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Case Report

Periosteal Needling to the Cervical Articular Pillars as an Adjunct Intervention for Treatment of Chronic Neck Pain and Headache: A Case Report

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Abstract: (1) Background: Periosteal dry needling (PDN) involves clinicians using a solid filiform needle to stimulate bone for analgesic purposes. This case report presents the use of PDN to the cervical articular pillars (CAPs) in an 85-year-old female with chronic neck pain and headache. (2) Case description: PDN was applied to the right C2–C3 articular pillars, following trigger point dry needling (TrPDN) and manual therapy, in order to provide a direct sensory stimulus to the corresponding sclerotomes. PDN added over two treatments led to improved cervical range of motion and eliminated the patient's neck pain and headache at 1 week follow-up. (3) Outcomes: At discharge, clinically relevant improvements were demonstrated on the numeric pain rating scale (NPRS), which improved from an 8/10 on intake to a 0/10 at rest and with all movements. In addition, the patient exceeded the risk adjusted predicted four-point score improvement and the minimal clinically important improvement (MCII) value of four points on the Focus on Therapeutic Outcomes (FOTO) Neck Functional Status (Neck FS). At one month post-discharge, the patient remained symptom-free. (4) Discussion: In the context of an evidence-informed approach for neck pain and headache, PDN led to marked improvements in pain and function. Patient outcomes exceeded predictive analytic expectations for functional gains and efficient utilization of visits and time in days. Combined with other interventions, PDN to the CAPs could be a viable technique to treat chronic neck pain with headache.

Keywords: periosteal; dry; needling; neck; pain

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1. Introduction

Periosteal dry needling (PDN) involves the use of a solid filiform needle by clinicians to prick the surface of bone for analgesic purposes. It was first described as periosteal acupuncture by Mann and later by Campbell who often applied it to treat patients with neck pain [1,2]. This style of acupuncture is similar to dry needling, having its roots within a western medical model of clinical reasoning [3] along with producing identical endogenous effects in the body using the same needle [4–6]. Given the similarities, we chose the term PDN to describe the technique used in this case report. Importantly, within the context of physical therapy, dry needling to periosteal structures is supported given that "underlying tissues" may be targeted for therapeutic purposes, according to recent definitions of dry needling [7].

Neck pain prevalence in adults ranges from 4.4% to 9.3% in the United States [8], with other countries reporting higher estimates [9,10]. Globally, point prevalence is higher in females, and neck pain-related health burden is high [11]. Chronic neck pain without radicular symptomology is attributed to cervical facet joints, intervertebral discs, and trigger points, among others [12–14]. According to Falco et al. chronic neck pain of facet joint origin is estimated to range from 36% to 60% [15]. Clinically, hypersensitivity to the cervical articular pillars is common and has been described in elderly female patients with chronic neck pain [16]. It may be due to sensitization of skeletal nociceptors due to release of nerve growth factors and inflammatory mediators [17,18].

Multimodal approaches show a positive effect on pain outcomes for patients with chronic neck pain [19], with manual therapy and exercise being the most frequently utilized by physical therapists [20]. Yet, adding trigger point dry needling (TrPDN) has been shown to amplify therapeutic effects [21], with benefits comparable to manual therapy [22,23]. In recent systematic reviews and meta-analyses, TrPDN produced significant reductions in pain intensity as a stand-alone intervention [24] or when added to other interventions for treating neck pain [25]. Although TrPDN is practiced more widely by clinicians [26], earlier studies report the therapeutic effects of periosteal needling in patients with neck pain [3,27,28]. However, the therapeutic outcomes resulting from periosteal needling specifically to the cervical articular pillars (CAPs) in isolation were not analyzed. Furthermore, to the authors' knowledge, no studies in the literature have investigated the effects of PDN to the upper (C2–C3) CAPs in patients with chronic neck pain or headache. This case report is the first to present the successful use of PDN to the upper CAPs as an adjunct intervention in an elderly patient with chronic neck pain and headache. The CARE guidelines framework for writing case reports was followed (File S1: CARE checklist).

2. Case Presentation

2.1. Initial Examination

An 85-year-old female presented to physical therapy with a diagnosis of neck pain following referral from her primary physician. Her past medical history was significant for hypertension and atrial fibrillation, treated with beta blockers and anticoagulants, respectively. The patient had no imaging on file related to her condition and no pertinent past surgical history. On subjective examination, she reported right-sided upper neck and occipital pain ongoing for 13 months duration with insidious onset and without previous episodes or previous management (Figure 1). She did not report radiation of pain or symptoms of paresthesia in the upper extremities. Aggravating factors included lying down on her right side at night, turning or side bending her head to the right, and extending her neck to look upward.

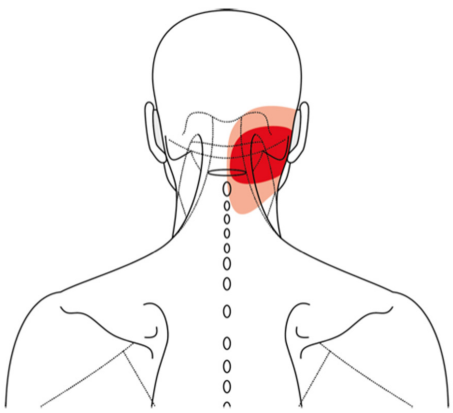

Figure 1. Patient neck pain and headache distribution.

Patient-reported measures of function, pain, and satisfaction were assessed using the Focus on Therapeutic Outcomes (FOTO) Neck Functional Status (Neck FS) [29], a Numeric Pain Rating Scale (NPRS) [30,31], and the FOTO Patient Satisfaction tool. The Neck FS is a patient-reported outcome measure that uses an item-response theory (IRT)-based 28 item bank. It was administered using computer adaptive testing (CAT) for reduced administration burden (median = 6 items) with a precision similar to that of scores based on all 28 items. Scores are reported on a 0–100 point scale with higher scores indicating better function. The Neck FS CAT has been reported to demonstrate excellent reliability and validity, with no ceiling or floor effects [29,32]. Additionally, clinical interpretation parameters have been identified, including reliability of point estimates and improvement scores at different levels of confidence, cutting scores of minimal clinically important improvement; from this, a physical functioning staging model was developed [32].

Score change interpretation for the Neck FS includes a predictive analytic model for risk-adjusted predictions of FS score change, number of therapy visits, and duration of time in days. The models are specific to patients with orthopedic neck impairments and use advanced methods that account for individual variables within the following categories of patient characteristics: age, gender, acuity, severity level, individual comorbidities, payer type, surgical history, post-surgical status/type, exercise history, medication use, and history of previous treatment [33]. Minimal clinically important improvement (MCII) values for the overall score range and per quartile of intake score have been established [32].

To capture the patients' reported pain level, the NPRS was used, which consists of an 11 point scale, ranging from 0 (no pain) to 10 (worst pain imaginable). The NPRS has demonstrated acceptable responsiveness and validity, along with moderate reliability in patients with mechanical neck pain (intraclass correlation coefficient (ICC) = 0.67) [31] and cervicogenic headache (ICC = 0.72) [30].

Patient satisfaction was assessed using an unpublished set of eight patient-facing questions used in the FOTO Patient Outcomes measurement system (Net Health Systems, Inc, Pittsburgh, PA, USA), each with a five-point response options scale, producing an overall satisfaction score on the basis of a simple mathematical average. At intake, the patient had a Neck FS score of 61 with a risk-adjusted predicted score change of +4 over nine therapy visits and 41 days, and the Intake NPRS was 8/10 with movement and 2/10 at rest (Table 1). Her goals were to reduce pain without taking medication and to be able to turn her head without pain.

The pain distributions in the upper cervical and occipital region warranted a differential diagnosis of potential pain sources including the C2–C3 and C3–C4 cervical zygapophyseal joints and dorsal rami [34], as well as muscles of the neck and shoulder girdle [35,36].

2.2. Differential Diagnosis

The patient was screened for vascular insufficiency by taking an evidence-informed medical history [37,38]. Cervical spine active range of motion (AROM) was measured using a standard universal goniometer for cervical rotation, which has demonstrated excellent between session intra-rater reliability (ICC = 0.79 to 0.97) [39]. All other AROM measures were taken using a standard inclinometer, a device also reported to have good reliability for clinical use in measuring cervical AROM [40]. Cervical AROM was limited and painful in right side bending and rotation, while extension was painful at the end range (Table 1). The patient rated her pain with movement at an 8/10 on the numeric pain rating scale (NPRS). The neurological examination was normal and revealed symmetrical reflexes, normal dermatome sensation, and full myotome strength at the tested levels (Table 1). Myotomes of the C1–C4 levels are difficult to assess clinically via manual muscle testing [41,42]; however, dermatomes were intact at C1–C4 levels, and no clinical suspicions arose to pursue further motor testing above C5. Segmental mobility was tested using a lateral gliding [43] and segmental side-bending maneuvers [44], revealing the right C2–C3 and C3–C4 articulations to be positive for the patient's main pain complaint; motion restriction was not detected, but a painful end-feel was present at the C2–C3 and C3–C4 segments on the right. Still, segmental mobility testing is reliable and clinically useful for identifying facet joint dysfunction if associated with pain provocation [45]. Normal range of movement was found on the flexion–rotation test bilaterally without pain provocation [46]. Ligamentous safety tests to assess the alar and transverse ligaments were negative and included the side-bending stress test [47] and anterior shear test [48,49]. The cranio-cervical flexion test (CCFT) was not administered; however, the initial treatment approach included dry needling to trigger points in the sternocleidomastoid muscle (SCM), which has been shown to improve cervical motor-control and reduce neck pain [50]. In addition, hyperactivity in the SCM has been found in elderly adults and appears to negatively impact function of the deep neck flexors, thus reducing performance on the CCFT [51]. Therefore, instead of the CCFT, home exercises were to be added to aid the patient in activation of deep neck flexors, promote endurance of deep neck flexors, and for gradually restoring active neck movements (Table 2). Active trigger points (TrPs) in the cervical spine region (Table 1) were identified using diagnostic criteria supported by expert consensus and included a taut band, a hypersensitive spot, and referred sensation of full or partial symptoms upon stimulation [52].

Table 1. Findings on initial examination.

Measure	Intake	
FOTO Neck FS	61	
Pain (NPRS) at rest	2/10	
Cervical AROM	Degrees	Pain (NPRS 0–10)
Flexion	45	0/10
Extension	50	8/10
Right lateral flexion	25	8/10
Left lateral flexion	30	0/10
Right rotation	60	8/10
Left rotation	70	0/10
Cervical myotomes	Right	Left
C5–Infraspinatus	5/5	5/5
C5–Biceps	5/5	5/5
C6–Brachioradialis	5/5	5/5
C6–Wrist extensors	5/5	5/5
C7–Triceps	5/5	5/5
C7–Finger extensors	5/5	5/5
C8–Abductor digiti-minimi	5/5	5/5
T1—Interossei	5/5	5/5
Cervical spine reflexes Biceps reflex (C5)	Right 2+ Average	Left 2+ Average
Wrist extensors reflex (C6)	2+ Average	2+ Average
Triceps reflex (C7) Cervical spine dermatomes	2+ Average Right	2+ Average Left
C1–T1	Intact to light touch	Intact to light touch
Muscle (TrP) palpation	Right	Left
Upper trapezius	+	–
Sternocleidomastoid	+	–
Splenius capitis	+	–
Splenius cervicis	+	–
Semispinalis capitis	+	–
Segmental mobility testing	Right	Left
Lateral gliding test	+ pain only	–
Springing/side-bending test	+ pain only	–
Flexion-rotation test	–	–
PA mobility test T1–T4	+	+

Abbreviations: AROM, active range of motion; TrP, trigger point; PA, posteroanterior; FOTO, Focus On Therapeutic Outcomes; FS, Functional Status; NPRS, Numeric Pain Rating Scale. Pain was recorded as worst pain with movement in painful directions.

Objective findings on examination were consistent with the referring diagnosis of neck pain (Table 1). On the basis of the unilateral location of neck pain and headache, limited cervical range of motion, headache provoked with pressure to the upper cervical segments, and symptoms reproduced with neck movements, a treatment diagnosis of chronic neck pain with headache was selected on the basis of the American Physical Therapy Association's revised clinical practice guidelines for neck pain (Figure 2) [53].

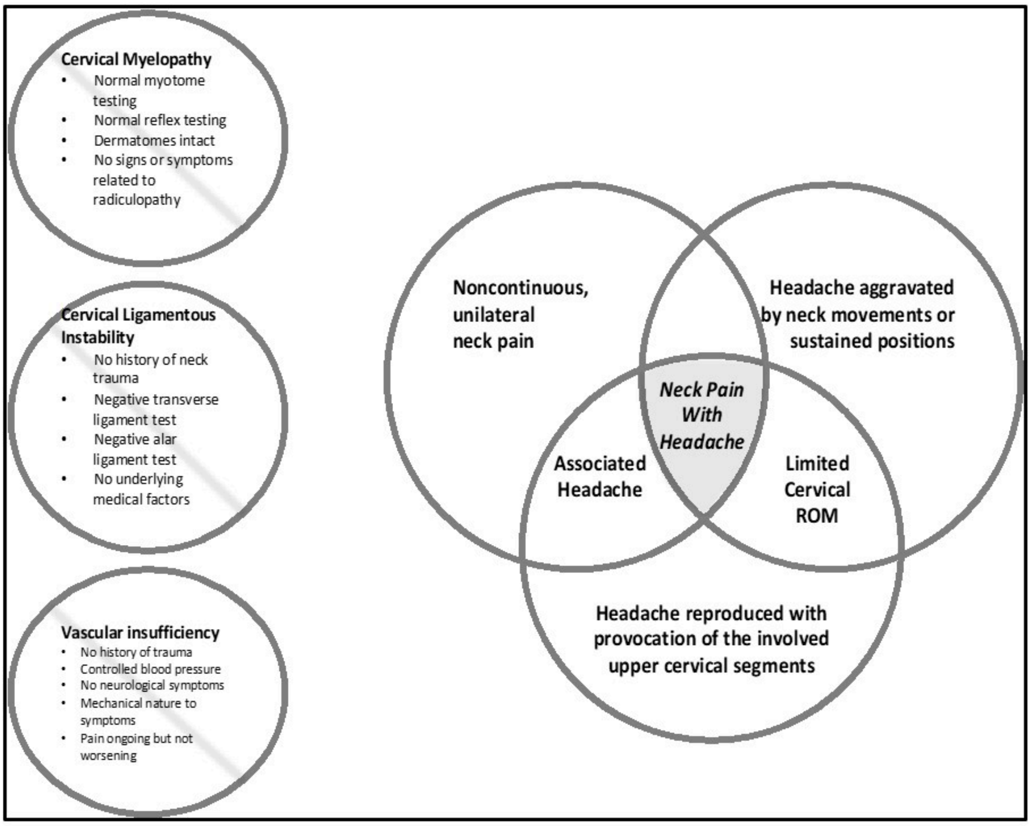

Figure 2. Differential diagnosis, according to American Physical Therapy Association's revised clinical practice guidelines for neck pain [53]. Abbreviations: ROM, range of motion.

2.3. Treatment

The first treatment (visit two) consisted of dry needling to muscles of the neck identified to have active TrPs on examination (Table 2). Since the patient was on anti-coagulants, precaution was taken in determining needling depth and degree of manipulation. Although asymptomatic bruising is a potential risk, significant bleeding is uncommon when using appropriate technique with needling (regardless of needle gauge) in the treatment of patients on optimal regimens of anticoagulant therapy [54]. Needles were inserted and intermittently rotated within TrPs to stimulate endogenous pain modulation without seeking to elicit local twitch responses [55,56]. After TrPDN, manual cervical traction and soft tissue mobilization to needled muscles was applied to assist with pain modulation. However, the patient reported continued pain when pressure was applied over the muscles near the right C2 and C3 facet joint and articular pillar region. She had a very slender neck, and it was easy to compress the muscles, feel bone, and apply pressure to the CAP at C2 and C3, which elicited her pain. At this stage, posteroanterior (PA) joint mobilization was considered. However, spinal non-thrust mobilization is known for eliciting non-segmental analgesic effects [57], and the patient's symptoms were more localized to the right C2–C3 segmental levels. In addition, PA mobilization to the upper cervical spine produces extension movement in the upper neck, and cervical extension increased the patients' pain on examination [58]. Therefore, to provide a direct sensory stimulus to the bones (sclerotomes), PDN was applied to the CAP at the C2 and C3 levels using shallow insertion of needles followed by several taps unto each bone within a 3–4 mm area (Figure 3), as previously described by Campbell [1]. Compression of the overlying muscles during the procedure allowed the use of shorter needles, as longer needles may lead to unwanted tissue trauma, can bend more easily, and can reduce the feel of needle palpation to the bone [59]. No adverse reaction occurred, and the patient exhibited very good tolerance to the treatment. The patient received an informative handout about dry needling and then scheduled a follow up session for three days later.

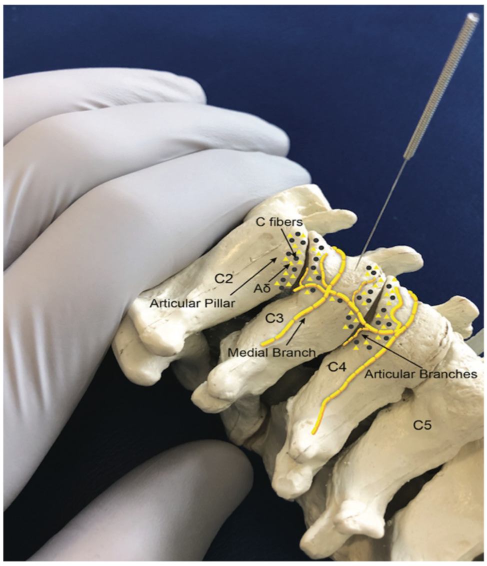

Figure 3. Description of PDN technique and potential mechanisms. (A) The patient was positioned in side-lying to expose the lateral neck in a neutral position. (B) Palpation began at the mastoid process of the temporal bone and progressed to the prominent transverse process of C1. Next, the articular processes of C2 and C3 were palpated by moving posterior and caudal along the neck. (C) Then, the overlying muscles were compressed and held down toward the articular pillars to feel bone, and the needle was inserted at a 60 degree anteromedial orientation towards an area of discrete hardness felt under the palpating hand. (D) PDN was applied to the dorsolateral region of the C2–C3 articular pillars using insertion of needles at 8–10 mm depth until reaching bone, followed by 6 taps onto each pillar within a 3–4 mm area using 0.25 × 30 mm Agupunt APS Regular Dry Needles. (E) Needling induces analgesia by distortion of the periosteum on the CAP activating Aδ and C-fiber afferents, and if contacted can exert high-pressure stimuli to the medial branches of the dorsal rami, as well as nearby facet joint nociceptors. Abbreviations: PDN, periosteal dry needling; CAP, cervical articular pillar.

At the third visit, her resting pain intensity on the NPRS was 0 and cervical AROM was improved with pain only at end range movement (Table 3). No bruising was noted following the previous treatment. The cervical lateral glide test again reproduced pain on the right with radiation to the occiput. Palpation over the C3 articular pillar did reproduce the same pain. Treatment at session three consisted of PDN to the CAP at C2 and C3, followed by the manual therapy that was applied in the previous session. The patient was instructed on a home exercise program (HEP) directed at improving cervical AROM and strengthening of postural and deep neck flexor muscles. Additionally, she was educated on modified use (folding) of her current feather pillows to promote neutral cervical spine alignment in the side-lying position to reduce neck pain (Table 2). A recent systematic review reported that the effects of different pillow types on sleep quality is inconclusive, but maintaining neutral neck positions at rest with proper pillow use is beneficial [60]. During a follow-up visit one week later (visit 4), she was pain-free at rest and with movement; no further dry needling or manual treatment was given. Cervical AROM was greatly improved in all previously limited directions (Table 3).

Table 2. Treatment approach.

Visit	Interventions	Response
1	Initial evaluation – Pt education regarding objective findings, treatment interventions (including TrPDN), and plan of care	N/A
2	First treatment – TrPDN • Right sternocleidomastoid, upper trapezius, semispinalis capitis, splenius capitis • Four needles (0.25 mm diameter × 30 mm length) inserted and retained 5 min using light needle rotation – Manual therapy • STM and light cervical traction – PDN • Right C2 and C3 articular pillars • Two needles (0.25 mm diameter × 30 mm length) inserted 8–10 mm with 6 taps onto each bone over 3–4 mm area	Pain was reproduced with needling onto the right C2 and C3 articular pillars
3	Second treatment – PDN • Right C2 and C3 articular pillars • Two needles (0.25 mm diameter × 30 mm length) inserted 8–10 mm with 6 taps onto each bone over 3–4 mm area – Manual therapy • STM and light cervical traction – HEP instruction • Supine chin tuck—1 x daily—7 x weekly—1 sets —10 reps—5 s hold ■ Small towel roll placed behind the neck just below the occiput ■ Chin tuck movement performed gently and slowly as a head nodding action (as though nodding and saying "yes") ■ Light pressure to the towel roll is sustained for 5 s • Standing cervical retraction with side-bending—1 x daily—7 x weekly—1 sets—10 reps—5 s hold ■ Chin tuck movement performed gently and slowly as a head nodding action (as though nodding and saying "yes") ■ Side-bending performed within pain free AROM • Seated cervical retraction and rotation—1 x daily—7 x weekly—1 sets—10 reps—no hold ■ Chin tuck movement performed gently and slowly as a head nodding action (as though nodding and saying "yes") ■ Rotation performed with pain free AROM • Standing bilateral low shoulder row with Anchored resistance-1 x daily—7 x weekly—3 sets—10 reps ■ Emphasis on scapular retraction and depression to recruit periscapular muscles – Instruction on pillow use and neutral cervical spine posture in side-lying	Pain reproduced with needling onto the right C2 and C3 articular pillars
4	Discharge – Review of HEP – Review of posture and positions for sleep – Reassessment of objective measures and goals – Collection of final outcome measures	N/A

Abbreviations: TrPDN, trigger point dry needling; STM, soft tissue mobilization; PDN, periosteal dry needling; HEP, home exercise program; TrPs, trigger points; Pt, patient; AROM, active range of motion.

Table 3. Outcome measures from intake to discharge.

Measure	Intake	Discharge	One Month Post Discharge	
FOTO Neck FS	61	73	N/A	
Pain (NPRS) at rest	2/10	0/10	0/10	
Cervical AROM	Intake	Follow-Up (Visit 3)	Discharge	Pain (NPRS 0–10) I/F/D
Flexion	45 degrees	48 degrees	50 degrees	0/10, 0/10, 0/10
Extension	50 degrees	50 degrees	52 degrees	8/10, 2/10, 0/10
Right lateral flexion	25 degrees	28 degrees	30 degrees	8/10, 2/10, 0/10
Left lateral flexion	30 degrees	30 degrees	30 degrees	0/10, 0/10, 0/10
Right rotation	60 degrees	68 degrees	71 degrees	8/10, 2/10, 0/10
Left rotation	70 degrees	70 degrees	73 degrees	0/10, 0/10, 0/10

Abbreviations; AROM, active range of motion; I, intake; F, follow up (visit 3); D, discharge; NPRS, numeric pain rating scale; FOTO, Focus On Therapeutic Outcomes; FS, functional status.

3. Outcome and Follow-Up

By the fourth visit, the patient's goals were achieved. She was symptom-free and discharged (Table 3). She reported that her sleep was no longer limited due to pain, and she had been able to perform household activities, drive, and resume recreational tasks without symptoms. She reported it was the first time in over a year without neck pain and headache. At the time of discharge, the Neck FS score was 73 for a change score of +12 points, well exceeding the risk adjusted predicted four-point score improvement and the intake score quartile-specific MCII value of four points (Table 3). This outcome was achieved in five fewer visits over 12 fewer days than was suggested by the analytic prediction model (Figure 4). Her satisfaction score was 100%, exceeding the 97% average. The improvements in the patient's NPRS scores exceeded the minimal clinically important difference (MCID) for both neck pain and cervicogenic headache [30,31]. At one month post-discharge, she was contacted by phone and reported that she remained symptom-free with a NPRS of 0/10 (Table 3) and was compliant with the HEP.

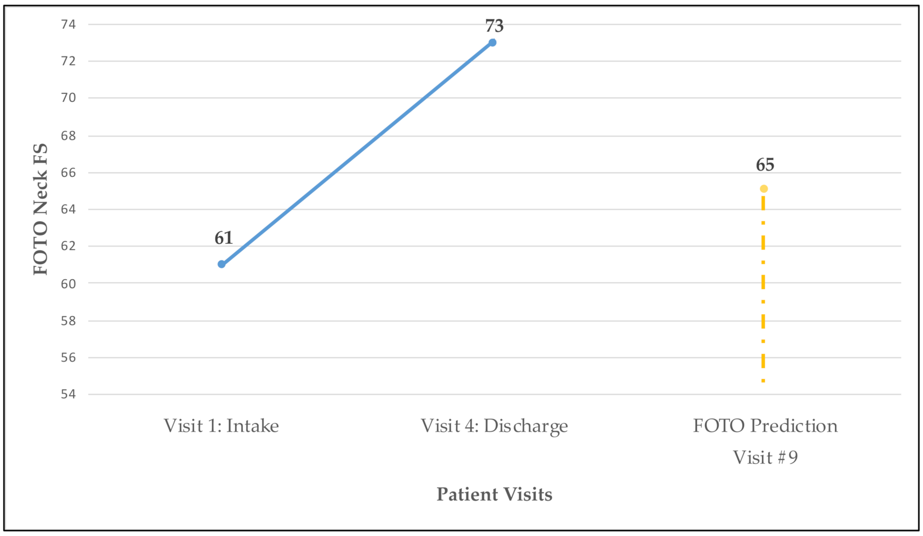

Figure 4. FOTO Neck FS outcomes from intake to discharge. Abbreviations: FOTO, Focus On Therapeutic Outcomes; FS, functional status.

4. Discussion

In the treatment of neck pain or headache, PDN is an unconventional modality in modern clinical practice [26,28]. Recommendations from current practice guidelines for neck pain [61] or neck pain with headache [53] do not include dry needling. Yet, TrPDN seems preferred by clinicians [62]. Validation studies of deep spinal muscle TrPDN advocate that the needle-tip contact the vertebral lamina as an indicator of safe placement [63–65]. For instance, needling active TrPs in the cervical multifidi involves the needle tip pricking the cervical lamina after the muscle is punctured to verify the target muscle was reached [64]. Aside from being an indicator of safety, clinicians should consider that needling to bone will engage mechanisms related to periosteal stimulation that may offer unique therapeutic benefits [1].

Periosteal needling may induce analgesia within a sclerotome via segmental mechanisms [66,67]; however, studies supporting the segmental arrangement of sclerotomes are lacking [68]. Spinal mechanisms mediating bone pain differ from muscle, skin, and other tissues [68,69]. While segmental mechanisms can be triggered by needling down to bone [70], they may be mediated by a spinal segment or segments different than the ones innervating the overlying myotomes and dermatomes stimulated along the needle pathway [71]. A limitation to this case study is the inability to distinguish between the therapeutic effects of PDN from those of needling the muscles and other tissues lying over the CAPs during the treatment. It is also likely that the adjunct interventions that were part of the treatment plan contributed to the positive outcomes. In addition, no imaging was available to confirm that the needle tip reached the periosteal region of the cervical articular pillars; this was only confirmed by needle palpation.

Periosteum is innervated by mechanosensitive, Aδ and C-fiber nerve endings that are encapsulated in the cambium layer [72–75]. In the upper cervical spine, medial branches from the dorsal rami wrap along the articular pillar before giving rise to articular branches that supply the zygapophyseal joints [76]. Afferent nerves in the periosteum project to lamina 1 in the dorsal horn and transmit impulses along the spinoparabrachial pathway [75]. It is conceivable that PDN to the articular pillar, using multiple taps within a small area (Figure 3), induces distortion of the bone surface, selectively activating mechanosensitive afferents that send impulses to projection neurons in the parabrachial complex. The noxious input from PDN is then transmitted to the periaqueductal gray and rostral ventromedial medulla to trigger descending pain inhibition [77–79]. Additionally, the medial branches of the cervical dorsal rami are easily targeted by needle pressure where they are held down by deep fascia along the dorsolateral articular pillar [76]. High-pressure needle stimuli to the medial branches and nearby facet joint capsules could activate descending pain inhibitory systems that explain the effects of PDN in this region [59,80,81]. Recent studies suggest that periosteal needling may attenuate local inflammation and reduce pain in patients with intertrochanteric fracture and knee osteoarthritis [82,83]. Further studies are needed to confirm these potentially beneficial effects.

5. Conclusions

In this case report, we illustrated the use of PDN in the context of an evidence-informed approach for neck pain and headache. The patient experienced marked improvements in pain and function and was completely satisfied with her care. Her outcomes exceeded predictive analytic expectations for functional gains and efficient utilization of visits and time in days. Aside from being an indicator of safety with needling to the deep muscles of the cervical spine, clinicians should consider that needling to bone will engage mechanisms related to periosteal stimulation that may offer unique therapeutic benefits, except in conditions of cervical myelopathy, cervical ligamentous instability, or vascular insufficiency. Future research is needed to confirm the benefits of PDN to the CAPs for patients with neck pain and headache, as well as to investigate its use in other related conditions.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/app12063122/s1, CARE checklist.

Author Contributions: Conceptualization, T.P. and M.C.; methodology, T.P., M.C. and J.D.; software, T.P. and D.H.; validation, T.P., M.C. and J.D.; formal analysis, T.P., M.C. and J.D.; investigation, T.P. and

M.C.; resources, T.P. and M.C.; data curation, T.P. and D.H.; writing—original draft preparation, T.P.; writing—review and editing, T.P., M.C., J.D., D.H. and J.H.; visualization, T.P. and M.C.; supervision, M.C., J.D. and J.H.; project administration, T.P. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

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