulation; splint does not shift inappropriately on extremity).
- Kinematic changes (splint does not inappropriately inhibit motion of unrestricted or partially restricted joints; splint does not inappropriately transmit torque).
- Contiguous fit of components on extremity.
- Good overall esthetic appearance.
- Corners rounded, edges and surfaces smooth and flanged appropriately.
- Joined surfaces stable and finished (bonds solid, securing devices of sufficient number and correctly applied; internal edges smoothed, securing devices finished).
- Ventilation (appropriately placed, splint strength not jeopardized).

6. Classical mechanical theories for CTS splint

Most splints used in upper extremity clinical practice apply consistent, linear-oriented, three-point pressure systems to affect joint motion. These splints incorporate three parallel reciprocal forces with the proximal and distal forces oriented in the same direction and the middle reciprocal force oriented in the opposite [6, 7, 12].

The diagnostic requirements, does the splint meet mechanical criteria, including adaptation.

6.1 Increase the area of force application

Pressure = total force/area of force application. Splinting materials are, to varying degrees, rigid; their improper application to the extremity may cause damage to the cutaneous surface and underlying soft tissue as a result of excessive pressure. Splint applies over bony prominences or in areas where the inherent structure of the splint influences to increase the pressure of mechanical counterforces.

6.2 Increase mechanical advantage

Splinting is acting like the lever system. Splint provides more mechanical advantage by the use of favorable force systems. The design and construction of splints significantly provide the mechanical advantages.

6.3 Use optimum rotational force

Splint restricts the compressive or tensile force through the mobilization (90° angle of approach to segments mobilized, perpendicular to joint axes) splint in stiffened joints through traction. Splint must be achieved without generating patient frustration or increased tissue damage. Two dimensions and three dimensions of force resolution are used for minimizing force load by the splint.

6.4 Consider the torque effect

Torque equals the product of the force times the length of the arm on which it acts. Patients may be taught to use the torque phenomenon advantageously by advancing their finger cuffs distally as their pain tolerance permits. The splint should be provided opposite torque for neutralization of torque effect.

6.5 Consider the relative degree of passive mobility of successive joints

Primary and secondary joints are responsible for maintaining static and dynamic equilibrium. When motion is limited or stopped at a given articulation, the remaining mobile joints are moved in the direction of the force with minimal motion occurring at the restricted.

6.6 Control reaction effect at secondary joints

The amount of stiffness between primary and secondary joints within the same longitudinal segment is marked; as a mobilization force is directed to a stiff joint and reciprocal force secondary joint motion is controlled, the end of the stabilized segment may have a tendency to displace or sublux at the level of the secondary joint.

6.7 Consider the effects of reciprocal parallel forces

The use of three parallel forces in equilibrium is achieved in the splint by two-point, three-point, or four-point pressure system.

6.8 Increase material strength by providing contour

Proper contour of splinting provides better controls of forces equilibrium in 3 dimensional plane.

6.9 Appropriate components

Parallel to providing elements of control and motion, articulated splints defend healing of soft tissue structures and improve function. Articulated splint mechanisms must be accurately aligned with anatomical joint axes. If a splint articulation is not aligned with its anatomical joint, the splint tends to the piston on the extremity as active movement occurs, causing shear forces and friction.

6.10 Eliminate friction

Kinetic friction develops when surfaces in contact with each other move relative to one another. If a difference in density exists between the surfaces, the harder surface may begin to erode the softer, less dense surface. If the surfaces are similar, damage may occur on either side or on both sides.

6.11 Avoid high shear stress

The important terms describe the material behavior of soft tissues.

7. Biomechanics of CTS

Quantitative biomechanical analysis of CTS is for finding how internal external forces/pressure inside flexed and extended wrists is related to wrist size hand force and hand position. Analyzing pathological condition of CTS is helpful for finding causes of wrist deformity and wrist pain. Biomechanics analysis is involved for finding deformed boney three-dimensional alignment, muscle devotion, deformed nerve condition, and ligament tendon pathological changes.

7.1 Biomechanical reflection for CTS

Biomechanics of CTS is playing an important role for proper application of CTS splinting. Here some kinematics and kinetic are discussed as per previous analysis.

Muscle force of extrinsic finger flexor muscles and flexor digitorum profundus and superficial and the flexor pollicis longus muscles that are providing effort force to the hand. Additionally forearm muscle forces are acting to the fingers with long tendons that pass through the carpal tunnel. Flexor retinaculum reinforced to wrist tendons in wrist flexion condition and in wrist extension condition tendons are reinforced by carpal bones.

Armstrong and Chaffin, 1978, found that the deviation of the wrist from the straight position causes the extrinsic finger flexor tendons to be displaced against, and past, the adjacent walls of the carpal tunnel.

7.2 Kinetic model of CTS wrist

Le Veau et al. 1974 also found that the tendon sliding over a curved surface is analogous to a belt draped around a pulley.

The force FL, exerted on a pulley, is a function of the belt tension Ft; the radius of the pulley curvature, r; the coefficient of friction between the pulley and the belt, μ; and the included angle of pulley-belt contact, α, and is expressed.

$$\text{FL Force (force/Arch length)} = \text{Fte}\ \mu\ \alpha/r \qquad (1)$$

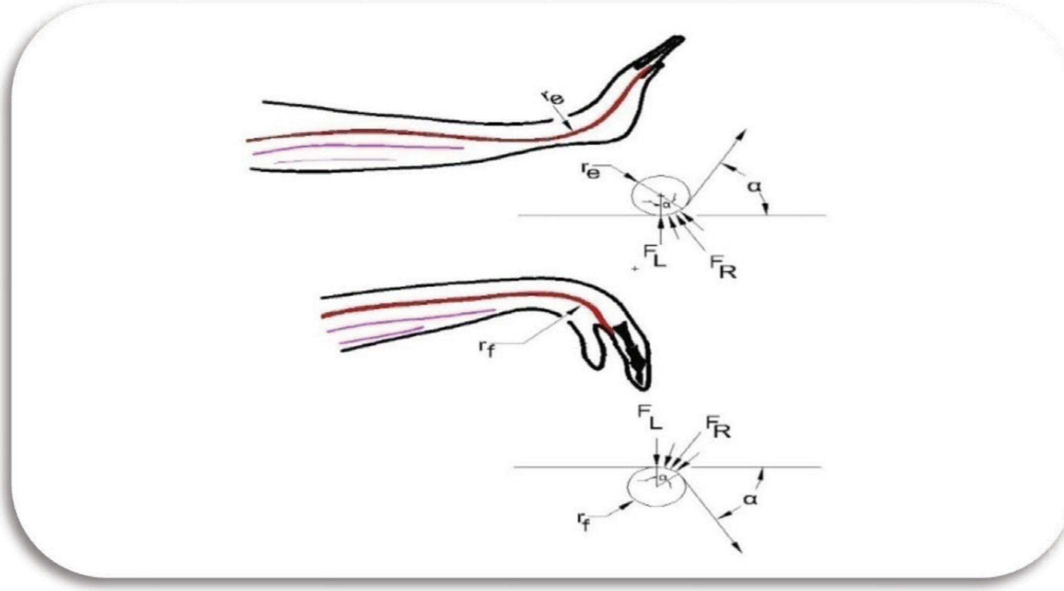

Figure 8.
2D force calculation for CTS.

Linn et al. (1968) and Linn and Radin et al. (1968) found that the coefficient of tendon-trochlear friction has not been measured directly; however, friction measurements of surfaces lubricated with bovine synovial fluid indicate that the coefficient would be in the range of 0.01–0.1.

For coefficients of friction in this range, friction can be neglected without greatly affecting force estimates; thus Eq. (1) can be approximated by

$$FL = Ft/r \tag{2}$$

Equation (2) indicates that the tendon load is approximately uniformly distributed over the trochlea.

- Tendon load per unit length as a function of tendon curvature and load.
- It can be seen that the contact force between the tendons and trochlea increases directly with tendon tension and inversely with the radius of tendon curvature.
- The radius of curvature can be estimated for different wrist thicknesses (Armstrong and Chaffin, 1978); the tendon tension can be estimated for given positions of given sized hands (Dempster, 1961; Smith et al., 1964; Chao et al., 1976; Armstrong, 1976) (**Figures** 7 and **8**).

It has been suggested that force between the extrinsic finger flexor tendons and the trochlea in the flexed wrist compresses the median nerve and is a factor of carpal tunnel syndrome (Brain et al., 1949; Robbins, 1963; Phalen, 1966).

- Compression of the median nerve by adjacent tendons has been confirmed by direct pressure measurements at the site of the median nerve by Tanzer (1959) and by Smith et al. (1977).
- In addition to the median nerve, the synovial membranes of the radial and ulnar bursas that surround the extrinsic finger flexor tendons are compressed by forces in both flexed and extended wrists. It has been suggested that repeated compression can lead to synovial inflammation and swelling,

which in turn leads to compression of the median nerve inside the carpal tunnel (Yamaguchi et al., 1965; Phalen, 1966, 1972; Tichauer, 1966, 1975, 1976).

- Armstrong et al. (1979) suggest that the resultant force is exerted by a tendon on adjacent wrist structures as a function of wrist angle and tendon load. The resultant force is independent of tendon and wrist size [13].

- Thomas J. et al. (1979) found that the CTS resultant force is exerted by a tendon on adjacent wrist structures as a function of wrist angle and tendon load. The resultant force is independent of tendon and wrist size (**Table 3**).

8. Kinematics and kinetics of orthotic CTS splint

Biomechanics of CTS splint is for analyzing the kinematics and kinetics of wrist with splinting. Kinematics analysis signifies the wrist range of motion, and kinetics analysis signifies wrist pressures with splinting. Many studies were performed on kinematics and kinetics of CTS splint. Here we summarized the previous results for finding range of motion and wrist pressure with splinting condition.

Keir et al. (1999) found the direction of determining MRI for tendon paths has provided new insight into the relationships between the finger flexor tendons and other structures at the wrist [14].

Weiss et al. (1995) reviewed the wrist pressure in the normal position, flexion position, and extension position [15] (**Table 4**).

- Weiss ND and Gordon et al. (1995) also found that the minimum wrist pressure for CTS is to be maintained in CTS splint with limited range of motion (**Table 5**).

- Di Domizio et al. (2008) found that when the splint was used, there was a significant reduction in extensor carpi radialis ECR and flexor carpi radialis FCR activity. That was presumably due to participants' use of the splint to support some of the load that would be expected in the radial muscles to counteract gravity given that the standard posture required a neutral forearm and no radioulnar deviation [16].

- Rempel et al. (1994) found the pressure of flexible wrist splint on carpal tunnel during repetitive hand activity [17] (**Table 6**).

Acknowledgements

Authors would like to thank Mr. Ananda Poddar, Project Assistance, Department of Rehabilitation Engineering; and also thank Mr. B.B.Bharti (MPO), Mr. SamirSamanta (MPO), Miss RashmitaDash (MPO), Miss Smurti Sahoo (MPO), Mr. HarshKumar (MPO), Miss Subhlata (MPO), Miss Shaliny (MPO), Mr. Subhasish (MPO), Mr. Mirtunjay (MPO), and Mr. Aryan (MPO), Department of Prosthetics and Orthotics, NILD, Kolkata.

Conflict of interest

No conflict of interest. Authors are donning clinical practice and clinical research for updated teaching.

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