PERIPHERAL NERVE

Posterior interosseous nerve dysfunction in the radial tunnel

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Posterior interosseous nerve syndrome; Radial tunnel syndrome; Radial tunnel

Summary
Dysfunction of the Posterior Interosseous Nerve (PIN) has previously been classified into two different groups: Posterior Interosseous Nerve syndrome (PINS) if motor weakness manifests or Radial Tunnel Syndrome (RTS) if forearm pain is the main feature. Its main differential diagnosis is the common Tennis Elbow. There is little evidence or consensus on incidence or aetiology or treatment. The findings of this review suggests that both RTS and PINS have a common aetiology, that some investigative modalities may be useful in the diagnosis of PIN dysfunction but require further trials to support initial findings. Management options are difficult to evaluate due to a lack of controlled trials however surgical results appear to be good considered in the light of questionable diagnosis.

Introduction
Dysfunction of the Posterior Interosseous Nerve (PIN) is a condition of uncertain incidence and unclear aetiology. Its main differential diagnosis is Lateral Epicondyle Tendinitis (Tennis Elbow), a very common condition with a point prevalence of two percent.1 In relation to PIN dysfunction terminology is inconsistent, clinical presentation poorly understood and there is scant evidence to support decisions on diagnosis and management. This article will summarise the available evidence regarding diagnosis, investigation and management.

Anatomy of the posterior interosseous nerve
The radial nerve comprises fibres derived from the nerve roots C5-T1.2 10 cm proximal to the lateral epicondyle the radial nerve runs between the brachialis and biceps brachii tendon medially and the brachioradialis, extensor carpi radialis brevis and longus muscles laterally (Fig. 1). The radial nerve bifurcates somewhere between points 3 cm above and 3 cm below the radio-humeral joint, dividing into the superficial terminal branch and the PIN.3 The PIN then passes through the radial tunnel and into the distal forearm. The radial tunnel is defined as a space created by structures surrounding the radial nerve and PIN.4 The radial tunnel originates where the nerve crosses the anterior aspect of the radio-humeral joint. The nerve passes 1 cm lateral to the biceps tendon and onto the supinator muscle. The superficial branch continues on the surface of supinator...
and out of the tunnel. The PIN, however, passes posteriorly and laterally to travel deep to the proximal edge of the superficial part of supinator, known as the arcade of Frohse, and continues to run between the two portions of supinator. The tunnel around the PIN consists of the muscle bellies of extensor carpi radialis brevis and longus and brachioradialis laterally and brachialis and biceps tendons medially, with the floor comprising the radiohumeral joint capsule and deep portion of supinator. Within the tunnel the PIN is crossed by vessels at the level of the neck of the radius. The length of the tunnel is approximately 5 cm.

The PIN innervates the supinator, extensor carpi radialis brevis, extensor carpi ulnaris, extensor digitorum communis, abductor pollicis longus and both extensor pollicis longus and brevis. The PIN also carries sensory fibres from ligaments of the wrist joint.

### Functions of the posterior interosseous nerve

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### Clinical features

There are two syndromes associated with dysfunction of the PIN: 1) Radial Tunnel Syndrome (RTS) and 2) Posterior Interosseous Nerve Syndrome (PINS). The two syndromes are differentiated according to their manifesting symptoms, though the separation into two syndromes is not accepted by all authors, some arguing that RTS is unlikely to be a result of PIN pathology.

The hallmark symptoms of RTS (Table 1) are generalised pain over the proximal radial forearm that is aggravated by repetitive pronation and supination, point tenderness 4 cm distal to the lateral epicondyle and pain on resisted middle finger extension. There is usually no motor weakness.

PINS is characterised by neurogenic weakness in muscles supplied by the PIN and therefore presents as an inability to extend the fingers or thumb on the affected side and weakness of thumb abduction. Wrist extension will still be present, as the function of extensor carpi radialis longus is not compromised, the wrist will however deviate radially when extended. Pain and focal tenderness may not be present.

An alternative classification has been described in which RTS is the result of compression of the PIN anywhere in the radial tunnel and PINS as compression of the PIN at the arcade of Frohse. This classification is used in only one article and is likely to be inaccurate, as a number of studies have identified PINS being as a result of compression of the PIN at other sites within the radial tunnel therefore this classification will not be discussed further.

Although PIN dysfunction is often grouped into the syndromes RTS and PINS, according to symptoms, some authors approach RTS and PINS as one combined syndrome. Others dispute RTS is due to PIN dysfunction at all.

### Causes of posterior interosseous nerve dysfunction

#### Posterior interosseous nerve syndrome

Traumatic causes of PINS that have been described include radial head fracture, traumatic penetrating wounds,

<table>
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<th>Table 1</th>
<th>Classical signs and symptoms</th>
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<td>PINS</td>
<td>RTS</td>
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<td>■ Inability to extend fingers or thumb</td>
<td>■ Generalised pain over the proximal radial forearm</td>
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<tr>
<td>■ Weakness in thumb abduction</td>
<td>■ Aggravated by repetitive pronation and supination</td>
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<td>■ Active wrist extension with radial deviation</td>
<td>■ Point tenderness 4 cm distal to the lateral epicondyle</td>
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<td>■ Pain on resisted middle finger extension</td>
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deep tissue massage\textsuperscript{16} and motor paralysis secondary to surgical procedures.\textsuperscript{17,18} Non-traumatic compression of the PIN is most commonly caused by: fibrous bands in front of the radial head, leashes of vessels from the recurrent radial artery, tendinous margins of extensor carpi radialis brevis, tendinous margins of the inferior border of supinator and the arcade of Frohse (the superior border of supinator).\textsuperscript{19,20} Compression of the PIN between the arcade of Frohse and hypertrophied synovium secondary to osteoarthritic changes, impingement of the PIN between the arcade of Frohse and a rheumatoid synovial cyst and compression from a cystic lesion in the proximal radio-ulnar interspace have all been described.\textsuperscript{13,21,22}

Radial tunnel syndrome

There is little published evidence describing the causes of RTS. A published study of twenty patients\textsuperscript{3} defined RTS as aching pain localised to the extensor mass just below the elbow, tenderness of the mass to palpation, painful resisted middle finger extension (in the same area) and pain on resisted supination. None of the patients displayed any motor weakness. There is limited information regarding the cause of the symptoms.

PIN dysfunction without differentiation between PINS and RTS

As previously mentioned, many authors do not distinguish between the two conditions. Three studies [W, H, E], reported RTS in forty two, twenty nine and fourteen patients respectively. RTS was defined, as above, as pain and tenderness over the radial tunnel, pain in the same area during resisted supination and pain with resisted middle finger extension. However, in 1, 3 and 12 cases respectively there also was PIN related muscle weakness. There appears to be a higher frequency in the number of manual workers performing repetitive upper limb tasks, suggesting a repetitive strain component to the syndrome.

Basic science evidence

There is evidence to suggest that PINS and RTS result from compression of the PIN in the radial tunnel and that the two syndromes may have the same underlying causation, which is manifest differently due to differing levels of severity not detected on superficial medical examination. The literature also highlights one main theme associated with the syndromes; that it is associated with repetitive manual activity.

An explanation as to why repetitive activity appears to have a causative role in PIN pathology is provided by a study reported by Pritchard et al.\textsuperscript{23} in which the authors identified a correlation between the symptoms that developed with repetitive activity and the local compartment pressure. The authors speculate that the underlying mechanism of repetitive work leading to compartment syndrome is due to a combination of overuse, fatigue and muscle structural damage causing reactive inflammation and oedema.

The influence of increased compartment pressure on the pathology of RTS/PINS may also explain why a motor nerve pathology commonly presents as pain, as it has been shown that increased muscle compartment pressure decreases capillary flow and can cause ischaemia of muscle, which in turn causes pain in the affected area.\textsuperscript{24} Persistent compression of nerves has also been shown to lead to cytokine release, fibroblastic invasion and endoneurial fibrosis, which will also stimulate nociceptive nerve endings thereby presenting another mechanism by which a non-sensory nerve compression may present with pain.\textsuperscript{24} For a schematic summary of potential mechanisms in PIN dysfunction see Fig. 2.

Summary

It is difficult to evaluate the different aetiological factors’ contribution to the non-traumatic onset of RTS and PINS from the clinical reports published on the topic, as they present little detail regarding these aspects of the subjects’ histories. The two themes that are suggested by the literature however are:

1) That there may be a link between manual work/repetitive upper limb activity and the onset of symptoms.\textsuperscript{25}
2) That in the majority of cases of PINS there is a preceding period of pain before the onset of paralysis.

Investigations

RTS and PINS are both syndromes defined by their clinical presentation. In the reports pertaining to RTS, diagnosis is made purely on the history of generalised pain in the proximal forearm distal to the lateral epicondyle supported by the physical findings of tenderness on palpation over the radial tunnel. The pain is reproduced on resisted supination or resisted middle finger extension.\textsuperscript{3,5,8,9,26} History and physical tests have been found to be only 52\%\textsuperscript{11} and 37\%\textsuperscript{9} accurate in relation to diagnosing radial tunnel compression prior to surgery, indicating a need for tests to be available in order to make a more accurate diagnosis.

Figure 2  Schematic summary of potential pathological mechanisms in PIN dysfunction.
The demand for investigative modalities is high, as RTS shares a very similar clinical picture to tennis elbow (Table 1) in that the pain symptoms present in a similar fashion i.e. with pain on palpation of the proximal forearm and with resisted wrist/finger dorsiflexion. The incidence of PIN dysfunction is difficult to assess due to inconsistency in correct diagnosis due to the crossover in symptoms shared by tennis elbow and RTS. Indeed, RTS was initially described in 1972 by Roles and Maudsley as a cause of persistent tennis elbow.10,27,28

Normal EMG studies are not reliably useful in the diagnosis of pathology of the PIN in the absence of muscle weakness.10,23,29

Supporting a diagnosis of PIN pathology is much clearer in the cases where motor weakness has developed. In these, EMG may positive13,18,19,21 and MRI scans have been used to show clear pathology.17,22 It is important to note, however, that the cases of PIN pathology with specific motor weakness are often related to trauma and have a more obvious lesion to detect. It has been suggested11,30 that the modalities of nerve conduction testing and MR imaging can be potentially useful in the diagnosis of PIN pathology with or without motor weakness. The studies are of relatively few subjects and require validation, but the potential has been identified.

Management

Conservative treatment

A number of conservative options for the management of PINs have been described, which include; non steroidal anti-inflammatory medication, wearing a splint, stretching and exercise, local steroid injection and rest.3,5,7,12,15,16,26,29 However no randomised or controlled studies investigating the efficacy of conservative treatment in the management of PIN dysfunction have been published.

A group of studies, primarily reporting surgical results, mention conservative treatment only in the context of it being unsuccessful prior to their subjects undergoing surgery. There is no specific information regarding individual conservative modalities.3,5,6,9,15 Although the surgical studies only report the failure of conservative modalities, some imply that that is not always the case as they recommend periods of conservative treatment with the aim of resolving the condition as a prerequisite to surgery.7,15

Significant conclusions regarding the value and efficacy of conservative treatment in PIN conditions are impossible with the current literature available.

Surgical intervention

Approaches

Three main operative approaches have been described for the surgical management of PIN dysfunction in the peer reviewed literature although a fourth is also noted:7

1) Posterior approach9,15
2) Anterior approach3,5,8,9,19
3) Trans-brachioradialis approach1,9

Posterior approach

The incision begins just distal to the lateral epicondyle and runs distally for 6–8 cm (Fig. 3) between the muscle bellies of extensor carpi radialis brevis and extensor digitorum communis. Supinator is identified with the PIN being found at its proximal edge located within fatty tissue. The arcade of Frohse, fibrous edge of extensor carpi radialis brevis and recurrent radial vessels can be identified and decompressed (Figs. 4 and 5).7

Anterior approach

The incision starts on the anterolateral aspect of the arm 4 cm proximal to the elbow flexion crease. When the incision reaches the elbow flexion crease it is directed medially, between biceps and brachioradialis muscles, to continue distally along the ulnar border of the mobile wad (brachioradialis and extensor carpi radialis longus and brevis muscle bodies) (Fig. 6). The subcutaneous tissues are separated and the lateral cutaneous nerve to the forearm is protected. Fascia is divided along the brachioradialis muscle (Fig. 7). The brachioradialis muscle is retracted laterally and biceps and pronator teres are retracted medially. The radial nerve can then be identified.
proximally and inspected distally for sites of compression. Pronation of the forearm and flexion of the wrist may demonstrate dynamic compression of the nerve. Decompression is then undertaken via extensor carpi radialis brevis release, ligation of the recurrent radial vessels, longitudinal section of the arcade of Frohse and removal of any fibrous bands present (Fig. 8).7,31 Results are reported as 58, 64 and 70% good/excellent in three studies.15,19,20

**Transbrachioradialis approach**

A 6 cm incision is made commencing just proximal to the radial head 3 cm lateral to the biceps tendon (Fig. 9). The lateral cutaneous nerve of the forearm is preserved, fascia split and then the brachioradialis muscle belly split. The radial nerve can then be located and decompression of the PIN, via division of the arcade of Frohse, extensor carpi radialis brevis, branches of the radial recurrent artery ligation and division, can be undertaken. Nineteen procedures (95%) resulted in complete relief. The only complications reported were three cases of hypertrophic scars.3

**Results**

The results of surgery are variable (58–95% success) with no randomisation or controls. The level of evidence pertaining to the surgical treatment of PIN compression is low, as none of the studies were controlled and therefore are unable to prove that any change in the condition was a result of the surgery. Since the group sizes were small it is hard to assess how relevant the findings of these studies.

Significantly, the evidence in the literature suggests that PIN dysfunction is often inaccurately diagnosed.9,11 It is therefore likely that on occasions surgery is performed on inappropriate patients, which will skew results and make the evaluation of surgery on correctly diagnosed patients difficult. Although the range of outcomes reported is large, all the studies report a benefit in the majority of patients. This suggests at least some efficacy of the treatment. Much more research, with the use of controls, is needed before any strong conclusions can be made regarding the place of radial tunnel decompression in the treatment of PIN dysfunction.
The level of detail concerning specific surgical techniques varies between texts. No studies undertake any comparison or evaluation of the clinical efficacy of the different surgical approaches used. Lister et al. reported that they used the anterior approach once, then changed their technique to the trans-brachioradialis approach due to their experiences with "unsightly scarring". Ritts et al. also note that the anterior approach often results in a cosmetically objectionable scar, although the technique does allow for a concomitant exploration of the median nerve if required. Lister et al. also state that all three described approaches allow adequate exposure of the radial tunnel. Lawrence et al. and Sotereanos et al. both advocate the anterior approach because of superior exposure of the radial nerve. Lawrence et al. acknowledge that the scarring is a drawback of the approach but do not discuss it further. Vrieling et al. and the case studies do not discuss their surgical approaches.

Conclusions regarding the efficacy of the different approaches are difficult to make. Although the approaches discussed produce variations in the exposure of the underlying structures further research is required to confirm that the different clinical approaches have a similar efficacy.

Conclusion

PIN pathology is a condition that can present with a range of signs and symptoms that can become functionally disabling for patients.

Summary of aetiological factors

- Trauma to radial aspect of forearm.
- Repetitive manual work.
- Long term computer use.
- Rheumatoid arthritis.

Summary of signs and symptoms (can occur together or individually)

- Generalised pain over proximal radial forearm.
- Pain aggravated by repetitive activity.

- Point tenderness over the radial tunnel.
- Weakness of finger extension, thumb abduction.
- Radial deviation on active wrist extension.
- Increased differential latency on EMG studies.

It is apparent that there is relatively little understanding of the underlying mechanisms of this condition and that diagnosis is often inaccurate. Some recent small reports appear to suggest a potential for improving investigations and therefore diagnosis, though more research is required to support these findings.

It is interesting to note that two-thirds of employees in industrialised countries use a computer on a daily basis and that one in five uses a computer for at least three-quarters of their working day. Based on this information, and the association of PIN dysfunction with repetitive minimal variation work, it is the author's hypothesis that as the use of computers continues to increase in daily activities the incidence of PIN dysfunction will increase accordingly. Due to this potential for increasing incidence and its close association with lateral tendinosis, another commonly presenting problem, it is important that PIN dysfunction is properly understood and that awareness of it is raised. Only when diagnostic criteria are properly delineated can patients be properly selected for treatment. Both nonoperative (NSAID, splints, stretches, injections) and surgical treatment options require better evaluation. Given the difficulties in diagnosis that do exist, reported results of surgery appear to be very good.

References