Posterior interosseous nerve entrapment

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ABSTRACT

The posterior interosseous nerve (PIN) is a branch of the radial nerve found in the forearm. It supplies extensor carpi radialis brevis, extensor carpi ulnaris, supinator, and the digital and thumb extensor muscles. It also has sensory branches to the wrist and carpal joints, but has no cutaneous supply. Posterior interosseous nerve syndrome (PINS) and radial tunnel syndrome (RTS) are two conditions believed to occur due to entrapment of the PIN in a series of structures in the proximal lateral forearm that make up an anatomical entity called the radial tunnel. The most commonly implicated compressive structure in PINS and RTS is believed to be the supinator muscle[6,20]. The PIN passes through the supinator muscle approximately four finger breadths distal to the elbow on the lateral aspect of the radius. Compression of the PIN is believed to occur secondary to repetitive activities that involve wrist supination and pronation, with a component of wrist extension[1,20]. Symptoms of PINS typically include true neurogenic weakness of the wrist and finger extensors, slight, vague forearm pain, and an absence of sensory symptoms. On the other hand, RTS presents significant pain in the forearm and often lateral elbow, with minor weakness related to pain of the wrist extensors. Although considered separately in the literature, these conditions appeared to be different parts of the same continuum. In light of this, a working diagnosis of posterior interosseous nerve entrapment (PINE) was used.

Over a two year period, six cases of PINE were diagnosed in a team of 35 America's Cup sailors. The prevalence of this condition was surprising, and proved challenging to manage. This paper will outline the management of this condition used by a multi-disciplinary medical team comprising a sports physician, an athletic trainer, physiotherapist, chiropractor, and massage therapist.

MANAGEMENT OF PINS

The first step taken in the management of this condition was to identify activities that were likely to cause and prolong the symptoms. Five main areas were identified: the postures common to the sailing program, sailing itself, training, shore activities, and fatigue in general.

The sustained functional and resting postures were identified as likely contributing factors to the development of RTS. The sustained functional postures commonly encountered in the sailing campaign can be summarised into those with a flexed trunk, protracted shoulder girdles, and a protracted and extended cervical spine. Sailors often also exhibited resting postures with increased shoulder girdle protraction and a protracted chin. The contribution of posture to RTS was assumed in two ways:

The first was from a neural dynamics perspective. Muscle is known to adapt in length and strength to sustained positions[9] that result in imbalances and postural changes[22]. These postural changes and muscle length changes are believed to increase physical pressure on nerves wherever they are crossed by muscles along their pathway[3,4,5,16,17,28]. The sub-clinical compression and irritation of a nerve at multiple sites is postulated to leave the nerve more vulnerable to damage by impairing blood supply and axoplasmic flow within the nerve[11,12,17,19].

The second contribution of posture was from a biomechanical perspective. Poor thoracic posture is associated with altered shoulder girdle mechanics and force production[7]. A loss of force output from the shoulder girdle may cause an increase in the loading

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applied to the forearm muscles in order to compensate. This concept is explored further in the following sections.

While sailing, the crew was involved in work dominated by pulling or pushing either equipment or their body weight. The training undertaken was diverse and intense, including extensive weight training and upper limb ergometer use. While on shore, the sailors were required to assist with loading and unloading of gear and boat maintenance, of which sanding was a common activity. Each of these activities involved intensive use of forearm musculature and are consistent with the repeated pronation, supination and wrist extension activities implicated in the development of RTS[1,18,20,25].

Grinding was an activity that was common to most sailors both on the boat and as part of gym-based training. It also seemed to be a common factor in the genesis of RTS symptoms in the sailors who presented this way. Analysis of this activity helped identify possible mechanisms leading to forearm overload, the principles of which were applied to the other 'high risk' activities.

The first general mechanism involved poor generation of force from the legs and trunk due to poor (upper-limb dominant) technique. The importance of the legs and trunk in the generation of force for upper limb activities is well recognised[8,23]. A lack of this proximal drive was thought to be a possible reason behind an increase in the reliance on the arm as a force generator, precipitating overload at places such as the forearm.

Grinding itself was also performed predominantly with a pronated forearm, particularly from the point where the athlete is required to pull the handle towards them using, amongst other movements, elbow flexion and forearm supination. At this point the forearm is in maximal pronation. While biceps usually provides strong forearm supination and elbow flexion moments, it is significantly less effective in these movements at maximal pronation[15]. In this position the supinator muscle is also on stretch and compresses the PIN[26]. With the biceps ineffectual, it was thought the required supination may come from supinator or brachioradialis, while elbow flexion can be generated by the brachioradialis and brachialis. In this situation, the supinator may therefore directly compress or irritate the PIN, while the brachioradialis may contribute to this irritation by providing a secondary site of compression along the path of the radial nerve consistent with a double or multiple crush syndrome[11,17,19,27]. This situation may also have been the case for other on-board activities such as sail gathering, sheet tailing, and top handle winching. A likely scenario is that it was a combination of all of these activities that precipitated the development of RTS. This overload concept at the forearm may also have developed as the result of both acute and general fatigue.

The shoulder girdle plays an important role in funnelling the forces generated by the trunk into the arm[8]. We postulated that in a number of the at-risk activities local muscle fatigue of the scapula stabilisers resulted in a loss of force transmission from the trunk to the arm, prompting the athlete to again compensate by demanding more from the arm distal to the shoulder girdle, causing an overload on the forearm, and resulting pressure on the PIN. The seemingly consistent co-existence of long head of biceps irritation that either preceded or followed the development of RTS symptoms appears to support this theory. It was theorised that fatigue in the scapular stabilisers may have lead to fatigue of the rotator cuff, and a resulting increase in the role of the long head of biceps as a depressor of the humeral head. With the biceps working proximally to depress the humeral head, and distally to flex and supinate the forearm, a more rapid fatigue of the biceps was anticipated. Therefore, a situation may have again developed where the supinator and brachioradialis were required to generate more force, precipitating compression of the radial nerve and PIN.

As well as intense bouts of exercise and activity, the sailors were also subjected to long working days, and often long working 'weeks' of up to 10 days. The general fatigue stemming from these conditions was intuitively thought to contribute to the issues regarding poor or altered technique, posture, acute muscle fatigue, and the athletes' general tolerance to stress.

TREATMENT

Treatment of this condition focused on symptomatic relief and prevention. Modalities used in the symptomatic relief of the condition included deep tissue massage, stretching, dry needling, myofascial release, neural mobilisations, and manual therapy to the proximal radioulnar, humeroradial, cervical, and upper thoracic joints.

Deep tissue massage (DTM) and stretching was aimed at increasing the extensibility of muscles that interfaced with the brachial plexus and radial nerve along its pathway. Focus sights were the thoracic outlet, pectoralis minor, triceps, brachioradialis, extensor carpi radialis longus and brevis, and supinator. Neural tension tests significantly improved following soft tissue mobilisation in most instances. In some subjects, DTM to the forearm caused symptoms to worsen.

Using the ice/stretch/heat technique and trigger points outlined by Travell and Simmons (1983), myofascial release and dry needling were used to reduce the tone, and increase the extensibility of the muscles local to the PIN. Short term relief from the myofascial release technique was variable, but generally good.

Neural mobilisations were used with a radial nerve bias in an effort to mechanically reduce extra- and intra-neural adhesions[10,12,21] as well as assist in neuromodulation of symptoms[2,14]. Care was required with these techniques as subjects had a tendency to react poorly to over-zealous neural glides.

Manual therapy was applied to the joints of the elbow to normalise movement and in anticipation of involvement of the reflexive fascial fibres from the radial head in the irritation of the PIN. In some subjects, local treatment again had a tendency to aggravate symptoms. Low and high velocity manual therapy was also applied to the cervical and upper thoracic spines. With one particular subject, the cervical techniques provided consistent, though transient, relief of local symptoms and neural tension.

Along with extensive hands-on treatment, the management of the condition involved as much activity modification as possible. This proved challenging, especially at various stages in the campaign during which pressures made it difficult to rest athletes or modify their activity sufficiently. Modification essentially involved avoidance of the forearm intensive activities already identified. When these activities could not be avoided, the athletes were encouraged to use a 'thumb over' grip when pulling or pushing. Postural awareness was also stressed, with attention paid to repeated correction and avoidance of the sustained functional postures identified earlier. Splinting was considered in the management of our RTS patients, but was not used due to practical reasons.

REHABILITATION AND PREVENTION

The rehabilitation, and ultimately the prevention, of this condition was broken into two components: The first component focused on decreasing the relative stress on the forearm. One of the key aspects to this phase was seen to be increasing the force generated by the trunk and legs. This was approached in two ways. Although specific strengthening exercises were used for the trunk and leg muscle groups, much emphasis was placed on more complex multi-joint exercises such as Olympic lifts as well as dynamic balance related exercises such as those possible on a Swiss-ball. This emphasis was used in recognition of the importance of strength transfer and neuromuscular coordination. Throughout these exercises the importance of correct posture was also stressed. A second key aspect of this phase of the rehabilitation/prevention approach was improving the role of the shoulder as a force funnel from the trunk to the arm. Again, specific strengthening exercises were used, although much emphasis was placed on exercising the shoulder in functional positions and with more complex tasks. Throughout the team training schedule, exercises combining the shoulder and trunk were commonplace and cables and free weights were the equipment of choice.

The second component of rehabilitation/prevention involved improving the athlete's local and general tolerance to the stresses that are thought to contribute to RTS. Specific exercises targeted the forearm extensors, supinator, brachioradialis, biceps, and rotator cuff, often with a large eccentric component. Eccentric control of these muscles was emphasised in light of promising literature on the merits of eccentric overload in rehabilitation[13]. Stretching of muscle groups identified as problematic in RTS was a consistent part of this aspect of the program. The general endurance characteristics of the athletes were also considered important since the more resistant an athlete was to fatigue in general, the more likely they were to maintain good postures and correct techniques for longer periods. As well as general aerobic conditioning work to address this aspect, athletes spent controlled periods using upper limb ergometers. These ergometers proved invaluable as they not only trained muscle groups very functionally but also allowed specific monitoring and correction of grinding technique.

Fatigue was also addressed from a nutrition and team management perspective. Nutrition was acknowledged as a key area that could improve the tolerance of the athletes to the physical stresses predisposing them to RTS and as such, athletes were given specific guidelines and were strongly encouraged to follow them. The physical and mental demands on the athletes were also adjusted through consultation with team management.

SUMMARY

The management of PINE proved challenging in the context of an America's Cup yachting team. A specific treatment and prevention approach was developed in response to the relatively high incidence of this condition. The development of this approach involved examination of the working environment and the consequent identification of high-risk aspects of this

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environment. Based on the observations made, and knowledge of the condition of PINE, treatment and rehabilitation principles were applied to those sailors who developed PINE. Broader principles of the rehabilitation program were also included in the generic team trainings. Outcomes of this management program were hard to measure due to the nature of the America's Cup campaign. Anecdotally, however, the incidence of PINE was significantly lower in the later six months of the campaign at a time when the work and stress loads on the sailors were most intense.

CASE REPORT – THE PAIN OF PIN

A 34 year old bowman presented with a four day history of pain in the proximal lateral right forearm associated with some weakness of grip. He had a high workload involving training, sailing and shore work. Examination revealed tenderness over the supinator muscle, palpation of which reproduced his pain. He also had pain on resisted supination. Relevant negative findings included no pain on resisted wrist extension or stretching of the wrist extensors and no wrist drop. He had poor general posture with a noticeably protracted chin and shoulder girdles. He also had a history of a spinal fusion at his fifth and sixth cervical vertebrae. The patient was treated locally with intensive myofascial release using ice and stretch. On two occasions this followed local anaesthetic injection into the supinator muscle at the point of maximal tenderness. Other local treatments included soft tissue therapy and neural dynamic techniques. These were applied most often to the proximal arm and neck regions. The athlete's training program was modified to reduce the loading on his forearm, and he was also encouraged to modify his activity as much as possible in the context of the campaign at the time. The response to treatment was promising, with significant rapid reductions in symptoms following injection, myofascial stretching and manipulation of the mid cervical spine. However, relief tended to be transient. The short-lived nature of the symptom relief was believed to be a combination of the stage of the yachting campaign at the time, as well as the nature of the PIN entrapment condition. Despite the difficulty in eliminating symptoms, the persistent use of a combination of treatments provided the athlete with a significant reduction in symptoms. At the end of the campaign the athlete still complained of symptoms consistent with PINE.

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