Clinical Case Report Competition

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Second Place Winner

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The effects of full body infrared sauna and manual therapy on carpal tunnel syndrome due to calcification of transverse tendon
Acknowledgements

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Abstract

Objective:
To investigate the effect of full body infrared heat therapy combined with manual therapy on decreasing symptoms of Carpal Tunnel Syndrome (CTS) due to calcification of the transverse tendon. Secondary objectives include improved quality of life, grip strength, nerve conduction velocity and decreased signs of inflammation.

Methods:
A series of 10 treatments occurred over the span of 26 days. Treatment consisted of a 30 minute full body infrared sauna session with temperature ranging from 120°-149°F followed by a 60 minute massage. Assessments were completed before treatment 1, 3, 7, and before and after treatment 10. Manual treatment modalities include myofascial, nerve flossing, neuromuscular, joint mobilizations and Swedish techniques.

Results:
Left median nerve conduction velocity at the wrist improved from 4.45 to 1.57 milliseconds (ms). CTS signs and symptoms improved by 11.4% based on the Boston Carpal Tunnel Syndrome Questionnaire. Girth measurement decreased from 161mm to 154mm. Decrease in temperature of the left wrist, right wrist and left temple ranged from 0.4 - 3.1°F. Grip strength on the left hand improved by 36 mmHg. Phalens test improved from 22.68 - 60 seconds. Reverse Phalens initially improved from pain at 60 seconds to tightness at 60 seconds; however, treatment 10 noted pain pre and post treatment at 42.33 and 34.5 seconds respectively. No change in distance between scaphoid tubercle and pisiform was noted. There was a decrease in taut, red and shiny skin most notably in the left hand.

Conclusion:
Full body infrared sauna and manual therapy with a focus on myofascial and nerve flossing techniques are effective modalities for intervention of carpal tunnel syndrome due to calcification of the transverse tendon.

Key Words:
carpal tunnel syndrome, myofascial technique, nerve flossing technique, infrared sauna, nerve conduction velocity
Introduction

Carpal Tunnel Syndrome (CTS) is the most common peripheral neuropathy.¹ According to 2013 WorkSafe BC document², CTS an Activity Related Soft Tissue Disorder (ASTD) resulted in an average of 264 accepted claims per year; $6, 355,605.00 in benefits paid per year; 31, 604 work days lost per year; $24,074 in benefits paid per year per claim; 120 work days lost per year per claim. In 1993, The Workers Compensation Board of Alberta stated that a National Institute of Occupational Safety and Health (NIOSH) reported that CTS resulted in a median of 30 work days lost, the longest recuperation period of all conditions that result in lost work days³.

CTS involves compression and local ischemia of the median nerve through the carpal tunnel resulting in pain, numbness, tingling and eventual muscle weakness.⁴⁻⁵ A distinguishing feature of CTS is nocturnal symptoms that wake the patient.⁶

The carpal tunnel is made up of the carpal bones dorsally and the transverse carpal ligament (flexor retinaculum) volarly. The structures that pass through the carpal tunnel are flexor digitorum superficialis, flexor digitorum profundis, flexor pollicis longus muscles and the median nerve.⁶⁻⁷⁻⁸ The etiology of CTS is generally believed to be repetitive strain injury (RSI) - high force and high repetition in a biomechanically unsound position⁶. Main aggravating factors for CTS are cumulative trauma, highly repetitive sustained activities such as flexion, extension and ulnar deviation of the wrist,⁶ and gripping⁸.

The median nerve could sustain compression or traction injury due to an increase in the size of the contents running through the carpal tunnel, a decrease in the size of the tunnel or a combination of the two. An increase in the size of the contents could be caused by edema, fibrotic and thick tendons, and systemic or metabolic conditions that cause fluid retention and
proliferation of synovial fluid such as pregnancy, osteoarthritis (OA) and rheumatoid arthritis (RA)\(^6,9\). A decrease in the size of the canal could be due to the presence of space occupying lesions such as callus formation, tumour, osteophytes (OA/RA), thickening or calcification of the flexor retinaculum\(^8,10,11\).

CTS typically affects people 40-60 years of age and women more common than men\(^10\). It may present bilaterally, however, most commonly it affects the dominant hand. CTS is often associated with occupational activities in younger patients whereas patients past 63 years of age have different risk factors than their younger counterparts. The elderly population may have different underlying pathogenic mechanisms.\(^4,9,10\) Some people are more susceptible to compression of the median nerve due to coexisting conditions including systemic conditions\(^6\).

Conservative interventions for CTS include altering biomechanics/ergonomics combined with patient education, steroid injections, splint immobilization of the wrist in a neutral position, rest, anti-inflammatories, diuretics and vitamin B6. Surgery is indicated in the absence of symptom relief, continued sensory and motor loss, and nerve conduction velocity decreases\(^6,9\). Results with surgery however are poor, with up to 12% of patients needing a second surgery, and 25-95% of those still experience persistent symptoms, even after multiple surgeries.\(^5\)

Myofascial manipulation is forceful, passive movement of musculofascial elements through restrictive directions progressing from superficial to deep layers\(^7\). Fascia is a strong yet mobile connective tissue that surrounds all muscles, bones and organs. Fascia has the potential to retain tissue fluid and metabolites. There are two techniques to release fascial restrictions - direct and indirect. Direct techniques engage the fascia toward the area of restriction or adhesion. The tissue
is engaged through as a series of releases. Indirect techniques moves the tissue in the direction opposite the restriction, following the tissue in the direction it wants to go. Tissue slack is taken up and held until the tissue barrier stops resisting the therapist pressure. The therapist follows tissue movement through a series of releases before moving on to another area. Myofascial (MFR) release can increase the anterior posterior and transverse carpal tunnel dimensions thereby alleviating compressive forces on the median nerve.

Nerve threading or nerve flossing technique involves placing the limb containing the affective nerve in a position that causes maximum tension on the nerve such as Upper Limb Tension Test (ULTT) 1 and 2. This could be used in diagnosis and treatment. In the case of the median nerve, this position involves shoulder depression, glenohumeral abduction to 110° (ULTT1) and 10° (ULTT2), supination of forearm, extension of elbow, wrist and fingers. Head side flexion and contralateral rotation can also be incorporated. The limb is progressively placed in the position noted above until slight tingling is present, the therapist alternates between adding more tension and reducing tension via increased or decreased extension of the fingers and wrist until the initial position can be held without symptoms. According to one study, conservative tendon and nerve mobilizations of the median nerve resulted in 43% receiving surgical intervention whereas the group not receiving treatment resulted in 71% receiving surgical intervention. One study reported nerve flossing technique (NFT) to provide greater pain relief and improvement in sensory symptoms compared to the control group. This technique may reduce adhesions and oxygenate the nerve thereby decreasing ischemic pain.

Increased joint motion and myofascial mobility may improve blood flow within the vasa
nevorum and alleviate ischemic conditions.$^5$

The cardinal signs of inflammation are swelling, heat, redness, pain and altered function.$^9,15$. In acute inflammation, pain and altered function is experienced due to increased pressure from edema on peripheral nerves. Chronic inflammation is marked by an accumulation of cellular mediators of inflammation such as leukocytes, neutrophils, macrophages and plasma cells (Appendix C) as a result of simultaneous tissue destruction and repair. Chronic inflammation may be caused by an unresolved trauma, repetitive micro trauma/irritation or a low-grade immune reaction. Clinically joints affected by Rheumatoid arthritis (can be chronic inflammation with flare-ups of acute inflammation) appear red, swollen, painful and a low grade fever may be present. Systemic inflammation produces fever, joint, muscle and organ dysfunction and malaise.$^9,11$. In one study conducted on rats, infrared low-level laser therapy markedly reduced signs of inflammation reducing the number of leukocytes, neutrophils and interleukin-1, a pro inflammatory mediator, in the knee joint cavity.$^{16}$ The reduction of these cellular markers post-infrared treatment, indicates that the use of infrared decreases inflammation. CTS and calcification tendonitis can be due to excess inflammation, therefore full body infrared therapy may decrease inflammation thereby decreasing CTS signs and symptoms.

The primary objective of this study is to investigate the effect of full body infrared heat therapy combined with manual therapy with a focus on myofascial and nerve flossing technique on decreasing symptoms of CTS due to calcification of the transverse tendon. Secondary objectives include improved quality of life, grip strength, decreased signs of inflammation and nerve conduction velocity.
Case Study Subject

The patient, an active 65-year-old female, is retired and in good general health. She attends cardio, Pilates and weights classes, three times a week, as well as walking her dogs 15 to 30 minutes, three times per day. She enjoys gardening and volunteering time in public service.

On initial assessment, subjective findings indicate that no pain has been experienced since the diagnosis six months prior, however she indicated there is now numbness and tingling “most of the time” which is particularly aggravated by driving or talking on a phone for an unspecified period of time. She has not received any treatment or medication for the symptoms aside from a wrist brace which she wears seven days a week, four to five hours per day and throughout the night. Her family physician confirmed a diagnosis of carpal tunnel syndrome on her left side. Nerve conduction velocity is currently 4.45 ms, past the threshold for surgery, and her neurologist has advised her to consider surgical procedure to prevent further nerve damage. She also reports experiencing arthritis symptoms each morning in her left shoulder, bilateral elbows and fingers.

Subjects’ medical history includes diagnosis of right carpal tunnel syndrome with symptoms starting 10 years ago. Her neurosurgeon advised her that right carpal tunnel symptoms were due to two factors: the relatively small size of her anatomical carpal tunnel and calcification of the transverse ligament or flexor retinaculum. Subject underwent right median nerve decompression surgery on May 31, 2012. Post-surgery the subjects’ symptoms on the right subsided and the subject reported a gain in strength.
Methods

A series of 10 treatments occurred over the span of 26 days with each treatment consisting of a 30 minute full body infrared sauna session with temperature ranging from 120°-149°F followed by a 60 minute massage.

Numerous assessment methods were used. The Boston Carpal Tunnel Syndrome Questionnaire is a standardized outcome measurement that is valid and reliable.\(^{17}\) Girth of the left wrist at the proximal row of carpals was measured in millimetres. Temperature of the volar surface of bilateral wrists and left temple using a non-contact infrared digital thermometer. Hand grip strength using a sphygmomanometer has been shown to be reliable compared to the Jamar dynamometer.\(^{18}\) The sphygmomanometer is rolled to accommodate the size of the patients hand, it is then inflated to 20mmHg and the patient applies maximal grip force. The gauge needle indicates the force applied by the patient. Phalens test involves the patient placing the dorsum of their hands together with the wrists flexed. The patient compresses them together for 60 seconds. Phalens has sensitivity of 0.85 and specificity of 0.79.\(^{9}\) Reverse Phalens is a variation of Phalens where the patient extends the wrists and compresses the palms together for 60 seconds. A positive test is a recreation of symptoms such as tingling or pain in digits 1-3 and the lateral half of digit 4.\(^{19}\) The Distance between scaphoid and pisiform was measured in millimetres. Observation of skin tissue of the hands was made. A nerve conduction velocity test (NCV) tests the speed in which electrical impulses are transmitted down a nerve. This test is used to determine nerve impairment or injury. A decrease in the speed of transmission indicates nerve impairment therefore an increase in speed of transmission would indicate restored nerve function.\(^{9,20}\) The NCV tests were performed by a technician at a local hospital and the results
were forwarded to the subjects’ neurologist. The NCV tests were completed on 2 separate occasions before and after the full series of treatments. All other assessments were completed before treatment 1, 3, 7, and before and after treatment 10.

Subject position was supine. The right upper extremity was treated first, starting with myofascial release to pectoralis major, deltoids, biceps brachii, triceps brachii, brachialis, forearm flexors and extensors. The left upper extremity received the same MFR treatment as the right and included the following additional techniques. A lateral clavicular glide was performed. Transverse skin rolling was first performed across the anterior forearm starting at the elbow working distally. As the tissue softened, longitudinal skin rolling was performed on the anterior forearm. Grade 2 joint mobilizations to the pisiform and myofascial release of the flexor retinaculum was followed by lateral distraction of the carpal tunnel. Swedish techniques were applied to the arm and forearm. Specific techniques included neuromuscular technique to flexor digitorum superficialis and pronator teres and neuromuscular frictions to the common flexor tendon. Grade 2 dorsal, volar, radial and ulnar glides were performed on the wrist. Stimulatory ROODS technique was applied to the intrinsic muscles of the hand combined with active flexion of the fingers and thumb. Median nerve threading at 10° and 110° glenohumeral abduction with 10 repetitions of wrist extension were incorporated during the treatment. As the treatment progressed the subject was asked to side flex and rotate the head away from the affected arm to increase tension on the median nerve during this process. Effleurage was used to clear the left upper extremity.
Results

On initial assessment, objective findings include Boston Carpal Tunnel Questionnaire (Appendix A) score of 11/44; median NCV of the left wrist 4.45 ms; girth measurement of left wrist at 161mm; raised temperatures in bilateral wrists and left temple; grip strength of the left wrist 100 mmHg; positive Phalens test; and tropic changes of the left hand such as taut, shiny and red skin.

Figure 1 shows the results of the Boston Carpal Tunnel Syndrome Questionnaire wherein the subjects’ baseline started at 11 points out of a possible 44 points. Over the full course of treatment the subject reported a decrease of 5 points, indicating an overall improvement of symptoms by 11.4 %.

Figure 1: Results from Boston Carpal Tunnel Syndrome Questionnaire.

Figure 2 shows the changes in girth measurements of the left wrist at the proximal row of
The subjects’ left wrist baseline started at 161 mm. By treatment 3 it was reduced to 155 mm and from treatment 7 through the remaining treatments plateaued at 154 mm.

Figure 2: Girth measurement of left wrist.

Figure 3 illustrates the overall decrease in temperature of the left wrist, right wrist and left temple. The decrease ranged from 0.4 - 3°F.
Figure 3: Temperature in degrees Fahrenheit for bilateral wrists and left temple using an infrared thermometer.

Figure 4 shows grip strength of the left hand improved by 36 mmHg.

![Grip Strength Chart](image)

**Figure 4**: Grip strength measured in millimetres of mercury in right and left hands.

Figure 5 shows the time to onset of signs and symptoms aggravated by Phalens test improved from 22.68 - 60 seconds. The time to onset of signs and symptoms aggravated by Reverse Phalens initially improved from pain at 60 seconds to tightness at 60 seconds; however, treatment 10 noted pain pre and post treatment at 42.33 and 34.5 seconds respectively.
Figure 5: Phalens and Reverse Phalens test results.

The distance between the scaphoid tubercle and pisiform was measured four times throughout the treatment. No observable change was shown in the distance between scaphoid tubercle and pisiform.

On the initial assessment, bilateral tropic changes of the hands presented as taut, red and shiny skin. This presentation was more pronounced on the left compared to the right. A decrease in these was observed (Appendix B).

Figure 6 illustrates the results of the left wrist Nerve Conduction Velocity tests. NCV improved from 4.45 to 1.57 ms.
Figure 6: Nerve Conduction Velocity Test.
Discussion

Manual therapy with a focus on MFR, NFT and full body infrared sauna proves to be effective in reducing the signs and symptoms associated with CTS. The subject experienced an 11.4% reduction in symptoms based on the Boston Carpal Tunnel Syndrome Questionnaire after a series of 10 treatments over 26 days. The subject decreased use of a wrist brace from 6-8 hours during the day time and 6-8 hours at night to strictly night time wear. Numbness, weakness and tingling consistently decreased over the course of treatment. Although the subject usually attended the gym, she was unable to attend her regular classes prior to the beginning of treatment due to a busier schedule but recommenced as of treatment 7. The subject didn’t wear her wrist brace at night a number of times from treatment 6-10 which could account for the slight increase in pain and numbness and weakness waking the subject up at night as noted in the final two questionnaire’s.

Inflammation is marked by swelling, heat, redness and altered function. The reduction in girth measurement (Figure 2) and decrease in temperatures in all categories (Figure 3) indicates a decrease in inflammation, as does the tropic changes in the form of reduces taut, red, and shiny skin. (Appendix B)

An increase in grip strength indicates an increase in restored function of both nerve and muscle fibres.

The subject originally experienced challenges when driving and talking on the phone resulting in
a decreased quality of life. During the course of treatment the subject no longer reported carpal tunnel symptoms while engaging in these activities. Phalens and reverse Phalens test places the subject in positions compromising the median nerve through the carpal tunnel; despite this, the subject reported a delay in the onset of symptoms within normal parameters by treatment 10. All of the above noted changes leads to an overall improvement of the subjects’ quality of life. There is a margin of error noted for the last recorded reverse Phalens test. A blanching of the palm and nail beds were observed by the researcher during the test. Such blanching was not noted in previous testing and indicates an increased in the amount of pressure applied by the subject. This could result in a false positive test.

Heat administered via full body infra-red sauna is able to penetrate the skin up to 1.5” [21]. Deep penetration improves tissue pliability thereby increasing the effectiveness of myofascial technique. Effective release of soft tissue decompresses the nerves and may account for decreased symptoms and as noted by the Nerve Conduction Velocity Test and increased function. (Figure 6)

After a full compilation of results, manual therapy is an effective, non-invasive means to decrease signs and symptoms of CTS. In the early stages of repetitive strain injuries, manual therapy modalities may be enough to prevent the need for surgical intervention; whereas chronic inflammation may benefit more from discovering the underlying cause and infrared sauna therapy. More studies need to be done to measure cellular markers of inflammation and full body infrared sauna therapy.
Results from this study corroborate with previous studies\textsuperscript{5, 14, 16} regarding the effectiveness of MFR, NFT and infrared therapies. Additionally they are effective modalities to be applied to many other compression neuropathies. The use of infrared therapy could be a possible treatment option for chronic soft tissue injuries, hypertoned muscles and calcific tendonitis. More research is necessary to validate the use of infrared heat for chronic inflammation.

Such non-invasive methods could potentially reduce the number of required surgeries and therefore surgical wait times. According to one study, conservative tendon and nerve mobilizations of the median nerve resulted in 43\% receiving surgical intervention whereas the group not receiving treatment resulted in 71\% receiving surgical intervention\textsuperscript{8}. The results found in this study indicate that the use of manual therapy could potentially decrease the number of WorkSafe BC claims, and reduced work days lost. Currently WorkSafe BC reports an average of 31, 604 work days lost per year and $6, 355,605.00 in benefits paid per year due to CTS\textsuperscript{2}. When initial symptoms and diagnosis of CTS is made, including massage therapists as a part of the patients’ medical team, could result in reducing the effect of carpal tunnel and other pathologies, on the patient, their lifestyle, their work and socioeconomic impact. Manual therapy, in comparison with surgery alone, may reduce the risk of post-surgical complications\textsuperscript{22} such as excess scar formation, infection, iatrogenic nerve damage, bowstringing of flexor tendons, pain from soft tissue damage and anti-inflammatory pharmaceuticals.\textsuperscript{4, 23} A program of preoperative and postoperative recovery care can also aid in optimum functional outcomes for the patient.\textsuperscript{22} The results of this study support the use of manual therapy in facilitating patient recovery.
Assessment methods in this study could be improved upon by adding wrist range of motion to further measure improvement in quality of life, diary of subject activity levels to determine possible correlations between patient activities and treatment efficacy, and incorporating measurement for pressure applied when carrying out Phalens and Reverse Phalens to ensure consistent testing. Suggestions for future studies include increasing the number of subjects in a before and after trial comparing results from infrared sauna therapy versus manual therapy.
Conclusion

A total of 10 treatments consisting of a 30 minute full body infrared sauna treatment followed by a 60 minute massage session with a focus on MFT and NFT resulted in an 11.4% decrease in overall signs and symptoms of CTS. Median nerve conduction velocity test of the left wrist improved from 4.45 to 1.57 ms. Body temperature in bilateral wrists and at the left temple decreased. Full body infrared sauna and manual therapy with a focus on myofascial and nerve flossing techniques are shown in this study as effective modalities for intervention of carpal tunnel syndrome due to calcification of the transverse tendon.
References


Appendix A – Boston Carpal Tunnel Questionnaire

Boston Carpal Tunnel Syndrome Questionnaire

Select the answer that best fits the question.

How severe is the hand or wrist pain that you have at night?

- None or Never (0)
- Mild (1)
- Moderate (2)
- Severe (3)
- Very Severe (4)

How often did hand or wrist pain wake you up during a typical night in the past two weeks (times/day)?

- Never (0)
- 1 (1)
- 2 to 3 (2)
- 4 to 5 (3)
- 5 or more (4)

Do you typically have pain in your hand or wrist during the daytime?

- None or Never (0)
- Mild (1)
- Moderate (2)
- Severe (3)
- Very Severe (4)

How often do you have hand or wrist pain during the daytime (times/day)?

- Never (0)
- 1 x (1)
- 2 to 3 x (2)
4 to 5 x (3)
5 or more x (4)

How long on average, does an episode of pain last during the daytime (minutes)?
0 (0)
<10 (1)
10-60 (2)
>60 (3)
Constant (4)

Do you have numbness (loss of sensation) in your hand?
None or Never (0)
Mild (1)
Moderate (2)
Severe (3)
Very Severe (4)

Do you have weakness in your hand or wrist?
None or Never (0)
Mild (1)
Moderate (2)
Severe (3)
Very Severe (4)

Do you have tingling sensations in your hand?
None or Never (0)
Mild (1)
Moderate (2)
Severe (3)
Very Severe (4)
How severe is numbness (loss of sensation) or tingling at night?

- None or Never (0)
- Mild (1)
- Moderate (2)
- Severe (3)
- Very Severe (4)

How often did hand numbness or tingling wake you up during a typical night during the past two weeks?

- 0 x (0)
- 1 x (1)
- 2-3 x (2)
- 4-5 x (3)
- 5+ x (4)

Do you have difficulty with the grasping and use of small objects such as keys or pens?

- None or Never (0)
- Mild (1)
- Moderate (2)
- Severe (3)
- Very Severe (4)
Appendix B - Photos

Figure 7: Photo taken before treatment 1.

Figure 8: Photo taken before treatment 3.
Figure 9: Photo taken before treatment 7.

Figure 10: Photo taken before treatment 10.
### Mediating Factors in Inflammation

<table>
<thead>
<tr>
<th>Factors</th>
<th>Source</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arachidonic acid metabolites (prostaglandins and leukotrienes)</td>
<td>Phospholipids of cell membranes, especially mast cells</td>
<td>Primary mediators of late-stage (&gt;6 hr) inflammation; increase dilation and permeability of blood vessels; stimulate neutrophil adhesion to endothelial tissue; bronchoconstriction; anaphylaxis</td>
</tr>
<tr>
<td>Bradykinin</td>
<td>Kinin system of plasma proteins</td>
<td>Primary mediator of prolonged (&gt;1 hr) inflammation; vasodilation and increased permeability of blood vessels; pain; release of leukotrienes and prostaglandins</td>
</tr>
<tr>
<td>Complement proteins</td>
<td>Macrophages; liver endothelium</td>
<td>Increase vasodilation and vascular permeability; coat antigens to enhance phagocytosis; attract neutrophils; destroy pathogens</td>
</tr>
<tr>
<td>Histamine and serotonin</td>
<td>Mast cells; basophils</td>
<td>Primary mediators of early (≤30 min) inflammation; rapid dilation and increase in permeability of venules; bronchoconstriction; stimulation of prostaglandin production</td>
</tr>
<tr>
<td>Interleukin 1 (IL-1)</td>
<td>Macrophages; B cells, dendritic cells, neutrophils, other nucleated cells</td>
<td>Increased production and activity of other chemical mediators, phagocytes and lymphocytes; promotes release of acute-phase proteins; causes fever</td>
</tr>
<tr>
<td>Interleukin 8 (IL-8)</td>
<td>T lymphocytes; monocytes</td>
<td>Attracts neutrophils and more T cells</td>
</tr>
<tr>
<td>Platelet-activating factor (PAF)</td>
<td>Platelets</td>
<td>Releases chemical mediators; activates neutrophils; dilates and increases permeability of vessels</td>
</tr>
<tr>
<td>Transforming growth factor β (TGFβ)</td>
<td>Activated macrophages and T lymphocytes</td>
<td>Attracts neutrophils and monocytes; stimulates growth of connective tissue; inhibits other mediators</td>
</tr>
<tr>
<td>Tumor necrosis factors (TNFα)</td>
<td>Activated macrophages and some lymphocytes</td>
<td>Increase synthesis of other cytokines; induce formation of new blood vessels; increase adhesion of neutrophils to endothelium; cause fever and cachexia</td>
</tr>
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