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Review Article

Radiofrequency Ablation in Coccydynia: A Case Series and Comprehensive, Evidence-Based Review

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Abstract

Objectives. Coccydynia is a condition with a multitude of different causes, characterized by ill-defined management. There are multiple prospective studies, including several controlled trials, that have evaluated conservative therapies. Additionally, a plethora of observational studies have assessed coccygectomy, but few studies have reported results for nonsurgical interventional procedures. In this report, we describe the treatment results of 12 patients who received conventional or pulsed radiofrequency for coccydynia and systematically review the literature on management.

Methods. We performed a retrospective data analysis evaluating patients who underwent pulsed or conventional radiofrequency treatment at Johns Hopkins Hospital and Walter Reed National Military Medical Center. A comprehensive literature review was also performed to contextualize these results.

Results. The mean age of patients treated was 50.25 years (SD = 11.20 years, range = 32–72 years), with the mean duration of symptoms being 3.6 years (SD = 3.36 years, range 1–10 years). There were 10 males and two females in this cohort. Among patients who received radiofrequency treatment, the average benefit was 55.5% pain relief (SD = 30.33%, range = 0–100%). Those who underwent conventional (vs pulsed radiofrequency) and who received prognostic blocks were more likely to experience a positive outcome. There were two cases of neuritis, which resolved spontaneously after several weeks.

Conclusions. Radiofrequency ablation of the sacrococcygeal nerves may serve as a useful treatment option for patients with coccydynia who have failed more conservative measures. Further research into this therapeutic approach and its benefit for coccydynia should incorporate a control group for comparison.

Introduction

Coccydynia as a nosological entity was first reported in 1859 by Sir James Simpson [1]. Coccydynia afflicts the coccyx, the vestigial end of the vertebral column whose name derives from the Greek word for "cuckoo bird"

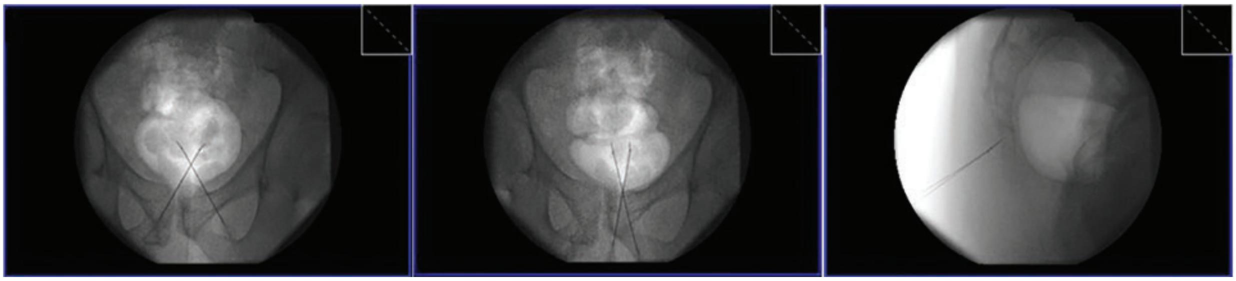

Figure 1 Anteroposterior (2 figures on left) and lateral (figure on right) fluoroscopic images demonstrating radiofrequency electrode placement at the sacrococcygeal junction (left-most figure) and mid-coccyx (middle image).

[2]. The prevalence rate of coccydynia has not been well studied but is generally acknowledged to be low; in one study from the 1950s, Ghormley found that 2.7% of patients admitted to the hospital with chronic low back pain had coccydynia [3]. The epidemiology of this enigmatic condition has not been well documented, although women are more commonly affected than men and the prevalence appears to be highest in middle age [4]. Coccydynia has numerous causes and contributing factors, ranging from obesity to childbirth to trauma [5–7], and may arise as a consequence to soft tissue, bony, or even visceral (i.e., rectal) pathology [8,9] (e.g., spinal cord convergence, pressure on the coccyx, or an atypical pain referral pattern. Perhaps because the etiology has not been well elucidated and the prevalence rate is low, the treatment of coccydynia or pain around the coccyx is ill-defined. Conservative management has typically involved anti-inflammatory drugs, warm water baths, and sitting aids [10,11], although physiotherapy and even intrarectal massage are increasingly utilized [12,13]. The surgical literature has focused upon coccygectomy as an intervention for refractory coccygeal pain; however, nonsurgical interventional approaches to coccydynia have not been catalogued in detail.

In this manuscript, we provide a review on the epidemiology, anatomy, and treatment of coccydynia and report a series of 12 patients who underwent radiofrequency (RF) ablation, 10 of whom reported substantial and durable reduction in symptoms. Ten patients underwent conventional RFA while two underwent pulsed RF. These cases suggest that this low-risk therapy can provide lasting relief in some patients with posterior coccygeal pathology who are refractory to more conservative treatment and represents a possible bridge to, or a less-invasive alternative to, surgery.

Treatment Methods and Inclusion Criteria

This was a retrospective investigation of 12 cases at two distinct pain treatment centers: the Blaustein Pain Treatment Center at Johns Hopkins Hospital and the Pain Treatment Clinic at Walter Reed National Military Medical Center. Patients included in this series received either conventional radiofrequency ablation or pulsed radiofrequency for coccydynia. All patients had tried and failed conventional management, with eight benefiting from preprocedure prognostic nerve blocks. Figure 1 shows radiographic images demonstrating electrode placement for this procedure. The number of lesions created ranged from two to nine, starting from the sacrococcygeal junction and sometimes extending down through the lower third of the coccyx. For conventional RF lesions, 20-gauge electrodes with 5 or 10 mm active tips were inserted at the respective target points using antero-posterior and lateral fluoroscopic views to guide placement. After sensory stimulation was performed at 50 Hz, 0.5–1 mL of 2% lidocaine, usually at each row of treatments (for example, two to three horizontally situated lesions due to the anticipated spread of the injectate [14]) rather than at each ablation site when multiple locations were treated, was administered to prevent procedure-related pain and enhance lesion size [15]. The electrodes were then inserted and 135 second lesions were created at 80°–90°C. For cooled radiofrequency, 150 second lesions were created at 60°C using 17-gauge electrodes, with 2% lidocaine also given before commencement of lesioning. After thermal lesions, 0.5–1 mL of 5 mg depomethylprednisolone mixed with normal saline was given in all cases except two to prevent neuritis [16,17]. For pulsed radiofrequency, treatment was initiated using the following parameters: voltage output 40–60 V; 2 Hz frequency; 20 ms pulses in a one-second cycle, 120 second duration per cycle; impedance range between 150 and 500 Ohms; and a 42°C plateau temperature. Two or three cycles were performed, with slight adjustments of the electrodes (i.e., 45° clockwise, then 45° counter-clockwise) made between cycles, as preclinical and clinical studies have demonstrated that multiple cycles may increase effectiveness [18,19]. A schematic representation of the sacrococcygeal nerve supply and location of the radiofrequency electrodes is depicted in Figure 2. Preoperative and postoperative pain scores are described in terms of percentage relief, which was garnered from either pre- and postprocedure 0–10 numerical pain scale scores or direct patient report.

Search Methods

The evidence-based narrative review was performed based upon a literature search performed on the NCBI Pubmed and EMBASE databases for articles written between 1990 through 2015. Key words used during the search strategy included “coccydynia,” “coccygodynia,” “coccygectomy,”

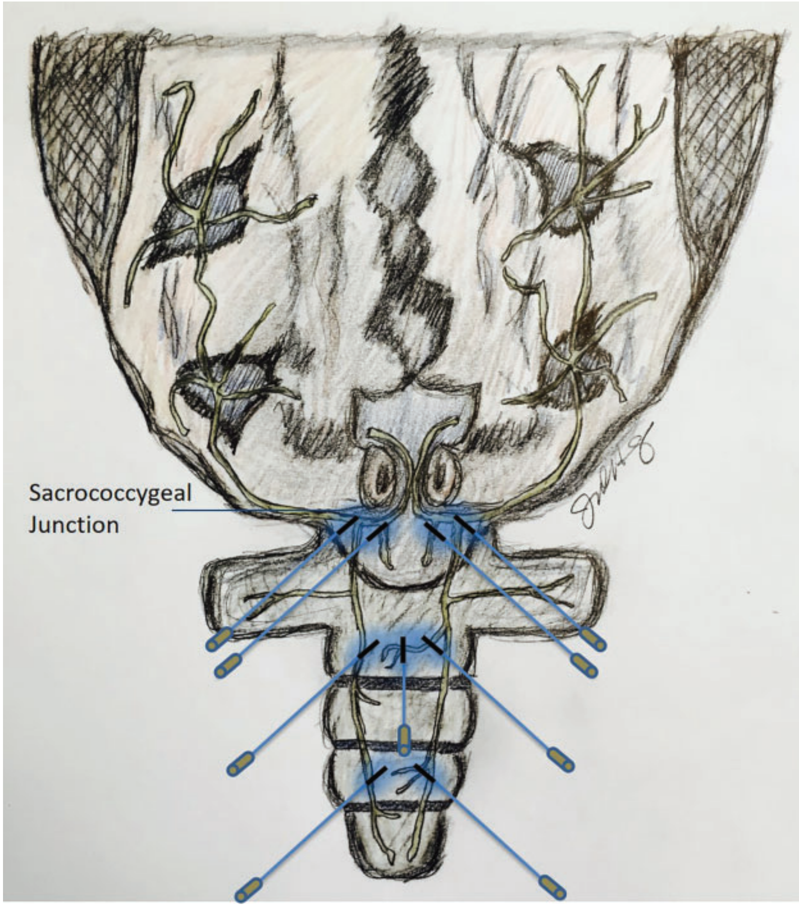

Figure 2 Schematic drawing demonstrating the coccygeal nerves arising from the dorsal rami innervating the posterior coccyx. The electrodes illustrate cannula position for radiofrequency ablation. The nerves pictured are representative and may vary in location and number from person to person.

"radiofrequency ablation," "interventional," "physical therapy," and "pharmacological," in various combinations. Nonindexed articles were also found by searching through the Google Scholar database as well as reference lists of retrieved and past review articles.

Anatomy of the Coccyx

The coccyx is a complex structure, consisting of interconnected joints, ligaments, nerves, vasculature and muscles. The coccyx consists of three to five bony segments, each with pedicles, lamina, and spinous processes, fused together in a triangular formation with articulation to the lower sacrum at the coccygeal cornua of the coccygeus [13]. The anterior surface of the coccyx has three transverse grooves representing areas of fusion, which provide attachments to sacroccygeal ligaments and levator ani muscle fibers [20]. The posterior surface is convex with transverse grooves; linear rows of tubercles line this surface, converging into the most superior coccygeal cornua, which articulate with the sacrum [21]. There is substantial variability in terms of the dimensions and angulation of the coccyx between different individuals [22,23]. Investigators have also reported heterogeneity in both joint mobility [24] and structure [25] in the sacroccoccygeal and intercoccygeal joints across the population. The innervation of the coccyx warrants discussion. It is composed mainly from the lower sacral spinal nerves and the coccygeal nerves, which derive from the lower sacral nerve roots. Anteriorly, the innervation is comprised predominantly from the sacrococcygeal plexus, which in turn arises from the ventral rami of the S4 and S5 sacral nerves and the coccygeal nerves, the termination of which results in the anococcygeal nerves [26]. In a recent cadaveric anatomic study, Woon and Stringer (2014) confirmed this pattern of innervation, finding that efferent fibers from this plexus pass through the ischiococcygeus muscle and sacrospinous ligaments, eventuating in the postanal subcutaneous fat [27]. There is considerable variation in the course of the nerves and innervation pattern of the sacrococcygeal plexus, but various anatomical studies have found that it supplies the sacrospinous and coccygeal ligaments, skin and soft tissue overlying the ventral coccyx, external anal sphincter, sacrococcygeal joint, coccygeal periosteum, and anterior musculature including the pubococcygeus, ischiococcygeus, coccygeus, and part of the levator ani [26–30]. Posteriorly, the paired coccygeal nerves join with the primary posterior rami of the fourth and fifth sacral segments to innervate the skin and soft tissue of the dorsal coccyx [9]. Pain originating from the posterior coccyx, which may occur following falls and other forms of trauma, may be associated with exquisite tenderness and difficulty sitting for prolonged periods of time. Whereas this may represent a smaller portion of coccydynia than pain emanating from structures situated anteriorly, it is particularly relevant for the pain practitioner as the posterior innervation is more amenable to interventional treatment.

Autonomic innervation from the sympathetic nervous system derives from the paravertebral sympathetic trunk, which terminates in the ganglion impar at the anterior surface of the coccyx [31]. Visceral afferent fibers from the rectum travel with sympathetic fibers, and visceral pain from this region is typically poorly localized and may be referred to the coccygeal region. Hence, the ganglion impar is also a therapeutic target for chronic coccydynia. Occasionally, pain in the coccygeal region can be referred from pelvic viscera, from which nociceptive stimuli are transmitted through the superior hypogastric plexus containing sympathetic fibers, and to a lesser degree via pelvic splanchnic nerves carrying parasympathetic fibers from the second, third, and sometimes fourth sacral segments [26].

Risk Factors, Pathophysiology of Disease, and Taxonomy

Coccydynia is associated with a number of factors and comorbidities, including excessive weight and female gender [5,13]. External trauma from falls or accidents constitutes a significant risk for tailbone pain [5,32]; similarly, internal trauma from difficult childbirth necessitating instrumentation has been associated with coccydynia [6,33]. Although it is most commonly idiopathic or traumatic in nature, coccydynia has also been reported as a symptom of conditions such as ankylosing spondylitis [34] or tumors of the pelvis and bone [35,36].

Pathophysiologically, coccydynia has been linked to a number of specific anatomical lesions. Maigne and colleagues described a large series of 208 patients with chronic coccydynia, 69% of whom reported a history of trauma [5]. The authors specifically identified several pathological states including posterior luxation, hypermobility (coccygeal flexion $> 25^{\circ}$), anterior luxation, and spicules (described as a small bony outgrowth on the dorsal aspect of the tip of the coccyx) as predisposing factors. Other investigators have found evidence of disc degeneration of the sacrococcygeal or intercoccygeal joints in patients with this syndrome [37,38]. Coccydynia can also be a manifestation of referred pain from nerves (radicular pain) or spinal structures, in which case coccygeal tenderness is generally absent on physical examination.

Review of Current Therapies

Conservative Management—Pharmacotherapy and Physical Therapy

Conservative management for coccydynia consists of measures ranging from correct positioning with aids to relieve pressure (such as cushions), mobilization, hot baths, and pharmacotherapy. Maigne et al. reported on a cohort of 53 adolescents with coccydynia who were treated with nonsteroidal anti-inflammatory drugs (NSAIDs) or steroid injection as first-line treatments and amitriptyline or coccygectomy as second-line treatments [39]. Patients were evaluated one to two months after their initial treatment and one to four years after their initial visit. The authors found that among 12 of 53 patients who initially received an anti-inflammatory medication, six patients reported "adequate pain relief," although no raw pain scores were described in the report; the remaining six patients who failed medication were then given steroid injections to either the sacrococcygeal disc, intercoccygeal disc, or along the inferior aspect of the coccyx, based upon the location of pain. The remaining 41 patients did not receive medication but were assigned to receive initial injections of prednisolone acetate (in the same locations as previously described). Overall, 10 patients whose initial treatment was inadequate received amitryptline, leading to three "good" results and seven treatment failures. The study's limitations include the lack of pretreatment pain scores, which prevented pre- and post-treatment comparison. Hodges et al. described a group of 32 patients who received escalating interventions, ranging from NSAIDS to local injections to coccygectomy [40]. In only four (13%) were NSAIDS sufficient by themselves (80–100% symptom improvement), while all others required further interventions.

Physiotherapy techniques have been used to variable effect. In an early study, Wray et al. performed ultrasound and short-wave diathermy in 50 patients, offering methylprednisolone/bupivacaine injections and then coccygeal manipulation to nonresponders [41]. At an average two-year, nine-month follow-up, they reported that only 16% of patients were cured by physiotherapy. As summarized in Table 1 [12,41–44], manual therapies in the form of intrarectal manipulation or massage treatments have been found to be only modestly beneficial. Maigne et al. compared two groups of 50 patients, assigning one group to intrarectal manipulation and the other to shortwave physiotherapy as placebo [12]. At one-month follow-up, patients who received intrarectal manipulation endorsed a 34.7% decrease in pain scores, which favorably compared with the 19.1% decrease reported in those who received physiotherapy. At six-month follow-up, 34 and 24 patients in the manipulation and control groups, respectively, who had

Table 1 Studies evaluating conservative and interventional therapies for coccydynia

Study (year)	No. of patients	Study design	Prognostic block	Follow-up period	Intervention	Outcome	Complications	Comments
Wray et al. (1991) [41]	50	Prospective, observational	Some	Average = 2.75 y	Ultrasound, diathermy, steroid injection	Pilot study: 38% relief with injections vs 71% relief with manipulation	Not described	Pilot study: 50 patients receiving physiotherapy, followed by steroid inection; low response to physiotherapy with improved response to manipulation and injection; in full randomized trial, 60% and 85% success with injection and manipulation, respectively
	120	Prospective, randomized, controlled	Some	Unclear	Ultrasound, steroid injection	Randomized trial: 60% relief with injections, 85% relief with manipulation	Not described	In full randomized trial, 60% and 85% success with injection and manipulation, respectively
Maigne and Chatellier (2001) [42]	74	Prospective, observational, randomized	No	7 d–2 y	Manual manipulation	Good outcome defined as > 60% relief, failure as < 60% or recurrence; 29.2%, 16%, and 32% reported satisfactory outcome in massage, mobilization, and stretching groups, respectively, at 6 mo	None	Three different types of manipulation studied, stretching most effective
Hodges et al. (2004) [40]	32	Retrospective, observational	Some	6 wk (for NSAIDS), 9 mo	NSAIDS, steroid injections, coccygectomy	Low benefit (13%) with NSAIDS only;	None	High surgical complication rate (27%)

(continued)

Table 1 Continued

Study (year)	No. of patients	Study design	Prognostic block	Follow-up period	Intervention	Outcome	Complications	Comments
				(for coccygectomy)		improvement in 9 of 11 surgical patients		
Maigne et al. (2006) [12]	102	Prospective, randomized, open-label	No	1 mo and 6 mo	Coccygeal manipulation vs physiotherapy	At 1 mo, 34.7% and 19.1% reductions in pain scores in manipulation and control groups, respectively; at 6 mo, 22% patients with ≥50% improvement in massage group, 12% of patients with ≥50% benefit in control		Study not controlled
Mitra et al. (2007) [43]	14	Prospective, observational	Yes	3 wk	Coccygeal steroid injection	Success defined as ≥50% pain relief at follow-up; 7/14 patients reported improvement overall; of patients with >6 mo symptoms, 4/11 improved		Study not controlled, raw pain scores not reported
Khan et al. (2008) [48]	37	Prospective, observational	Yes	15 d (after 1st injection), 4 wk (after 2nd injection), unclear for 3rd injection	Dextrose prolotherapy	Mean preprocedural pain score 8.5; after first injection, pain score 3.4; after 2nd injection, pain score 2.5; 7 patients reported minimal or no improvement		Study not controlled, unclear follow-up period for third injection
Wu et al. (2009) [57]	53	Prospective, observational	No	12 wk	Digital massage and diathermy	Mean pain score decreased from 6.15 to 2.7; coccygeal surface temperature decreased from 30.16° to 28.7°C	None	Study not controlled, high predominance of female subjects

(continued)

Table 1 Continued

Study (year)	No. of patients	Study design	Prognostic block	Follow-up period	Intervention	Outcome	Complications	Comments
Datir et al. (2010) [44]	8	Prospective, observational	Yes	2 wk–6 mo	CT-guided ganglion impar injection	At 6 mo, 3/8 patients reported pain score of 0; 3/8 patients reported 2–5/10; 2/8 patients 8–9/10	None described	Small N, study not controlled, no reported complications; bony pathology not excluded in this study, cost-effectiveness questionable
Demircay et al. (2010) [45]	10	Retrospective, observational	Yes	9.1 ± 1.2 mo	Radiofrequency thermocoagulation of ganglion impar	Mean improvement 66% in pain score and 50% in function at 6 mo	None described	Small N, study not controlled, no reported complications; bony pathology not excluded in this study, thus problematic in terms of etiology
Atim et al. (2011) [55]	21	Retrospective, observational	Yes	3 wk–6 mo	Pulsed RF	75% decreased in pain scores at 6-mo follow-up	None described	Study not controlled
Khatri et al. (2011) [56]	36	Prospective, randomized, controlled	No	10 d	Manual manipulation vs phonophoresis/TENS	Higher pain score reduction in manipulation group (5.3 vs 1.4/10); longer pain-free sitting time	None	Study not indexed, short follow-up time, pretreatment pain scores not reported
Maigne et al. (2011) [39]	53	Retrospective, observational	Some	1–4 y	Nonsteroidal anti-inflammatories or steroid injection	NSAIDS effective for 50% of 12 patients, amitryptiline effective for 30% of patients who failed steroid injection		No pretreatment pain scores recorded; post-treatment scores not reported
Chen et al. (2013) [47]	3	Retrospective, observational	No	6–12 wk	Dextrose prolotherapy	66–100% relief	None described	Small N, study not controlled
Gunduz et al. (2015) [46]	22	Prospective, observational	Yes	Mean = 17 mo (range = 7–21)	Ganglion impar block	18/19 patients had ≥50% relief after		Small N, technical failure in 3 patients

(continued)

Table 1 Continued

Study (year)	No. of patients	Study design	Prognostic block	Follow-up period	Intervention	Outcome	Complications	Comments
						first injection; all patients who received repeat injection had ≥50% relief		who received first round of injections; median duration of benefit 17 months
Lin et al. (2015) [49]	42	Prospective, randomized, controlled	No	5 wk–8 wk	Extracorporeal shock wave therapy vs physiatry	Mean 66% improvement in pain score in ESWT group vs 35% in control group; mean improvement of 60% in function in ESWT vs 50% in control group	None	1 patient excluded due to incomplete questionnaire; control group reported substantially worse functionality prior to intervention

ESWT = extracorporeal shock wave therapy; NSAIDS = nonsteroidal anti-inflammatory drugs; RF = radiofrequency; TENS = transcutaneous electrical nerve stimulation.

previously derived 50% or greater pain relief at one month were re-examined; 11 of 34 manipulation group patients and six of 24 control group patients reported 50% or greater pain relief. Maigne and Chatellier prospectively followed 74 patients divided into three groups that received different manual manipulation techniques: massage, mobilization, or stretching [42]. Overall, they found comparably low rates of satisfaction (defined as better than 60% pain relief) at six-month follow-up; massage, mobilization, and stretching yielded 29.2%, 16%, and 32% satisfaction rates, respectively.

Interventions

Coccydynia has been treated with numerous different procedural interventions, though methodologically sound clinical trials are lacking and there is no consensus regarding optimal management. Perhaps the mainstay of therapy has been local anesthetic and steroid injections. Wray et al. performed a pilot study comparing physical therapy, injection of local anesthetic and steroid around the coccyx, and coccygeal manipulation under general anesthesia combined with injection in 50 patients [41]. The authors reported success rates of 16%, 38%, and 71%, respectively, at one-year minimum follow-up (mean two years nine months). They proceeded to perform a subsequent randomized trial in 120 patients comparing injections as a stand-alone treatment to manipulation and injections and reported success rates of 60% and 85%, respectively. Among the 23 treatment failures who underwent coccygectomy, 21 obtained excellent outcomes. More recently, Mitra and colleagues (2007) reported that seven of 14 patients experienced 50% or greater pain relief (at three-week follow-up using fluoroscopically guided injections in patients with acute (less than six months) coccydynia [45]. Patients received steroid and local anesthetic, with half of the injectate (80 mg triamcinolone and 2 mL 1% lidocaine) administered at the sacrococcygeal junction and half over the posterior coccygeal segments.

The ganglion impar, traditionally a target for visceral pain secondary to conditions such as pelvic malignancy, has also been targeted by several investigators to treat coccygodynia [46–48]. The ganglion impar is the midline caudal termination of the paired, paravertebral sympathetic chain, located anterior to the coccyx. It is important to note that the ganglion impar has been reported to exhibit significant anatomic variability [31] and does not typically innervate the bony structures of the sacrum and coccyx. Instead, it contains postganglionic fibers from the sympathetic chain, along with visceral afferents that innervate the distal rectum, distal urethra, anus, and the distal third of the vagina, vulva, and penis. Datir et al. (2010) described eight patients who received CT-guided ganglion impar injections; at six months, 75% of these patients experienced a substantial (50–100%) reduction in pain score [46]. In a small (N = 10) retrospective chart review evaluating radiofrequency neurotomy of the ganglion impar for coccydynia in individuals who had obtained at least 80% pain relief from a prognostic block, Demircay et al. (2010) reported that 90% experienced a successful outcome lasting at least six months (mean preprocedure pain score decreased from 8.7 to 2.9 at six months) [47]. Bony pathology was not excluded from either of these studies, which suggests that not all of these patients had referred pain from pelvic or perineal viscera.

An assortment of other therapies including prolotherapy [49,50] and extracorporeal shockwave therapy [51] have been used to treat patients with coccydynia. Although these studies are almost universally small and do not have available comparisons in the literature, they provide intriguing avenues for further investigation. Whereas conventional radiofrequency ablation has become a standard treatment for joint pain [52–54], its reported use in the literature for coccygeal pain has been infrequent. Scemama et al. reported on a 44-year-old patient with posttraumatic coccydynia of one-year duration presenting after a fall who received radiofrequency ablation of the first intercoccygeal disk [55]. The authors reported that the patient endorsed an approximately 66% decrease in her pain score after the procedure, which lasted for six months. Radiofrequency ablation targeting intervertebral discs has not been shown in systematic reviews to provide significant benefit compared with placebo treatment [56]. As an isolated case with a questionable mechanism of action, this report does not provide generalizability for a heterogenous disorder.

Recently, Atim and colleagues described a group of 21 patients who received caudal epidural pulsed RF; five of these patients had failed coccygectomy for coccydynia [57]. At six months, the median pain score decreased from nine of 10 to four of 10 in the postsurgical subgroup, and from eight of 10 to 1.5 of 10 in the patients without a prior surgical history. Although intriguing, no control group was included in this study, and it is unclear what mechanism is responsible for this benefit. Pulsed radiofrequency is generally reserved for neuropathic pain conditions, and comparative-effectiveness studies performed for facetogenic pain have shown it to be inferior to conventional radiofrequency [58,59].

For interventional therapies in general, there is significant variation in the techniques and outcomes described. Whereas ganglion impar studies have demonstrated some benefit in a majority of patients, they tend to be small and have not included a control comparison. As previously discussed, these studies have also not excluded patients with bony pathology, which raises questions regarding generalizability. Thus, it is unclear what injection target is optimal for injection therapy.

Surgical Therapy

Surgical intervention remains the final treatment option for refractory cases of coccydynia that fail to respond to conservative measures. As summarized in Table 2 [5,40,41,60–80], many investigators have reported very high success rates with coccygectomy, with over 50% of patients in every reported investigation deriving benefit. However, there are many caveats to these studies. First, the majority of studies are observational, retrospective, and not controlled, thus limiting the conclusions that can be drawn. Interventional treatments are difficult to mask in double-blind studies and tend to be associated with significantly higher placebo response rates than medications or more conservative measures [81]. Additionally, in a number of these studies, baseline and postprocedure pain and function scores were not clearly reported, which prevents precise determination of how much benefit patients received. For example, while a number of these investigators reported specific changes in pain scores, others reported results as “good” or “excellent,” which does not reveal the magnitude of benefit.

Whereas most surgical studies report outcomes without comparison to other interventions, several have examined differences between an operative and nonoperative group. Wood and Mehbod (2004) retrospectively examined 51 patients with coccydynia who were seen in clinic; after losing six patients to follow-up, they compared 25 patients treated with bupivacaine/depomedrol injections to 20 patients who underwent coccygectomy [65]. At an average follow up of 23 months, only 20% of patients undergoing injections reported partial or complete improvement in pain, while at an average follow-up of 30 months 90% of operative patients reported partial or complete improvement. As previously described, Hodges et al. (2004) reported on a group of 32 patients who underwent conservative management, injections, and/or surgery [40]. The 17 patients who received local steroid injections obtained between 60% and 100% relief, with one patient who failed to derive benefit refusing surgery. Eleven patients who did not respond with long-term relief to more conservative measures underwent coccygectomy. At nine-month follow-up, they experienced between 30% and 90% relief, with only one patient failing to achieve any benefit.

With regard to postsurgical complications, most studies have reported a low incidence of postoperative infection. Wood and Mehbod (2004) reported the highest rate of infections—six out of 20 patients who received operations [65]. Half of these patients were treated with antibiotics while the other half received bed rest and dressing changes; none of their patients with site infections required surgical exploration. A recent systematic review of coccygectomy studies published in 2011 found an overall adverse event rate of 10.9%, with wound infection representing the most common postsurgical complication [11].

Results of Radiofrequency Neurotomy

This was deemed to be a quality assurance project at Walter Reed National Military Medical Center and was approved by the Johns Hopkins Internal Review Board as an exempt protocol. Databases were searched at

Table 2 Studies evaluating coccygectomy for coccydynia

Study (year)	No. of patients	Study design	Prognostic block	Follow-up period	Intervention	Outcome	Complications	Comments
Hellberg et al. (1990) [60]	65	Retrospective, observational	No	Mean = 15 y (range = 2–26 y)	Coccygectomy in patients who failed conservative mgmt	46/55 patients with satisfactory results, of which 32 had complete relief	4 patients with superficial postop infection	Retrospective analysis with loss of follow-up in a number of patients (N = 10) who were eventually excluded from study
Wray et al. (1991) [41]	23	Prospective, observational	Yes	Not noted	Coccygectomy in subgroup of patients who failed multiple therapies	21/23 patients reported "excellent" results	None	Consisted of a subset of patients who failed multiple therapies from randomized trial; single surgeon; no parameters for outcome described; follow-up period not noted
Grosso et al. (1995) [61]	9	Retrospective, observational	No	Mean = 56 mo (range = 26–92 mo)	Coccygectomy	3/9 patients reported "complete" relief, 5/9 "markedly improved," 1/9 "slightly improved"	Not described	Small number of subjects; study not controlled; all patients had undergone multiple therapies; single surgeon; parameters for outcome not described
Zayer et al. (1996) [62]	10	Retrospective, observational	Unclear	Mean = 5.1 y	Coccygectomy	9 of 10 patients described being "very satisfied" and did not return for examination; 1 patient died, but had no relief	Not described	Small number of subjects; no return examination; no pre- or post-procedural pain scores

(continued)

Table 2 Continued

Study (year)	No. of patients	Study design	Prognostic block	Follow-up period	Intervention	Outcome	Complications	Comments
Maigne et al. (2000) [5]	37	Prospective, observational	Unclear	27 patients at 24–30 mo, 10 patients > 30 mo	Coccygectomy	62% of patients with excellent results, 50% with good results, 8% with poor results at 2 y	3 patients with postop infection	Study not controlled; no parameters for outcome described; single surgeon
Perkins et al. (2003) [63]	15	Retrospective, observational	Yes	Mean = 43 mo (range = 19–74 mo)	Coccygectomy	Mean improvement 3.7/10 in pain score and 19/100 points in function	1 patient with postop infection and 1 patient with wound dehiscence	Small N, study not controlled, retrospective analysis, 2 reported complications
Karalezli et al. (2004) [64]	14	Retrospective, observational	No	Mean = 30 mo (range = 4–48 mo)	Coccygectomy	5 patients with complete relief and 7 with occasional discomfort, 2 with no relief	2 patients with superficial infection	Small N, study not controlled
Wood and Mehbod, (2004) [65]	20	Retrospective, observational	No	Mean = 30 mo (range = 14–59 mo)	Coccygectomy	18 patients “somewhat improved” or “much improved”; 2 patients reported no change	High percentage (6/20) of patients had wound infections; 3 treated with antibiotics, 3 with dressing change/reduced activity	High complication rate
Feldbrin et al. (2005) [66]	8	Retrospective, observational	Some	Not noted	Coccygectomy	5/8 patients with no pain, 1/8 with 66% decrease, 2/8 without benefit	None	Small number of patients; study not controlled
Pennekamp et al. (2005) [7]	16	Retrospective, observational	Some (local infiltration)	Mean = 7.3 y (range = 2–16 y)	Coccygectomy	7/8 patients with trauma-induced pain had good or excellent results (based upon pain score), 1/8 not improved; 3/8 idiopathic patients had good or	3 cases of postop infection	Small number of patients; criteria for success not reported; study not controlled

(continued)

Table 2 Continued

Study (year)	No. of patients	Study design	Prognostic block	Follow-up period	Intervention	Outcome	Complications	Comments
						excellent results: 3/8 fair, 2/8 poor		
Balain et al. (2006) [67]	38	Retrospective, observational	Yes	Mean = 6.75 y (range = 2–16 y)	Coccygectomy	22/31 patients benefited	1 case superficial infection	No pre- or postop success criteria; study not controlled; 7 patients lost to follow-up
Mouhsine et al. (2006) [68]	15	Retrospective, observational	Yes	Mean = 2.8 y (range = 14 mo–6 y)	Coccygectomy	11/15 reported excellent (81–100/100 points), 3/15 reported good (61–80), 1/15 reported fair (41–60) results	None	Study not controlled; success criteria not noted; 3 different surgeons
Capar et al. (2007) [69]	24	Retrospective, observational	Some	Mean = 28 mo (range = 12–70 mo)	Coccygectomy	54.2% of patients with >75% relief, 29.2% with 50–75% relief; remaining patients had <50% relief	2 cases of postoperative infection	Small number of patients; study not controlled
Cebesoy et al. (2007) [70]	21	Retrospective, observational	Some	Mean = 26 mo (range = 24–32 mo)	Coccygectomy	Mean decrease in pain score from 51.89 to 2.76 after 24 mo	Not described	Small number of patients; study not controlled
Sehirlioglu et al. (2007) [71]	74	Retrospective, observational	No	Mean = 4.1 y (range = 2–8 y)	Coccygectomy	71/74 patients reported complete or > 50% pain relief	4 superficial, 1 deep wound infection	Study not controlled
Traub et al. (2009) [72]	10	Retrospective, observational	No	Mean = 21.7 mo	Coccygectomy	Postoperative pain score 3.4/10; function score 25.75/100% (with 100% representing highest dysfunction)	4 patients with wound dehiscence	Small N, study not controlled, 2 patients lost to follow-up, no preoperative pain or dysfunction assessment for comparison

(continued)

Table 2 Continued

Study (year)	No. of patients	Study design	Prognostic block	Follow-up period	Intervention	Outcome	Complications	Comments
Bilgic et al. (2010) [73]	25	Retrospective, observational	Yes	Mean = 10 mo (range = 8–13 mo)	Coccygectomy with or without periosteal resection	Pain score while sitting decreased by 4.7 and 6.2 in patients receiving total and periosteal-sparing resection, respectively; pain score while standing decreased by 3.9 and 5.1, respectively	4 patients with postop infection	Two different operations: a total coccygeal resection and periosteum-sparking operation
Trollegaard et al. (2010) [74]	41	Retrospective, observational	Yes	Mean = 82.8 mo (range = 5–187 mo)	Coccygectomy	61% of patients with excellent (pain score ≤2), 20% with good (pain score 3–4), 12% with moderate (pain score >4), and 7% with poor (marginal benefit) results	5 patients with postop infection	Medium-size study with well-defined success criteria; study not controlled; single surgeon
Cheng et al. (2011) [75]	31	Retrospective, observational	No	Mean = 3.3 y (range = 1–6 y)	Coccygectomy	87.1% of patients reported “good” or “excellent” results at mean follow-up of 3.3 y	2 patients with postop infection	Study not controlled; no parameters for outcome described
Kerr et al. (2011) [76]	26	Retrospective, observational	No	Mean = 37 mo (range = 2–133 mo)	Coccygectomy	84.6% of patients reported a ≥ 3-point decrease in pain score; 4 patients reported no change	3 patients with postop infection	Large number of nonresponders in this study; thus, possible nonresponse bias
Ramieri et al. (2013) [77]	31	Retrospective, observational	No	Mean = 33 mo (range = 24–70 mo)	Total or partial coccygectomy	Mean pain score decreased from 6.7 to 1.8/10 in	None	Study not controlled, 3 patients

(continued)

Table 2 Continued

Study (year)	No. of patients	Study design	Prognostic block	Follow-up period	Intervention	Outcome	Complications	Comments
						21 patients who received total coccygectomy (2 patients lost to follow-up) and from 6.3 to 4.6/10 in 7 who received partial coccygectomy (1 lost)		lost to follow-up and not reported
Antoniadis et al. (2014) [78]	10	Retrospective, observational	Unclear	1 y	Coccygectomy	3/10 patients reported postoperative pain score of 1/10, 5/10 patients reported postop pain of 2/10, 2/10 patients reported postop pain of 3/10	1 patient with postop hematoma	All patients reported preoperative pain score of 8–10; small number of patients; study not controlled
Haddad et al. (2014) [79]	14	Retrospective, observational	No	Mean = 80 mo (range = 24–132 mo)	Coccygectomy	Median pain score during sitting decreased from 9 to 5.5/10 in 8 patients with traumatic etiology and 8.5 to 3/10 in 6 patients with nontraumatic etiology; similar decrease in pain during activity	2 patients with postop infection	Small study that was not controlled
Doursounian et al. (2015) [80]	33	Retrospective, observational	Yes	10 patients for ≥72 mo), 10 patients for 48–66 mo, 13 patients for 30–42 mo	Coccygectomy (for coccygeal spicule)	79% of patients reported a satisfactory outcome	2 patients with postop infection	Surgery performed for spicule pathology after failure of conservative management

Johns Hopkins and Walter Reed National Military Medical Center using the ICD-9 (724.79) and ICD-10 (M53.3) codes for “coccydynia” and “coccygodynia” between 2006 and the end of 2015. Inclusion criteria were the presence of coccydynia as a primary complaint and documented treatment by heat or pulsed radiofrequency. Exclusion criteria were treatment by radiofrequency in conjunction with other procedures and lack of adequate follow-up information. A total of 97 consecutive patients were identified, 14 of whom were found to have undergone radiofrequency treatment after chart review. Two of these were subsequently excluded for lack of any follow-up data.

The results are summarized in Table 3. The patients consisted of 10 males and two females with a mean age of 50.25 years (SD = 11.20 years, range = 32–72 years) and a mean duration of pain of 3.6 years (SD = 3.36 years, range = 9.5 years). The subjects reported moderate levels of pain, presenting with a preprocedure mean score of 5.7 (SD = 1.40 years, range = 4–8.5 years). Ten patients reported a specific inciting event, including four individuals who had an airplane/parachute or motor vehicle collision. Nine patients underwent conventional radiofrequency ablation, one received cooled radiofrequency, and two were treated with pulsed radiofrequency.

Overall, the mean decrease in pain score was 55.5% (SD = 30.33%, range = 0–100%). This included two patients who experienced no or minimal response to treatment, two others who obtained 30% or greater but less than 50% benefit, five who experienced 50% or greater but less than 80% pain relief, and three who experienced at least 80% symptom alleviation. Among the eight individuals who underwent “prognostic” sacrococcygeal nerve injections, seven obtained 50% or greater benefit. One of the two patients who experienced minimal relief underwent pulsed radiofrequency treatment. Two patients reported symptoms consistent with postprocedural neuritis (i.e., localized burning pain that developed within 24 hours and resolved within one week postablation); one of these patients underwent multiple treatments. The demographic and clinical factors of the 12 study subjects are shown in Table 3.

Discussion

In this article, we reviewed the literature regarding the etiology and therapy for coccydynia, a clinical syndrome frequently associated with trauma that has a diverse presentation with ill-defined treatment options. As summarized in Table 1, conservative therapy has not been studied extensively. There are two studies that reported modest benefit from NSAIDs in small numbers of patients, but their results did not draw a comparison to untreated patients. There are a greater number of studies evaluating interventional therapy, with coccygeal steroid and local anesthetic injections providing relief for about 50% of patients in one study and ganglion impar blocks providing varied but substantial benefit in a number of reports. However, due to the heterogeneity of these techniques and the uncontrolled nature of the studies, it is impossible to draw conclusions regarding efficacy or to make any evidence-based recommendations. Coccygectomy represents the last line of therapy for coccygeal pain. But whereas it has been reported to be very successful in numerous studies, many of these were small, retrospective, and observational in nature, and the outcomes for the most part were neither objective nor standardized (Table 2). Coccygectomy is also associated with a significant risk for complications such as postoperative infection. Overall, it is important to understand that since coccydynia is not a disease but rather a symptom that may be secondary to myriad different etiologies, there is probably not any single best treatment for all patients; instead, different patients may respond to different management strategies.

In an effort to improve the treatment of coccydynia, we retrospectively reviewed the records of 12 patients who were treated with standard or pulsed radiofrequency ablation. As this was not a standardized protocol and multiple different practitioners with different preferences performed the procedures, the procedures, including the RF technique, number of lesions, and use of a prognostic (or therapeutic, as most employed steroids in addition to local anesthetic) block, varied. This variability makes it challenging to determine effectiveness, but provides valuable information into what may and may not prove useful in the future design of clinical trials.

Most patients had failed multiple therapeutic modalities prior to receiving their RF. The majority of individuals received multiple lesions per treatment. These patients included 10 males and two females between the ages of 32 and 72 years. Two had spontaneous onset of symptoms, while the others recalled an antecedent event that was usually traumatic in nature. This suggests that these individuals may have had originating from the posterior elements of the coccyx, which is more vulnerable to trauma, and more likely to be amenable to interventions targeting the sparser posterior innervation. On average, our patients experienced greater than 50% benefit from the procedure, which appeared to be safe and well tolerated. The only complications were two cases of neuritis that resolved spontaneously after one month; one of the patients who had this symptom returned for further conventional RF treatments. Based on our exploratory results and extrapolating from the results of other studies evaluating RF denervation for different mechanical pain conditions, we believe that this treatment may provide benefit in a select group of patients whose symptoms are attributable to pain from the somatic structures (e.g., bone, muscles, and soft tissue) that compose the coccyx.

The treatment of coccydynia with radiofrequency ablation would be expected to provide benefit to only a subset of individuals who present with somatic pain from the soft tissues overlying the posterior coccyx. As noted above, individuals may have true coccygeal pain, but if the pain arises from structures innervated by the anteriorly situated sacrococcygeal plexus, such as from one

Table 3 Patient characteristics and outcomes for radiofrequency ablation of the sacrococcygeal nerves

	Gender	Age	Duration, y	Prognostic block	Preop pain score (0–10)	Inciting injury	Procedure	Follow-up	Outcome	Result, % relief	Comments
1	Male	38	8	No	7	None	RF	3 mo	Fair	35	Prior ganglion impar blocks, medical therapy
2	Female	57	2	Yes	5	Manipulation therapy	RF	2 mo	Excellent	100	Prior medical management, ganglion impar blocks, sacral nerve pulsed RF, pudendal nerve block, pudendal nerve pulsed RF
3	Male	38	2	Unclear	4	Sports	Pulsed RF	6 mo	Poor	0	Bilateral S5 sacrococcygeal junction pulsed RF
4	Male	44	3	Yes	6	Fall	RF	3 mo	Good	66	Failed medical management, physical therapy, mobilization
5	Male	58	14 mo	Yes	5	Bus trip	Cooled RF	7 mo	Excellent	80	Failed medications, acupuncture; 4 lesions created
6	Male	72	1	Yes	4.5	Long flight	RF	3 mo	Good	75	Underwent multiple treatments; new burning pain for 2 wk attributed to neuritis
7	Male	53	Not known	Yes	8.5	Paragliding accident, postsurgical	Pulsed RF	1 mo	Excellent	90	No further follow-up after last treatment
8	Male	52	8	No	Not reported	Parachute accident	RF	6 mo	Poor	10	9 lesions; 80% relief for 6 mo
9	Male	49	6 mo	Yes	7	None	RF	4 mo	Good	50	9 lesions; buttock paresthesias for 1 wk attributed to neuritis
10	Male	61	10	Yes	4	Airplane crash	RF	4 mo	Good	60	Received 2 subsequent RF procedures, which provided 40% relief for 3 mo; 3 lesions
11	Female	32	2	No	6	Childbirth	RF	3 mo	Good	67	7 lesions; failed ganglion impar block
12	Male	49	2	Yes	6	Motor vehicle accident	RF	2 y	Fair	33	2 lesions

RF = radiofrequency.

*"Excellent" defined as ≥80% relief, "Good" defined as ≥50% relief, "Fair" defined as ≥30% relief, and "Poor" defined as <30%. Neuritis "diagnosed" by a burning sensation in the area treated that developed within 24 hours after ablation and resolved within 1 week.

of the associated muscles (e.g., pubococcygeus, ischiococcygeus, coccygeus, levator ani) or ligaments, it would be unlikely to respond to denervation of the posterior nerve supply. On a similar note, although some patients with visceral pathology may present with coccydynia from either referred pain, spinal cord convergence, or irritation of the coccyx from the rectum, these conditions should theoretically not respond well to ablation of the coccygeal nerves.

Only one of the two individuals in our study experienced a positive outcome with pulsed RF, and considering the negative evidence for pulsed RF for other mechanical pain conditions [58,59], we would not recommend this treatment. We could not confirm a diagnostic or prognostic block in four individuals, and only one of these people experienced a good or excellent outcome, compared to 7 of 8 patients reporting a positive outcome who did undergo a prognostic injection. The decision as to whether to perform a prognostic block is contingent on multiple factors including the prevalence of the condition and false-positive rate, the predictive value of the injection, the relative risks and costs of both the prognostic procedure and definitive treatment, and individual patient-related factors (e.g., a patient traveling a great distance, on anticoagulant therapy, or in whom missing work is difficult). In one randomized study comparing the utility and costs of performing zero, one, or two blocks before lumbar facet radiofrequency neurotomy, the authors found that proceeding straight to treatment was associated with a higher overall success rate and lower costs than performing diagnostic/prognostic blocks [82]. Yet, given the positive results of studies evaluating injections with local anesthetic and steroids [43,46,48], which may obviate the need for radiofrequency denervation, and our poor outcomes in those who proceeded straight to radiofrequency, we would advise the use of a preceding diagnostic/prognostic injection unless extenuating circumstances dictate otherwise.

Limitations to our study include its relatively small sample size, the retrospective nature of the review, and the fact that patient encounters from only two centers were examined. It would be instructive to review outcomes in RF for coccydynia from other treatment centers to increase the sample size and enhance generalization. Given our limited knowledge regarding the innervation of the coccyx and the possible variations in neuroanatomy, until more information is available on the subject, similar to sacroiliac joint denervation (which is characterized by significant variation in the number and location of afferent nerve fibers) [53], it might be prudent to utilize techniques designed to increase the likelihood of capturing all nociceptive input such as creating multiple lesions; employing techniques to amplify lesion size to include the use of cooled RF or injecting electrolytic fluid such as lidocaine or saline before commencing ablation; and increasing electrode size, lesioning time, and/or temperature [15,83,84]. However, caution must be exercised when utilizing maneuvers to enhance lesion size as they may result in excess tissue damage or even skin injury in thin individuals [85].

Future research evaluating radiofrequency therapy for coccydynia should include enrolling patients in a blinded, randomized clinical trial and evaluating different treatments as part of a comparative effectiveness study. Blinding may be challenging in the context of complex, invasive interventions for chronic pain, but would significantly reduce the placebo effect and help establish efficacy. A logical next step would be to develop a systematic algorithm to treat coccydynia, which would involve a standardized diagnostic workup, and progression from conservative to more invasive interventions, which could include radiofrequency denervation in those whose symptoms are attributable to mechanical posterior, somatic pathology.

Conclusions

In this report, we systematically reviewed the established forms of treatment for coccydynia. After highlighting the gaps and shortcomings in the literature, we provided preliminary evidence supporting the use of radiofrequency ablation. Our results suggest that radiofrequency ablation, which is being increasingly utilized for other forms of mechanical bone pain [52–54,86], may serve a role as part of a multimodal, interdisciplinary approach in individuals with somatic, mechanical pain who have failed treatment with more conservative measures. Individuals who are likely to benefit from radiofrequency include those with pain arising from the posterior structures of the coccyx, which may be associated with sitting intolerance and tenderness. Given the other possible pain generators and our preliminary findings, performing a prognostic block beforehand may obviate the necessity of ablation therapy and improve outcomes in those who obtain only short-term benefit from the block. More research into this treatment should focus on large, blinded studies that include either a placebo or comparator group to establish efficacy, identifying those individuals most likely to respond to denervation and determining ways to optimize treatment outcomes in those who are considered ideal candidates.

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