Doctoral theses at NTNU, 2022:44

Ante Matti Kalstad

The Treatment of Coccyx Disorders

Doctoral thesis

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Medicine and Health Sciences
Department of Neuromedicine and Movement Science

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Norsk sammendrag

Behandling av halebenslidelser

Kroniske halebenssmerter, eller coccygodyni, er en lidelse hvor både diagnose og behandling gjennom årene har vært omstridt. Denne avhandlingen omhandler resultatene etter behandling av coccygodyni i fem publiserte artikler. Artiklene har tatt utgangspunkt i til sammen 481 pasienter som ble behandlet ved St Olavs Hospital i perioden 2009-2020, og omfatter både resultater etter lokale kortisoninjeksjoner og operativ behandling med fjerning av halebenet. Vi har undersøkt korttidsresultater, sluttresultater etter minimum ett år fra avsluttet behandling, og potensielle komplikasjoner ved kirurgi. Gjennom dette har vi tilegnet oss ny kunnskap omkring utredning og behandlingsresultater i denne pasientgruppen.

Flere kirurger fraråder å operere dersom halebenet ser normalt ut på røntgen eller MR. Vi finner at normal preoperativ billeddiagnostikk ved denne lidelsen ikke predikerer et dårligere resultat etter operasjon, og således ikke bør benyttes til å ekskludere kirurgi som behandlingsalternativ.

Videre finner vi at langtidsresultatene etter injeksjonsbehandling ikke er så gode som forventet sammenlignet med tidligere publikasjoner på emnet, med under en tredjedel suksessrate ved langtidsoppfølging. Injeksjonsbehandling er imidlertid lite invasivt og medfører svært liten risiko. Behandlingen bør således fortsatt vurderes før eventuell kirurgi.

Hos pasienter som opereres er langtidsresultatene bedre. 71% av pasientene var enten helt smertefri eller mye bedre ved langtidsoppfølging. Halebenskirurgi har imidlertid høy infeksjonsrisiko, med inntil 10% dype infeksjoner. Etter at vi forlenget postoperativ peroral antibiotikaprofylakse fra 24 til 48 timer falt infeksjonsraten til 2%.

Lite kunnskap har tidligere eksistert om behandlingen av barn med denne tilstanden. Ved St. Olav har vi tilbudt barn tilsvarende behandling som voksne, og fulgt opp 28 barn i alderen 11-17 år. Vi har sammenlignet resultatene med matchede voksne pasienter i en case-controllstudie. Våre funn tilsier at barn med halebenssmerter har

sammenlignbare resultater med voksne, både med tanke på injeksjonsbehandling og kirurgi.

Tradisjonelt sett har halebenskirurgi vært forbundet med flere dagers sykehusinnleggelse etter operasjonen. Vi har innført et dagkirurgisk behandlingsalternativ for pasienter med kort reisevei hjem, og sett på resultatene etter dette. Vi finner at dagkirurgisk halebensfjerning gir lignende resultater som ved sykehusinnleggelse, både med tanke på suksessrater og infeksjonsrater, og således bør anses som et trygt alternativ.

Disse funnene vil kunne ha betydning for utredning, behandlingsstrategi, og metodevalg for pasienter med denne lidelsen i fremtiden.

Overnevnte avhandling er funnet verdig til å forsvares offentlig
for graden PhD i medisin.
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Acknowledgements

This project started in 2012, and was instigated by the tireless work of Dr Rainer Günter Knobloch, who over the previous years had received several coccydynia patients, and started treating them systematically with local injections or surgery, based on the experiences and prior publication from his colleague Prof. Vilh. Finsen.

Dr Knobloch invited me to join him and Prof Finsen in researching the results of this treatment.

After three years of planning, preparing and collecting data, it became evident to me that this project would result in several more years of work and multiple publications. At this time, I applied and was accepted as a PhD-student at the Norwegian University of Science and Technology (NTNU). Dr Knobloch agreed to serve as my mentor, and Prof Vilh. Finsen and Dr Ivar Rossvoll became my supervisors.

I would like to express my sincere gratitude to Dr Rainer Knobloch, for giving me this opportunity. Your knowledge and clinical insights have been a continuous pillar of support. Without you, this project would have never existed, and your steadfast support could not have been better.

Furthermore, I would like to express my gratitude to Prof Vilh. Finsen, my lead supervisor. You were always available for questions and advice, you inspired me, and provided exactly the guidance I needed to complete this journey.

I thank Dr Ivar Rossvoll, my second supervisor, for supporting me and answering any question I presented along the way, particularly when performing the statistical analysis.

To my family: Dear Anh, Victoria and Isak. This project resulted in endless hours away from you, and despite that, you always supported me. I am eternally grateful for having such a loving and understanding family.

List of original papers

Finsen V, Kalstad A, Knobloch RG. Normal Preoperative Images Do Not Indicate a Poor Outcome of Surgery for Coccydynia. Spine. 2020;45:1567-71.

Finsen V, Kalstad AM, Knobloch RG. Corticosteroid injection for coccydynia: a review of 241 patients. Bone Jt Open. 2020;1:709-14.

Kalstad AM, Knobloch RG, Finsen V. Coccygectomy in the treatment of chronic coccydynia. Spine. August 30, 2021 (Accepted. Published-Ahead-of-Print)

Kalstad AM, Knobloch RG, Finsen V. The treatment of coccydynia in adolescents: A case-control study. Bone Jt Open. 2020;1:115-20

Kalstad AM, Knobloch RG, Finsen V. Resection of the coccyx as an outpatient procedure. Orthop Rev (Pavia). 2020;12:8813

List of abbreviations

BMI	Body-mass index
CI	Confidence interval
Co	Coccygeal vertebra (referring to vertebral level)
CT	Computed tomography
EHR	Electronic health record
IQR	Interquartile range
MRI	Magnetic resonance imaging
NSAID	Non-steroidal anti-inflammatory drug
NRS	Numeric rating scale
OR	Odds ratio
PROM	Patient reported outcome measures
RCT	Randomized controlled trial
SD	Standard deviation
S5	Fifth sacral vertebra
VAS	Visual analogue scale

Introduction

General background

The coccyx, also known as the tailbone, is a rudimentary triangular-shaped osseous formation at the end of the vertebral column, consisting of 3 - 5 vertebral segments with intervertebral discs. The name derives for the Greek word for cuckoo and was named by the physician Herophilus around 300 BC; presumably due to its shape resembling the head and beak of this bird when seen from the side. It is concave on its anterior surface, continuing the sagittal curvature of the sacrum.

The coccygeal vertebrae tend to unite with each other as age advances.

Although it is a relatively small structure, the coccyx has several functions. Several muscles, tendons and ligaments in the pelvic floor attach to the coccyx. During the seated position it also serves as weight-bearing support for the person, as one leg of a tripod along with the ischial tuberosities[1].

The condition known as coccygodynia, or coccydynia in its short form, is characterized by pain in and around the coccyx. This term was first described by Simpson in 1859 and has been popularized since then, but descriptions of pain in the region of the terminal spine has existed since the 16th and 17th centuries[2]. Unfortunately, the term coccydynia is only descriptive in its anatomic and symptomatic sense, and does not give information on the etiology or pathogenesis of the pain[3].

This condition constitutes less than one percent of all non-traumatic spinal complaints[4].

The typical patient with coccydynia is an adult female in her 30s or 40s[5]. The female to male sex ratio for this condition is around 5:1[1-3, 6]. This difference in risk has traditionally been attributed to anatomical differences in the male and female pelvis. Females are presumed to have a more posterior situated os sacrum and coccyx, and a longer coccyx[7, 8], but the evidence is conflicting, with Woon et al.[9] finding that the female coccyx in fact is slightly shorter than in males.

Anatomy

The coccyx is normally around 4 cm in length[9]. While primary ossification in the axial skeleton can be evident from around 9 weeks of gestation the coccyx does not begin to ossify before after birth.

The coccygeal cornu articulates with the sacral cornu at the inferior sacral apex of the 5th sacral vertebra. This articulation may be a symphysis or a synovial joint, although it may also be fused to the sacrum[10]. The first coccygeal vertebra is the largest, while the last three segments diminish in size and usually consist of a single piece of bone[2].

The coccyx accounts for aproximately 0,4% of the dry weight of the vertebral column, and is the attachment of several ligamentous structures, namely the anterior, posterior, and lateral sacrococcygeal ligaments, the intercornual ligaments, the anococcygeal ligament, and the distal portion of the sacrotuberous and the sacrospinous ligaments. The coccyx is also the attachment of the levator ani and isciococcygeus muscle groups[11].

The sacral branches of the sympathetic trunks converge distally to form a solitary retroperitoneal ganglion that transmits both sympathetic efferent signals, and nociceptive afferent signals from the perineum and urogenital regions. This ganglion has been named the ganglion impar, or ganglion of Walther after its discoverer, German anatomist Augustin Freidrich Walther who first described it in the early 1720s, and a targeted nerve block of this structure is regarded as a potential treatment option for coccygeal pain[12].

Etiology

The causes of coccygeal pain are most commonly direct trauma towards the coccyx. This may be through an external force, usually through falling backwards and landing on the coccyx, resulting in a coccygeal fracture or articular dislocation through the sacrococcygeal or intercoccygeal levels.

The coccyx is also susceptible to injury from the internal traumatic forces seen during childbirth, where the head of the baby may force the coccyx posteriorly until a dislocation or fracture occurs, especially during instrumented delivery. In the Tile classification system of pelvic ring fractures, a fracture of the coccyx is regarded as an A3 fracture[13].

Chronic microtrauma, such as uncomfortable and repetitive sitting on hard or narrow surfaces may also lead to chronic coccygeal pain[1].

Traumatic causes are reported to account for between 50%-70% of all cases of coccydynia[4, 14].

Nontraumatic etiologies of coccydynia include degenerative disc disorders, hypermobility at the sacrococcygeal or intercoccygeal joints, and osseous deformities such as coccygeal spiculae[15]. There is evidence of a relationship between weight and coccygodynia, with increased risk when the body-mass index is >27.4 in females and >29.4 in males[16]. There is also anecdotal evidence that rapid weight loss may lead to coccygeal pain due to loss of the soft tissue cushioning covering the coccyx[1].

In many patients, the cause of coccygeal pain may not be identified. This is referred to as idiopathic coccydynia. Around 30% of patients have no identifiable cause of their pain[17, 18].

Diagnostics

The diagnosis of coccydynia is typically established through a combination of history taking and clinical examination, supplemented by diagnostic imaging.

In terms of history, the patients are often able to relate the onset to a specific traumatic event. They will usually complain of pain in the coccygeal area while sitting. This pain may be alleviated by leaning forward. Often, the patients describe a short, sharp pain when rising from a sitting position.

Some patients describe pain while walking or jogging, or during prolonged sitting on trains, planes or automobiles. Patients may also experience pain during defecation. Some women describe coccygeal pain during sexual intercourse.

Clinical examination should be performed by an experienced clinician, and other causes of pain in the coccygeal region must be excluded, such as pilonoidal cysts, haemorrhoidal disease or neoplasms. The coccygeal pain may be elicited from direct pressure on the dorsal aspect of the coccyx. Furthermore, the typical pain may be reproduced through digital intrarectal mobilization of the coccyx, moving the coccyx in a sagittal direction. The normal coccyx only has approximately 13 degrees range of motion, and a range of motion between 5 and 25 degrees in the sagittal plane is regarded normal mobility[14, 16]. Any finding of hypermobility on examination should be noted.

The diagnosis may also be further confirmed by injecting a local anaesthetic into the most painful or hypermobile coccygeal area. Alternatively, by performing a ganglion impar block directly ventral to the proximal coccyx. If the pain is coccygeal in origin and the injection is performed correctly, this should give a temporary pain relief lasting a few hours. If the local anaesthetic agent is combined with a corticosteroid, the injection may also lead to a longer lasting relief.

Diagnostic imaging:

Standard radiography is the oldest imaging modality for this condition, and provides a morphological evaluation of the coccyx, where certain bony abnormalities such as spiculae may be seen. It also gives the possibility of classifying the coccygeal position[17]. The coccyx may be found to be abnormally flexed in a ventral direction or extended dorsally. It could also have a parallel shift in any direction, as a sign of dislocation.

MRI-studies have been recommended in the diagnostic process to obtain further information about coccygeal pathoanatomy[19].

Dynamic radiographic imaging, with lateral images taken in a standardized standing position, and a painful sitting position for comparison, as described by Maigne et al.[20], has been advocated as an additional measurement of the mobility and degree of displacement. However, a dynamic MRI-study of 112 healthy volunteers has found that up to 9% had coccygeal hypermobility without any evidence of coccydynia[21], and did not find any correlation between coccygeal mobility found on imaging and coccydynia.

Some surgeons refrain from performing surgery if the coccygeal imaging studies look normal[22]. However, while diagnostic imaging can prove helpful in identifying coccygeal abnormalities, there is no previous evidence with regard to whether or not such coccygeal abnormalities found on diagnostic imaging can predict the results of surgery.

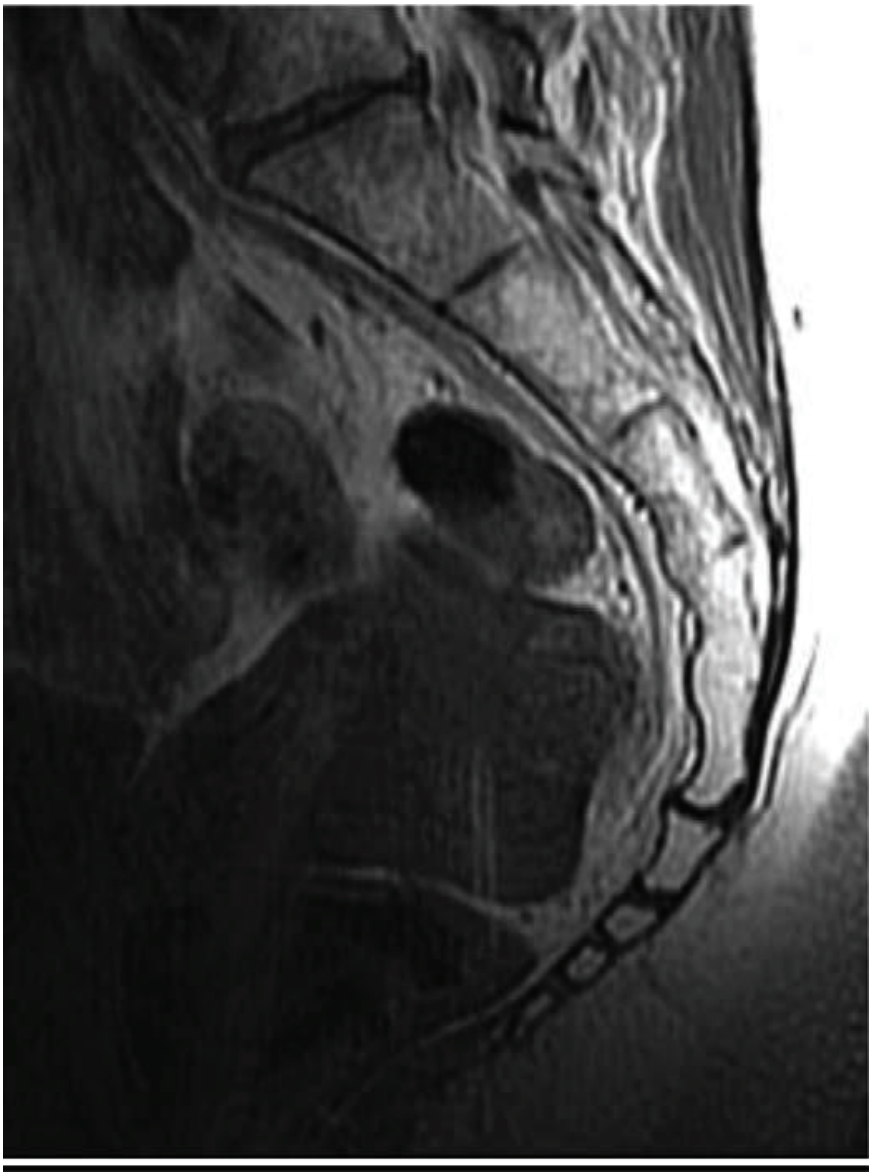

Figure 1. MRI. Normal coccyx

Treatment modalities

The management of coccygeal pain has been debated over the years. The diagnosis of coccydynia was originally regarded as a neurosis by many practitioners, and treatment directed at the coccyx was not thought to help[23]. This view has gradually faded, and several treatment options have been proposed over the years.

Conservative treatment options include medication with NSAIDs and rest. A ring or heart-shaped cushion to protect the coccyx while sitting may decrease the symptoms. Most acute presentations of coccygeal pain can be successfully handled by such conservative measures, and more invasive treatment options need only be considered for refractory cases[1].

Physical therapy with manipulation of the coccyx is described and may be of some benefit although the evidence is limited. Maigne et al.[24] found in a randomized control trial (RCT) that manipulation therapy of the coccyx can lead to a mild improvement, with 22% good results at six month follow-up, compared to 12% good results among patients treated with low intensity external short wave physiotherapy, assumed to be tantamount to a placebo.

Furthermore, a targeted injection of local anaesthetic and corticosteroids may be administered, either into the most painful, hypermobile area of the coccyx, or towards the coccygeal tip or ganglion impar at the proximal ventral aspect of the coccyx.

The traditional corticosteroid injection technique into the most painful level of the coccyx, usually the sacrococcygeal or Co1 to Co2 levels, seems to be a well-established method[2, 25, 26], and has become a mainstay treatment method at St Olav's University Hospital, where the technique was popularized by Finsen in 2001[27]. Despite this, we have been able to identify only a few papers that describe first-hand experience with this type of injection[28-32].

The results from this method seem to vary, ranging from 50% to 80% successfully treated (Table 1)

Author	Type of injection	Number of patients injected	Results
Mitra et al.[30]	80 mg triamcinolone and local anaestetic	14	7 improved at follow-up at 3 weeks
Perkins et al.[29]	Long acting corticosteroid and local anaestetic	77	62 successfully treated
Wray et al.[28]	40 mg methylprednisolone and local anaestetic	29	17 improved (mean follow-up 2 years and 9 months)
Yeganeh et al.[31]	40 mg methylprednisolone and local anaestetic	30	Mean pain score 5.9 before injection and 2.1 after two months
Kodumuri et al.[32]	40 mg triamcinolone and local anaestetic	201	80% cured at six-week review

Table 1. Reported results from injection therapy

Many techniques to target the injections has been described, ranging from under fluoroscopic imaging, CT imaging, or with digital intrarectal control[27, 33, 34]. Our preferred technique has been the latter.

In case of treatment failure with conservative management, operative treatment with coccygectomy has been regarded as a last resort. A coccygeal excision was first reported in 1726 by the French surgeon Jean Louis Petit for what was thought to have been skeletal tuberculosis[3]. The procedure most used today for chronic coccydynia was described and popularized in 1937 by Key[23]. It consists of a vertical short incision over the coccyx, extending down to the bone, and subperiosteal dissection around the coccyx, which is released in an antegrade direction and removed. Closure is performed in layers, uniting the fascia in the midline, obliterating any dead space.

An alternative method, proposed by Gardner[35], advocates dissecting and removing the coccyx in a retrograde direction, starting at the coccygeal tip. This technique has had a tendency towards more complications, presumably due to the increased risk of injuring the rectum, and seems to be less favoured than the former technique[36].

There are authors who advise against operative treatment based on moderate long-term results and the chance of major complications[1, 7], however several case series on coccygectomy shows promising results with between 70%-92% success rates[10, 17, 18, 22, 28, 29, 37-42], although the numbers of patients have been limited.

Operative treatment has traditionally been fraught with a high risk of infection and expectation of patient dissatisfaction among many orthopaedic surgeons, who therefore resist performing this operation even when conservative therapy has failed[43]. Despite this, it is estimated that more than 1300 coccygectomies are performed yearly in the USA, and around 150 within the English public health sector[11].

At St Olav's University Hospital this treatment has been offered and regarded as an acceptable treatment option when other less invasive treatments have failed. However, our results have not previously been evaluated.

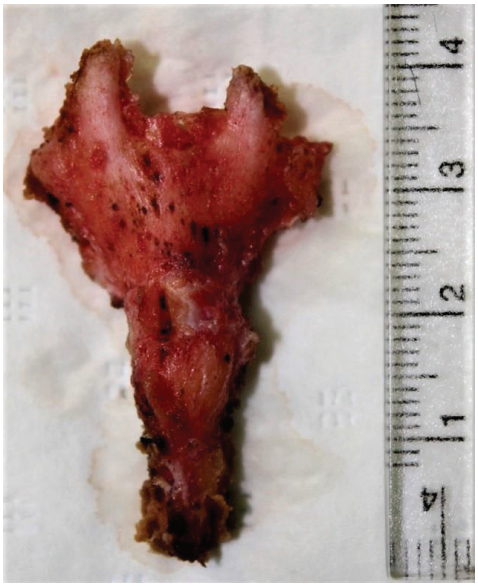

Figure II. Resected coccyx

After coccygectomy-procedures it is common for patients to spend several days in hospital before discharge. In the 1990s the average hospital stay after this procedure was 7-10 days[26]. In line with modern advances in peri- and postoperative pain control regimens and early rehabilitation protocols, there has been a trend towards more outpatient surgery in several surgical disciplines. The goals of this trend have been to encourage early rehabilitation and reduce treatment costs, without compromising results. In line with this development, we have started to perform coccygectomy as an outpatient procedure for selected patients at our hospital. Although there is much available literature about other orthopaedic outpatient procedures, nothing has to our knowledge been published with regard to coccygectomies.

Adolescents

While the typical patient with coccydynia is an adult woman, juveniles seem to make up between 7% to 12% of the patient population[44]. From the existing literature on coccydynia, little is known about the treatment of adolescents and the results thereof[45]. This is especially so when it comes to surgery, where there is a lack of published data from this age group. This seems to indicate a reluctance to perform this type of surgery on minors.

At our hospital, we have taken a pragmatic approach and treated adolescent patients with this condition in a similar manner to adults, and have identified a need to evaluate our results in these patients.

Aims of the thesis

-To compare preoperative X-ray or MRI findings to postoperative results, in order to establish particular findings on imaging that can predict the end-result (paper I).

-To evaluate the results of injection therapy (paper II).

-To evaluate the results of a large cohort of patients treated for coccydynia with local injections or resection of the coccyx (paper III).

-To compare the results of adolescents treated for this condition with adult patients (paper IV)

-To evaluate the results of outpatient surgery compared to inpatient treatment (paper V)

Patients and methods

Design

The study was conducted as a retrospective cohort study.

Inclusion criteria and period

Our primary patient cohort consisted of all patients with the diagnosis of chronic coccydynia at our institution between 2009 and 2016.
Furthermore, due to a seemingly high number of post-operative infections in the primary patient cohort, an additional cohort consisting of all patients operated for coccydynia between 2016 and 2020 with a newer technique for wound closure and antibiotic regimen were included and followed with regards to post-operative complications only.

As our hospital is the only one in a large area that performs this type of treatment, the patients had been referred from both general practitioners and other hospitals after having failed conservative measures, including watchful waiting and physiotherapy. This ensured a pre-screening of the patients. It is thus conceivable that some patients with mild or transitory symptoms have not been referred to us and thus not been included among the patients we report on.

Exclusion criteria

We excluded pregnant patients and patients with known psychiatric disorders that could mimic or potentiate coccydynia symptoms. Patients who were not able or willing to give informed consent were excluded.

Diagnostic process

Patients were diagnosed by a senior orthopaedic spinal surgeon (R.G.K) based on a thorough medical history and physical examination.

The time and cause of onset was noted. Patients were questioned about typical characteristics of pain, including pain on symmetrical sitting, relief from leaning forward, sharp pain when rising from a sitting position, pain on walking/jogging, pain while seated in planes/trains or automobiles, pain during defecation, pain on sexual intercourse (for women), and the use of ring-shaped cushions for relief.

Clinical examination was performed, with palpation and manual manipulation of the coccyx to confirm that the patient's pain was caused and provoked by coccygeal pressure and movement, and to evaluate any hypermobility of the coccyx.

Coccygeal imaging with either radiographs, MRI, or both was performed, most of the time these had been performed before the first consultation in our out-patient department.

Any relevant conditions that could aggravate or mimic chronic coccydynia were taken into consideration before making the diagnosis.

The condition was regarded as chronic if the pain had been present for at least 3 months.

Injection technique

Patients with severe symptoms were offered a targeted injection of lignocaine/corticosteroid combination into the hypermobile and most painful area of the coccyx, usually the sacrococcygeal level or the level between Co1 and Co2.

The injections were performed by the examining surgeon with the patient in the lateral decubitus or prone position, with an aseptic technique, injecting 1 ml 1% lignocaine mixed with 1 ml Betamethasone (Celeston Chronodose 6 mg; Schering-Plough, Kenilworth, New Jersey, USA), or 1 ml Triamcinolone (Lederspan 20 mg; Meda,

Solna, Sweden). During the first part of the study the former corticosteroid was used, while the latter was mainly used during the last part of the study.

Injections were performed with a 21 G needle into the desired area of the coccyx. The injections were performed without fluoroscopic imaging, with digital intrarectal control, as described by Kersey[33].

Operative technique

The procedure was performed under either spinal or general anaesthesia with antibiotic prophylaxis started preoperatively (Cephalotin 2 g intravenously every 90 minutes, 4 doses in total, and one oral dose of Metronidazole 1g). The gluteal cheeks were separated and strapped laterally with adhesive tape. The operative field was prepared and draped, and a sterile transparent adhesive film was used to cover the exposed disinfected skin. The skin was incised with a 4-5 cm midline incision centred at the level of the sacrococcygeal articulation. The incision was extended through subcutaneous fat and fascia with a monopolar diathermy. The dorsal surface of the coccyx was exposed through subperiosteal dissection, and the most mobile level was identified by manipulation. The coccyx was then gradually released in an antegrade fashion through this level, aided by gentle manipulation of the coccyx with a towel clamp. Care was taken to avoid injuring the rectal wall on the anterior side. Hemostasis in this area was achieved with bipolar diathermy.

If the distal edge of remaining bone seemed prominent after the mobile segment had been excised, this was bevelled off with a rongeur or osteotome, leaving a well-rounded raw surface of bone. Closure was performed in layers, with attention to eliminating dead space, adapting the fascia and periosteum in the midline with heavy resorbable (Vicryl) sutures, and closing the subcutaneous layer with 3-0 Vicryl, before suturing the skin. Drains were not used.

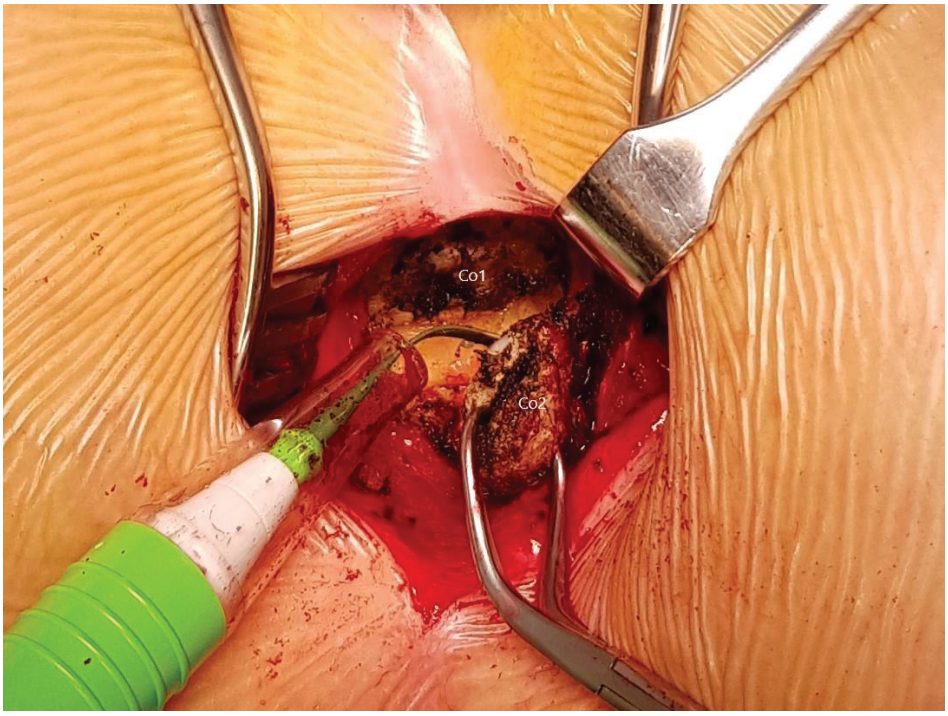

Figure III: Antegrade resection of the mobile coccygeal segment aided by a towel clamp

During the first half of the inclusion period, the skin was closed with a running resorbable intracutaneous suture. From June 2014 a topical seal of skin adhesive (Dermabond advanced®, Ethicon) had been added to the suture line to decrease the risk of bacterial wound breach. From August 2016 the skin was closed with nylon sutures and covered with skin adhesive as a sealant.

From 2019 the prophylactic antibiotic protocol was extended to include 48 hours post-operative coverage. Patients were thus given oral doses of Cephalotin 500 mg every six hours and Metronidazol 400 mg every 8 hours for two days.

Patients

Between 2009 and 2016 a total of 358 patients were referred to St Olav's University Hospital and diagnosed with chronic coccydynia. Their mean age was 38 (range 11-75) years. There were 291 (81%) females. Their mean duration of symptoms at referral was 39 (2-348) months.

The aetiology of the coccydynia was a direct trauma in 199 cases, childbirth in 61 cases, and pronounced weight-loss in 13. There were 85 patients who could not ascribe their condition to any specific cause.

On clinical examination we found that 80% of patients had hypermobility of the coccyx, and 83% had a reproduction of their symptoms when the coccyx was manipulated. On direct external palpation of the coccyx, 84% experienced pain.

There were 277 patients who initially were treated with local injections. Out of these patients 146 were subsequently operated.

In total, 184 patients were operated. There were 38 patients who did not want injections and were operated without any prior injection therapy.

43 patients did not want any treatment and were excluded from further analysis.

The mean time between final treatment and follow up was 34 (range 12-86) months.

Furthermore. Between the years 2016 and 2020, an additional 123 patients were operated in the same manner as the primary cohort, but with a new closure technique and an extended antibiotic prophylaxis protocol. Post-operative complications were compared to the primary patient cohort. Complications within the first three months post-operatively (superficial wound infection requiring antibiotic treatment or deep infection requiring re-operation) were recorded from the electronic health records (EHR) of these patients.

Primary cohort

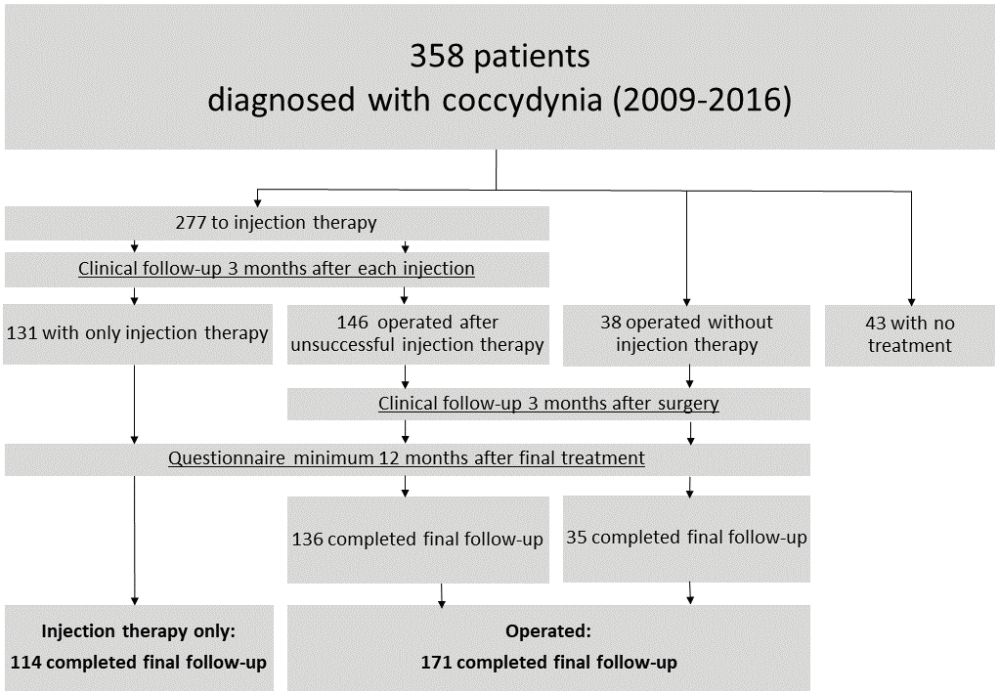

Figure IV. Flow chart of primary patient cohort

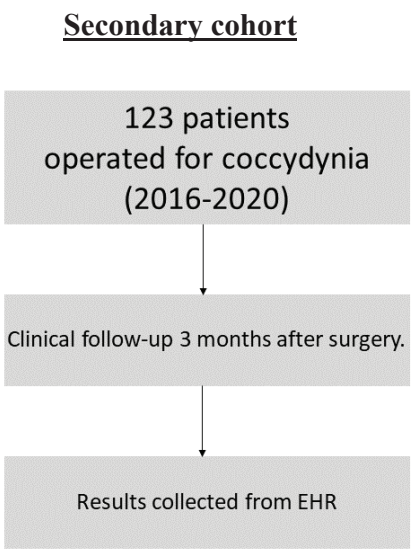

Figure V. Flow chart of secondary patient cohort

Data collection 2009-2016

A registration form was created for recording data from the patients' electronic health records (EHR) that we determined as relevant for the research project. Patients were anonymized and given a unique identifier code on the data registration forms. The information was collected by accessing the patient's electronic health record and radiographs.

Patient baseline characteristics, including history of presenting illness, examination findings and imaging findings were recorded in a standardized fashion. Details regarding treatment modalities, and complications were registered in the same manner. Treatment results after three months had been evaluated clinically through follow up appointments, and were recorded on the forms in the same manner.

Radiographs and MRI images were assessed by two consultant orthopaedic surgeons (R.G.K. and A.K.) who conferred when in doubt. Extension of flexion deformities were

defined as a deviation of more than 25 degrees from a continuous natural curvature along the anterior border of the sacrum and coccyx.

EHR registration form

The following information was collected on the initial EHR registration form:

Relevant history

Gender
Duration of symptoms (months)
Initial cause (birth, trauma, weight loss >5 kg, or not known)
Presence of pain in the following domains:

- Pain on symmetrical sitting
- Relief of pain by leaning forward
- Sharp pain when rising from a sitting position
- Pain from defecation
- Pain from sexual intercourse (females only)
- Pain from walking
- Pain from jogging
- Use of a cushion or ring-shaped pillow for sitting
  - Relief from this cushion/pillow
- Pain from traveling in trains, planes or automobiles

Clinical findings

Hypermobility when manipulating the coccyx
Reproduction of pain by manipulation
Pain when applying local pressure to the coccyx

Radiological findings (specified for either plain radiographs, MRI or both)

Parallel displacement of 2 mm or more
Flexion deformity
Extension deformity
Spicula
Other pathology
Normal

Treatment given

No treatment
Injection therapy:

- Number of injections given
  - Date of first injection
    - Type of corticosteroid (Betamethasone or Triamcinolone)
    - Result, (short term result at 3 month follow-up)

Not good
Somewhat better
Temporary relief (duration in days)
Completely well
Information missing

Date of second injection
Type of corticosteroid (Betamethasone or Triamcinolone)
Result, (short term result at 3 month follow-up)
Not good
Somewhat better
Temporary relief (duration in days)
Completely well
Information missing

Date of third injection
Type of corticosteroid (Betamethasone or Triamcinolone)
Result, (short term result at 3 month follow-up)
Not good
Somewhat better
Temporary relief (duration in days)
Completely well
Information missing

Operative treatment:

Type of anaesthesia (spinal/general/not recorded
Type of procedure
Complete resection of Co1
Bevellation of S5
Bevellation of Co1
Co1 intact

Re-operations performed (number and dates)
Cause of re-operations (pain or infection)
Post-operative infection/delayed healing, treated with antibiotic therapy alone

Follow-up after treatment

All treated patients had been followed with a clinical evaluation after three to four months and their preliminary results had been recorded.

After a minimum of 12 months after the treatment had been completed, patients were contacted by mail and asked to complete separate questionnaires regarding their treatment results. They all received a general questionnaire regarding their result after coccydynia treatment. If the patients had been through out-patient surgery, we added a separate questionnaire regarding this treatment.

As no validated disease-specific scoring system for the coccyx exists, a form to measure the patients' evaluation of the results was designed for the purpose of this study.

The questionnaire was constructed by three experienced clinicians, and meant to include daily activities that frequently had been found to be affected by coccydynia. On this questionnaire, an overall patient evaluation of the treatment result on a 5-point Likert scale, was regarded as our primary outcome measure, while a numeric rating scale for pain was our secondary outcome measure.

Numeric Rating Scale (NRS):

The self reported NRS consists of a numeric version of the Visual Analogue Scale (VAS) ranging from zero to ten, which has been deemed valid and reliable for rating pain intensity. It has the benefits of being easy to complete, allows international use without translation difficulties, and can be administered verbally and in writing. In tests the NRS has produced a measure of pain intensity that is very similar to VAS[46].

We initially contemplated adding a general quality of life scoring system, but as some patients would already be filling in two questionnaires, we assumed that the addition of further questionnaires could affect the response rate negatively.

General questionnaire

The general questionnaire was formulated as follows:

"We would like you to score any pain you experience now compared to the pain you experienced prior to when the treatment was started.

What we are asking for is how you experience pain in the region of your tailbone, or where the tailbone previously has been. If there are questions regarding symptoms that you have never had, please skip these questions. Use only one cross per category"

The scoring scale was a 5-point Likert scale, formulated as follows (depending on the question):

"Completely well/much better/somewhat better/unchanged/worse" or
"Never/much rarer/somewhat rarer/unchanged/more often" or
"Unlimited/much longer/somewhat longer/unchanged/shorter"

The following questions were asked:

The pain while sitting is: (score)
I have a short worsening of pain when rising from a sitting position: (score)
I have pain around the tailbone during defecation: (score)
I have pain on sexual intercourse (women only): (score)
I have pain while walking/jogging: (score)
I have pain while riding trains, planes, or automobiles: (score)
(Completely well/much better/somewhat better/unchanged/worse)

I use a tailbone cushion or pillow: (score)
(Never/much rarer/somewhat rarer/unchanged/more often)

The duration I can sit pain free is: (score)
(Unlimited/much longer/somewhat longer/unchanged/shorter)

Please rate how much tailbone related pain you have had on average during the last week: (score)
(NRS scale 0-10, with 0 being "no pain" and 10 being "worst imaginable pain")

How would you rate the treatment result today?: (score)
(Completely well/much better/somewhat better/unchanged/worse)

If you were operated, please answer the following:
I would have consented to the operation if I had known my outcome in advance:
(yes/no)

Outpatient questionnaire

The outpatient surgery questionnaire was formulated as follows:

"Dear patient,

You were between 2009 and 2015 operated at St Olav's University Hospital as an outpatient. This means that you were discharged on the same day as your operation. We ask you to answer the following questions:

1) Outpatient surgery (cross whatever applies)

I feel that the outpatient procedure worked well: (cross)
I would have wished to stay hospitalized overnight: (cross)

Because the journey home was very painful: (cross)
Because of other practical problems: (cross)

You were called the day after surgery by a nurse from the Orthopaedic outpatient surgery department. Were you satisfied with the answers you received to your questions?: (yes/no/I was not telephoned/I was telephoned but do not remember)

2) Anaesthesia (answer for either spinal anaesthesia or general anaesthesia)

I received spinal anaesthesia: (cross)
The spinal anaesthesia worked well: (yes/no)

I had the following problems: (cross whatever applies)
Nausea
Much pain
Dizziness
Headache

I regret having spinal anaesthesia and would have preferred a general anaesthesia: (cross)

I received general anaesthesia: (cross)
The general anaesthesia worked well: (yes/no)
I had the following problems: (cross whatever applies)
Nausea
Much pain
Dizziness
Headache

I regret having general anaesthesia and would have preferred a spinal anaesthesia: (cross)

Additional data collection, 2016-2020

The following additional data, for analysing and comparing postoperative complications was collected from the EHR:

Type of coccygeal resection:

- Resection at level of Co1-Co2, without bevelling of Co1
- Resection at level of Co1-Co2, with bony bevelling of Co1
- Resection at level of S5-Co1, without bony bevelling of S5
- Resection at level of S5-Co1, with bony bevelling of S5

Type of closure:

- Resorbabale intracutaneous sutures
- Non-resorbable skin sutures
- Dermabond topical coverage of surgical wound

24 or 48 hours post-operative antibiotic prophylaxis

Occurrence of superficial wound infection requiring antibiotic treatment

Occurrence of deep infection requiring re-operation

Statistical analysis

All statistical analyses were performed using SPSS software, version 25.

Paper I:

The Chi square test was used for dichotomous results (success/failure). Group comparison for these scores was performed with the non-parametric Mann-Whitney U test.

Paper II:

The Chi square test was used for dichotomous results. Stepwise logistic regression analysis was used to determine which variables affected short and long-term success/failure.

Paper III:

The Mann-Whitney U test was used to compare NRS-pain levels between patient groups.
The Chi-square test was used to compare dichotomous variables.
Stepwise logistic regression was used to analyse which variables determined the lowest NRS-scores.

Paper IV:

The Chi-square test was used to compare dichotomous results. The Likert-scale functional results were compared with the Mann-Whitney U-test
The independent samples t-test was used to compare results for the NRS-pain

Paper V:

The Chi square test was used for dichotomous results.

Ethics

The project was evaluated by the Regional committee for medical and health research in Central Norway (2016/460). The committee replied that patient data registration and follow-up data collection were regarded as a quality-control project for an existing treatment modality which did not require additional ethical approval. Patient data collection, handling and storage was evaluated and approved by the St Olav University Hospital data protection officer.

Summary of papers I-V

Summary of paper I

Finsen V, Kalstad A, Knobloch RG. Normal Preoperative Images Do Not Indicate a Poor Outcome of Surgery for Coccydynia. Spine. 2020;45:1567-71

This retrospective cohort study focuses on preoperative radiographical findings and MRI-findings of 171 operated patients and compares the findings on these images to the post-operative results after a minimum of one year follow-up.

Pre-operative images were evaluated and categorized as either “normal” (19%), “flexion deformity” (44%), “extension deformity” (18%), “spicula” (10%), and “subluxation” (23%). Some images showed more than one abnormality

The main finding in this study was that the post-operative results were good regardless of whether the preoperative images showed pathology or not. There was a 70% success rate for patients where preoperative images had shown some type of deformity, whereas we found a 76% success rate for patients with normal looking preoperative images.

As patients with normal images seem to be just as likely to profit from the operation, we concur with Wray et al. that the main value of diagnostic coccygeal radiography is to exclude more sinister pathology[28].

Summary of paper II

Finsen V, Kalstad AM, Knobloch RG. Corticosteroid injection for coccydynia: a review of 241 patients. Bone Jt Open. 2020;1:709-14

In this paper we investigate the results of 241 patients who had undergone local injection therapy with a combination of lidocaine and a corticosteroid. The corticosteroids used were Betamethasone in the first part of the study and mainly Triamcinolone in the second part (not randomized). Patients were reviewed after three to four months and offered new injections in case of partial or temporary relief. Patients who did not achieve lasting satisfactory pain relief after a total of three injections were considered failures of injection therapy and offered surgical treatment as a last resort. The patients were followed with mailed questionnaires after a minimum of 12 months after the last injection.

We found that only 9% were pain-free at the three to four month follow-up, and 23% had improved. At the long-term follow-up 15% with only one injection were regarded as successfully treated. The success rate rose to 29% in patients who had received two injections.

When analysing several independent variables that might affect the outcome (sex, age, traumatic aetiology, duration of symptoms for more or less than 12 months, and the type of corticosteroid used) we found that the use of Triamcinolone rather than Betamethasone seemed to significantly improve the short term success rate.

For long term success, we found that the use of Triamcinolone, and injecting patients with less than 12 months of symptoms, significantly increased the success rate.

Summary of paper III

Kalstad AM, Knobloch RG, Finsen V. Coccygectomy in the treatment of chronic coccydynia. Spine. August 30, 2021 (Accepted. Published-Ahead-of-Print)

This paper presented the results of 184 patients who had been operated for chronic coccydynia at out hospital between 2009-2016. A total of 171 (93%) patients responded to our final follow up, at a minimum of one year after surgery.

Our findings showed that about three quarters of the patients operated could be regarded as successfully treated (completely well or much better) when evaluating their final result. Furthermore, most patients (89%) would have consented to the operation if they had known their result in advance.

The patients were followed-up in eight different domains of daily living, namely: pain on symmetrical sitting, pain on rising, pain on defecation, pain during sexual intercourse (women), pain on walking/jogging, pain in public transport, regular use of sitting-cushion, and duration of pain-free sitting. We defined success as either completely well or much better at review. Our results showed that the mean long-term success rate for these eight domains was 73% (range: 60%-82%).

We found two factors that correlated with better results (less pain on NRS) at long-term follow-up. Patients who did not have a traumatic or birth-related etiology for their coccyx pain were found to do better ($p=0.039$). We also found that patients did better if we did not perform a bony bevelling with an osteotome/roungeur to round off the remaining bony edge before closure, but rather kept the remaining dorsal bony surface intact ($p=0.002$).

Due to a relatively high rate of post-operative infections soon after surgery, we decided to search more thoroughly for variations in our operative technique that might have influenced the rate of infections. This was done by increasing the study group by also including a further 123 patients who had been operated between 2016 and 2020. We then investigated these factors in a stepwise multiple logistic regression analysis.

There was a 10% chance of post-operative infections from this procedure, and the only variable found to significantly reduce this rate was by extending our prophylactic antibiotic protocol to 48 hours after surgery. The introduction of this subsequently brought the infection rate down to 2% ($p=0.018$).

Summary of paper IV

Kalstad AM, Knobloch RG, Finsen V. The treatment of coccydynia in adolescents: A case-control study. Bone Jt Open. 2020;1:115-20

This case-control study evaluated the results of 28 adolescents who had been treated for coccydynia at our institution and compared the results to adult patients who had been matched to the adolescent cases. Half of the patients were treated with only injection therapy, while the remainder were operated, mostly after having first tried injection therapy without lasting effect. No significant difference was found between the groups, neither in terms of overall success, nor in terms of pain, as rated on a numeric pain scale. We also compared the results of several daily activity domains, including pain on symmetrical sitting/pain on rising/pain on defecation/pain on walking/pain in public transport, and found no significant differences in these domains.

We noted that our results after injection therapy were not as good as we would have expected based on previous literature for this age group, with only one third of our adolescent patients being successfully treated through injections (and about one fifth in our adult control group). We had expected a somewhat higher success rate from injection therapy but were unable to reproduce the results of others for unknown reasons.

In terms of operative treatment there was no previous literature for this age group. We were thus not able to compare our results to others, but we found that just under half of our operated adolescents could be regarded as successfully treated, compared to about two thirds of their adult controls. A large proportion of the adolescents still reported to be somewhat better from their operation, and the overall results were thus comparable to those of adults.

Summary of paper V

Kalstad AM, Knobloch RG, Finsen V. Resection of the coccyx as an outpatient procedure. Orthop Rev (Pavia). 2020;12:8813

A total of 68 patients were operated at our institution and discharged without overnight hospitalization between 2009 and 2016. The patients were selected for outpatient surgery on the basis of a relatively short travel distance to their homes (less than 2 hours). This is in contrast to the traditional method of post-operative hospitalization for several days after this procedure.

Patients were followed up via telephone after one day, clinically at three months, and a final follow-up with two questionnaires a minimum of one year after the operation. Final results and complication rates were then compared to 116 patients who had been hospitalized after the same procedure, and patient satisfaction with outpatient treatment was analysed.

We found no significant differences in overall final results or complication rates between the outpatient and the hospitalized group. We did, however find that about a third of the outpatients would have preferred overnight hospitalization due to the post-operative pain on discharge. We also found that there were significantly fewer complaints of post-operative pain when patients had been operated under spinal, rather than general anaesthesia.

Main results

Imaging

There were 33 out of 171 operated patients who had normal preoperative images. Eight of these (24%) were treatment failures at final review, compared to 32 out of 138 patients (30%) in the group with imaging pathology. Their median pain scores were 2 (IQR: 0-3) and 1 (IQR: 1-5) respectively. When asked whether they would have consented to surgery if they had known the result in advance four (12%) with normal imaging said no, compared to 14 (10%) in the other group. None of these differences were statistically significant.

Injections

Out of the 241 patients who were treated with injection therapy, 22 (9%) were pain free at the early review three to four months after the injection, and 56 (23%) were improved.

Patients with triamcinolone injections were significantly more likely to be well at the early review, compared to betamethasone ($p=0.0001$). In addition, they were less likely to require subsequent injections ($p=0.033$) or surgery ($p=0.018$).

Overall the patients treated with triamcinolone were also more likely to be regarded as successfully treated at late review ($p=0.001$).

At late review, 15% of patients treated with only one injection stated that they were either pain free or much better. There were 62 patients who had been given a second injection, and this increased the overall success rate of injection therapy to 29%.

Surgery

On an overall evaluation of the post-operative results for all patients 151 out of 171 patients (89%) would have consented to the operation if they had known the outcome in advance.

However, when patients were asked to evaluate their final result, the overall success rate (completely well or much better) was 121 out of 171 (71%). The distribution of this result was 71 patients who were completely well, 50 who were much better, 29 who were somewhat better, 14 who were unchanged, and 7 who were worse.

In terms of pain, the median 0-10 NRS pain results was 1 (IQR 4). We found that 86 out of 171 patients (50%) had no or negligible pain (a 0-10 NRS score of 0 or 1) at final review. The scores for the operated patients was distributed as follows:

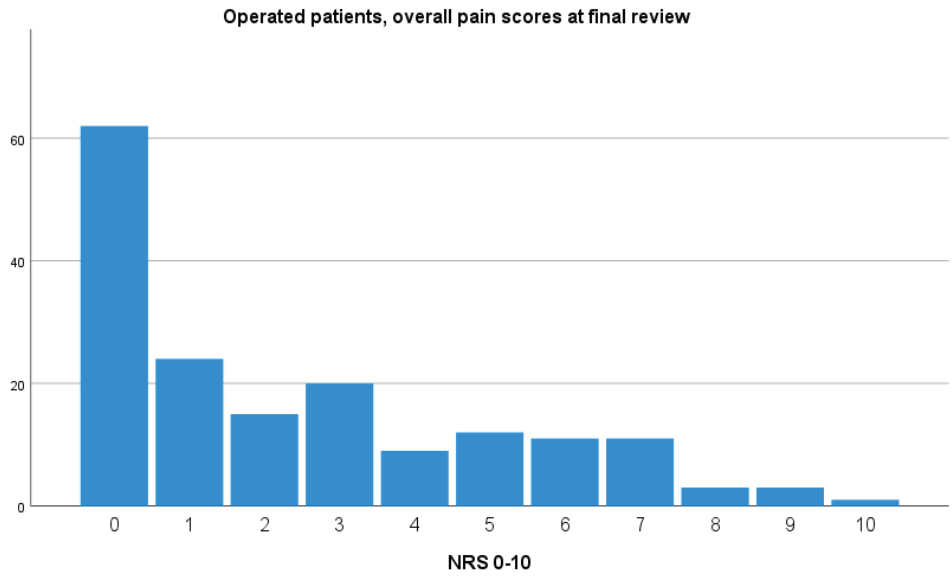

Figure VI. NRS pain score distribution of 171 operated patients at final review

When the aetiology of coccyx pain had been a trauma the success rate of surgery was 89 out of 132 patients (67%). Non-traumatic causes were successful in 32 out of 39

patients (82%; p=0.078). When comparing pain on review, traumatic aetiologies had a median pain score of 2 (IQR 5), while non-traumatic causes scored 1 (IQR 3; p=0.039).

We found no significant differences between patients when comparing complete and partial coccygectomies. However, when comparing patients where the distal edge of bone had been either left intact or bevelled off before closure, there was significantly less pain on median NRS in the intact group (1; IQR 3), as compared to the bevelled group (2.5; IQR 5; p=0.002). The intact group was significantly more likely to have consented to the operation if they had known the result in advance (77/80) than the bevelled group (74/90; p=0.004)

Adolescents

28 adolescents responded to final follow-up. Out of these 24 had initially been treated with injections, and 10 of them were later operated due to unsuccessful injection results. The remaining four adolescents had been operated without prior injections.

At the three-month review we found that seven out of 24 adolescents had been pain-free, whereas 12 experienced partial or temporary relief. Five had no improvement.

Injections had been successful in eight out of 14 patients at final review, whereas operative treatment was successful in six out of 14 adolescents. Seven adolescents were somewhat better from surgery.

Ten out of the 14 adolescents would have consented to surgery if they had known the result in advance.

In comparison, a matched adult control group showed that injection therapy had been successful in five out of 14 adults, and surgery had been successful in nine out of 14 adults. Three adults were somewhat better from surgery. 13 out of the 14 adult controls would have consented to surgery.

There were two deep infections in the adolescent group. This was also the case in the adult group.

On testing, there were no statistically significant differences between the groups.

Outpatient surgery

61 out of 68 outpatients responded to final follow-up. Out of these, 39 were satisfied with having the operation as an outpatient, while 18 explained that traveling home the same day had been painful.

Among the outpatients, 53 (87%) reported that they would have consented to surgery if the outcome had been known in advance, compared to 98 (89%) of inpatients.

There were 34 patients residing less than 30 minutes travel time from the hospital, while 27 resided between 30 to 120 minutes from the hospital. In the former group, 10 (29%) reported dissatisfaction with out-patient surgery because the journey home had been painful. In the latter group eight (30%) reported the same.

15 (83%) of the patients who reported that their journey home had been painful had been operated under a general anaesthetic, while only 3 (17%) had had a spinal anaesthetic ($p=0.048$).

When compared to inpatients, there were no differences in long-term satisfaction.

When comparing postoperative deep infections, there were no significant differences between outpatients (10%) and inpatients (8%). Neither were there any differences found with regards to superficial infections treated with antibiotics (12% among outpatients, and 14% among inpatients).

Complications

We did not experience any complications from injection therapy.

Among all 307 patients operated between 2009-2020 there were 26 (8%) deep infections requiring re-operations. There were an additional 34 (11%) superficial wound infections requiring a course of oral antibiotics.

Among the 50 operated male patents there were 16 infections (32%), whereas the 257 operated females had 44 infections (17%) (p=0.015).

In our subgroup analysis we found no significant decrease in infections from the addition of topical skin adhesive, or changing to nylon sutures. There was however a reduction in infections from 25 out of 260 to one out of 47 (p=0.018) when we extended the post-operative antibiotic prophylaxis to 48 hours.

General discussion

Imaging

Our findings have shown that normal findings on preoperative imaging do not preclude a good result from operative treatment. This is in line with Kerr et al.[47] who found no relationship between coccygeal configuration and clinical outcome after 61 coccygectomies. On the other hand, Maigne et al.[20] advise to reserve surgery for symptomatic patients with signs of hypermobility, defined as more than 25 degrees coccygeal excursion on dynamic imaging. However, a functional MRI-study by Grassi et al.[21] has shown that 9% of healthy volunteers have this type of coccygeal mobility, challenging this criterion. As our results showed that patients with normal images did as well as those with anomalies, we advise against denying surgery to patients with severe, refractory coccydynia symptoms only because their imaging studies look normal.

Injections

Our findings show that injection therapy for coccydynia, has a 15% chance of long-term success after one injection, and around twice that after two injections. Our success rate is much lower than what other authors have found, both in the short and long-term follow-up, where published results range between 50% and 80% success[28-32]. The reason for this might be that some of these studies are small, and it is unclear what the authors would define as “improvement”, “cured”, or a “satisfactory result”. Our definition of success has been rather stringent, and only the patients who stated that they were “completely well” or “much better” (and did not end up with operative treatment) at their long-term follow-up were considered successfully treated with injections.

Complications of injections

It has been reported that Triamcinolone can lead to local calcifications after injections into a lumbar disc[48, 49]. For coccygeal injections, Maigne[25] has reported four cases of local calcifications in patients injected with Cortivazol into a coccygeal disc. We did not observe this complication in any of our patients, but cannot with certainty rule it out as we have rarely obtained radiographs of MRI studies after the initial diagnostic imaging.

Another potential complication after injections with long-acting corticosteroids is local skin or soft tissue atrophy. This manifests as a painless blanching of the skin and will usually resolve spontaneously within a few months[50, 51]. None of our patients have reported this finding spontaneously, but as it is difficult to inspect one's own coccygeal area, and we have not systematically examined for this after injections, we cannot rule out that this side-effect may have occurred.

From our experience we believe that complications from this type of injection therapy are rare. The literature supports the notion that major complications, including skin atrophy, after extra-articular corticosteroid injections, are "relatively rare"[50].

Surgery

Although nine out of ten operated patients would have consented to the operation if they had known their outcome in advance, this is a subjective measurement of patient satisfaction, which should be evaluated in combination with more objective measures such as pain scores.

When the patients were asked to range their level of improvement on a Likert scale, ranging through completely well, much better, somewhat better, unchanged, or worse, we found that only 42% of operated patients were completely well. There were 29% who were much better, while 17% were somewhat better. In contrast, 8% of patients were unchanged, while only 4% were worse.

We decided that our definition of a successful operation had to be stricter than "somewhat better", and only included patients who were completely well or much better

in this category. This was our primary outcome measure. When we consider the number of patients who would have undergone the same procedure if they had known their outcome (89%), this corresponds to all the patients who had experienced improvement, also those who were only "somewhat better". Our definition of success may thus have been stricter than what the patients would define as a successful outcome.

We had regarded a pain score of 0 or 1 as a successful secondary outcome measure. This rather stringent cut-off for pain levels was chosen in case of a ceiling effect on our primary outcome measure.

When looking at the pain scores, 50% of operated patients had an NRS of 0 or 1. This corresponds to no pain or negligible pain. However, in clinical practice and published literature, a NRS pain score of 0-3 is generally regarded as mild, 4-6 as moderate, and 7-10 as severe pain[52].

When we include NRS up to 3, this cumulates to 71% of patients, and also correlates with our rather strict definition of success (completely well or much better).

Kleimeyer et al.[42] reported on 48 patients after coccygectomy and found a long-term success rate of 79%. However, their median pain VAS at final follow-up was 2, compared to a median pain NRS of 1 among our patients, suggesting that our criteria for success may have been stricter than in comparable studies.

We have found that traumatic or birth-related aetiologies are left with more pain on long-term follow-up than non-traumatic aetiologies. This is in contrast to three other studies who had slightly a higher success rate with traumatic aetilogies[4, 43, 53], and two studies who found no difference between these aetiologies[18, 47]. Kleimeyer et al., in their more recent study did however report that traumatic coccydynia did worse after surgery than idiopathic coccydynia[42]. As the evidence seems divided on this topic, we would advise against basing the choice of treatment on aetiology.

In terms of operative technique, we found no significant differences between partial (intracoccygeal level of resection) and complete (sacrococcygeal level of resection) coccygectomies. This is in line with the findings of Ogur et al.[54] who reported on 22

patients operated with either partial or complete coccygectomy and found no significant differences.

We did however find that when we bevelled off any prominent-looking distal edge of bone and left a well-rounded surface before closure, as advocated by other authors[10, 55], the results were significantly worse, both in terms of pain and willingness to consent to the operation if the result had been known in advance. A reason for this may be that such a raw bony surface, although well-rounded, can predispose to local hematoma formation and bony growth involving sensory nerve fibres. Hanley et al. presented a series of 98 operated patients where they recommended that fibrous tissue should be left on the distal aspect of the sacrum in order to minimize any ectopic bone formation[22].

Complications of surgery

The most frequent complication after coccygectomy is infection.

The infections can be a superficial skin infection, which manifests itself through delayed wound healing and some ongoing serous spotting in the bandages beyond the first post-operative week. This can be resolve with a course of oral antibiotics, combined with meticulous wound care and dressing changes. Alternatively, there can be a deep infection requiring surgical debridement. This usually manifests itself through signs of local inflammation, such as rubor, tumour, calor, or signs of wound breakdown.

Although many authors do not report superficial skin infections/delayed healing after this procedure, the rates of deep infections have been reported to range from 0-27%[4, 5, 18, 20, 22, 29, 38-40, 43, 47, 56-61] with a mean of 8%. This correlates with our findings, where the rate of deep infections during the study period was 8% (Table II).

From our subgroup analysis, we found that extending post-operative antibiotic prophylaxis to 48 hours significantly reduces deep infections from 10% to 2%. This is in line with other authors, who recommend extended antibiotic prophylaxis for this procedure[43, 54, 61].

Author	Number of patients operated	Number of infections (%)
Maigne et al.[20]	37	3 (8%)
Doursounian et al. (2004)[38]	61	9 (14%)
Perkins[29]	13	2 (15%)
Ramsey et al.[56]	15	4 (27%)
Wood and Mehbod[40]	20	3 (15%)
Karalezli et al[57]	14	2 (14%)
Hodges et al.[58]	11	3 (27%)
Pennekamp et al.[4]	16	3 (19%)
Balain et al.[39]	31	1 (3%)
Mouhsine et al.[59]	15	1 (7%)
Cebesoy et al.[43]	21	0 (0%)
Sehirlioglu et al.[5]	74	5 (7%)
Bilgic et al.[60]	25	4 (16%)
Trollegaard et al.[18]	41	5 (12%)
Doursounian et al. (2011)[61]	136	2 (1%)
Kerr et al.[47]	26	3 (12%)
Hanley et al.[22]	94	5 (5%)
Kleimeyer et al.[42]	40	4 (10%)
Present study	***307***	***26 (8%)***

Table II: Number of deep infections in present study, compared to previous litterature

Adolescents

We have identified only one paper focusing on the treatment of coccydynia in adolescents[45]. They followed 47 adolescents treated with injection therapy, and found that 40% were excellent at two-month follow-up, while 60% of their total cohort were totally or almost pain free at final follow-up, one to four years after treatment. Our

injection results were not as good, with only 29% of adolescents pain-free three months after injection, and 33% regarded as successfully treated at final follow-up.

Our long-term results of coccygectomy were somewhat better. While less than half of the adolescents were classified as successfully treated (either completely pain free or much better), compared to around two thirds of their adult controls, seven adolescents still reported to be somewhat better from the surgery, as opposed to three adults. Our stringent cut-off for success may explain why as many as 10 out of 14 adolescents still would have consented to the operation if they had known their result in advance.

From our review of the literature we found seven papers on operative treatment that have included some adolescents[4, 5, 17, 18, 28, 39, 62]. However, none reported any specified results of adolescents. There is thus a lack of evidence on this topic, but our findings suggest that adolescents can be treated in a similar manner to adults, with comparable results.

Outpatient surgery

Although several studies have been published about other previously typical in-patient procedures that have been converted to outpatient procedures[63-65], we have not found any papers about coccygectomy as an outpatient procedure. Our results suggest that this is a safe method when patients reside within two hours from the hospital and are medically fit, with an ASA score less than 2. The main caveat from this procedure is post-operative pain, worsening the journey home. Our results suggest that choosing spinal anaesthesia over general anaesthesia results in less pain in this regard, and we are as a consequence now performing most coccygectomies under spinal anaesthesia.

Strengths

-The main strength of this study is the large number of patients, combined with a high final follow-up rate (90%).

-The cohort size and standardized treatment regimens makes it possible to investigate results from subgroups of patients that have previously not been investigated, such as the adolescent group and the out-patient surgery group, and compare these results to the main patient group.

Weaknesses

-No validated scoring system for coccydynia exists. Patient reported outcome measures (PROMs) applicable to back pain were considered but found to be too imprecise for coccygeal pain. We thus decided to construct a questionnaire for coccygeal PROM, based on the Paris questionnaire for coccygeal pain[24], which is an unvalidated scoring system. It was however beyond the scope of this project to do a separate validation study of this outcome measure tool.

-A weakness of this study is that we did not have a preoperative score to compare our findings to. To mitigate this we had preoperatively confirmed the presence of pain in the specific domains that we followed. Patient were at follow-up asked to rate any improvement/worsening in these specific domains.

-Another weakness of the study was that there was no randomization of treatment modalities, which is a factor that introduces potential bias.

-The follow up period ranged from one to seven years after the treatment, which could introduce a bias, as patients might experience gradual improvement or relapse as time goes by.

Conclusions

-Normal preoperative images do not predict a worse outcome after surgery than abnormal preoperative imaging.

-Injection therapy for chronic coccydynia has a success rate between 15% and 29%. Complications are rare, and this treatment should thus be considered before surgery.

-Coccygectomy for chronic coccydynia produces good to excellent results in 71% of patients, but since the treatment carries up to an 8% risk of post-operative infections resulting in re-operations, this treatment should still be regarded as a last resort.

- There is a 4% risk of worsening after surgery

-Adolescents with chronic coccydynia can be treated surgically if injection therapy has not been successful. The results are similar to those in adults.

-Out-patient coccygectomy procedures may be regarded as a safe treatment modality for patients living near the hospital. Spinal anaesthesia should then be preferred over general anaestesia, as patients report less post-operative pain in this group.

Future directions

A validated, disease-specific Patient Reported Outcome Measure (PROM) would be a valuable instrument for the evaluation of this disorder.

There has never been a prospective randomized controlled study of this treatment. Although our research has shown very acceptable results from coccygectomy for patients with chronic pain that is refractory to less invasive therapy methods, we have not been able to account for the phenomenon of regression towards the mean[66]. Patients who experience severe pain will have a tendency of regressing towards more moderate pain over time. This potential bias could be reduced through randomization to surgery or conservative treatment.

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Appendix

Appendix 1, EHR registration form (in Norwegian)

Avsluttet: ☐ Ja ☐ Nei

Pas. nr. ☐☐☐

Kjønn: ☐ MANN ☐ KVINNE

ANAMNESE: **Symptomvarighet i mndr.** ☐☐☐

UTLØSENDE ÅRSAK: ☐ FØDSEL ☐ TRAUME ☐ VEKTTAP >5 KG ☐ IKKE KJENT

SMERTE VED SYMMETRISK SITTING	☐ JA	☐ NEI	☐ UBESVART	
SMERTELINDRING VED FREMOVERBØY	☐ JA	☐ NEI	☐ UBESVART	
SKARP SMERTE VED Å REISE SEG OPP	☐ JA	☐ NEI	☐ UBESVART	
SMERTE VED AVFØRING	☐ JA	☐ NEI	☐ UBESVART	
SMERTE VED SAMLEIE (bare kvinner)	☐ JA	☐ NEI	☐ UBESVART	☐ N/A
SMERTE VED GANGE	☐ JA	☐ NEI	☐ UBESVART	
SMERTE VED JOGGING	☐ JA	☐ NEI	☐ UBESVART	☐ N/A
-- BRUKT SITTEPUTE/-RING	☐ JA	☐ NEI	☐ UBESVART	
LINDRING AV SITTEPUTE	☐ JA	☐ NEI	☐ UBESVART	
SMERTE VED TOG/FLY/BILKJØRING	☐ JA	☐ NEI	☐ UBESVART	

KLINISKE FUNN

HYPERMOBILITET VED RUGGING	☐ JA	☐ NEI	☐ UBESVART
REPRODUKSJON AV SMERTE VED MANIPULASJON	☐ JA	☐ NEI	☐ UBESVART
ØMHET VED LOKALT TRYKK	☐ JA	☐ NEI	☐ UBESVART

RØNTGEN ☐ JA ☐ NEI

☐ PARALLELLFORSKYVNING >= 2mm ☐ SPICULA

☐ STÅR I FLEKSJON ☐ ANNEN PATOLOGI

☐ STÅR I EKSTENSJON ☐ NORMALT

MR ☐ JA ☐ NEI

☐ PARALLELLFORSKYVNING >= 2mm ☐ SPICULA

☐ STÅR I FLEKSJON ☐ ANNEN PATOLOGI

☐ STÅR I EKSTENSJON ☐ NORMALT

☐ Ingen behandling ☐ Injeksjon **Antall** injeksjoner ☐ Pas. nr. ☐☐☐

INJEKSJONSDATO 1: ☐☐.☐☐.20☐☐

☐ Celeston Chr. ☐ Lederspan ☐ N/A

RESULTATER: ☐ Ikke bra
☐ Noe bedre
☐ Midlertidig bedring varighet: ☐☐☐ dager
☐ Helt bra
☐ Ikke opplysninger

INJEKSJONSDATO 2: ☐☐.☐☐.20☐☐

☐ Celeston Chr. ☐ Lederspan ☐ N/A

RESULTATER: ☐ Ikke bra
☐ Noe bedre
☐ Midlertidig bedring varighet: ☐☐☐ dager
☐ Helt bra
☐ Ikke opplysninger

INJEKSJONSDATO 3: ☐☐.☐☐.20☐☐

☐ Celeston Chr. ☐ Lederspan ☐ N/A

RESULTATER: ☐ Ikke bra
☐ Noe bedre
☐ Midlertidig bedring varighet: ☐☐☐ dager
☐ Helt bra
☐ Ikke opplysninger

Operasjon: bedøvelsesform ☐ Spinal ☐ Narkose ☐ Ubesvart

☐ Totalfjernet Cx1 ☐ S5 tiljevnet ☐ Cx1 part. resescert ☐ Cx1 intakt ☐ Ubesvart

Reoperert pga.smerter ☐ Nei ☐ Ja Reop. dato: ☐☐.☐☐.20☐☐

Infeksjon med reop ☐ Nei ☐ Ja 1. Reopdato: ☐☐.☐☐.20☐☐

2. Reopdato: ☐☐.☐☐.20☐☐ 3. Reopdato: ☐☐.☐☐.20☐☐

Infeksjon/forsinket tilheling med bare AB-behandling ☐ Ja ☐ Nei

Appendix 2, Patient follow-up form (in Norwegian)

Nr. ☐☐☐

Vi ber deg om å rangere smertene du opplever **nå** i forhold til dine smerter **før** behandlingen ble startet.

Det vi spør etter er hvordan du opplever smertene i området rundt halebenet eller området der halebenet satt tidligere. Hopp **bare** over spørsmål om du aldri har hatt denne plagen.

Sett bare **ett kryss** på hver linje

	Helt borte	**Mye mindre**	**Noe mindre**	**Uendret**	**Verre**
Smertene ved sitting er	☐	☐	☐	☐	☐
Jeg har en kortvarig økt smerte i det jeg reiser meg fra sittende:	☐	☐	☐	☐	☐
Jeg har smerter rundt halebenet under avføring	☐	☐	☐	☐	☐
Jeg har smerter ved samleie (besvares bare av kvinner)	☐	☐	☐	☐	☐
Jeg har smerter ved gange/jogging	☐	☐	☐	☐	☐
Jeg har smerter når jeg sitter i bil, fly, buss eller tog	☐	☐	☐	☐	☐

	Aldri	**Mye sjeldnere**	**Noe sjeldnere**	**Uendret**	**Oftere**
Jeg bruker halebenspute eller ringpute	☐	☐	☐	☐	☐

	Ubegrenset	**Mye lengre**	**Noe lengre**	**Uendret**	**Kortere**
Tidsrommet jeg kan sitte smertefritt er	☐	☐	☐	☐	☐

Kan du angi hvor mye halebeinsrelaterte smerter du har hatt i gjennomsnitt <u>den siste uken:</u>

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Ingen smerter — Verst tenkelige smerter

Hvordan vurderer du behandlings-resultatet per i dag? Sett bare ett kryss.

Jeg er: Helt bra	**Mye bedre**	**Noe bedre**	**Uendret**	**Verre**
☐	☐	☐	☐	☐

Om du ble operert, ber vi deg å krysse av på følgende:

Jeg ville latt meg operere om jeg hadde visst utfallet på forhånd: ☐ Ja ☐ Nei

Appendix 3, outpatient surgery follow-up form (in Norwegian)

Nr. ☐☐☐

Kjære pasient!

Du ble i tidsrommet 2009 til 2015 operert med fjerning av halebenet ved St. Olavs Hospital som **dagkirurgisk** pasient. Det vil si at du ble utskrevet på operasjonsdagen.

Vi ber deg om å svare på følgende spørsmål:

1. Dagkirurgi

☐ Jeg synes at dagkirurgisk operasjon fungerte bra

☐ Jeg hadde ønsket å kunne være innlagt på sykehuset over natten

☐ fordi hjemreisen var veldig smertefull

☐ pga. andre praktiske problemer

Du ble oppringt dagen etter av en sykepleier ved Ortopedisk dagkirurgi.
Var du fornøyd med svarene du fikk på dine spørsmål?

☐ Ja ☐ Nei ☐ Ble ikke oppringt ☐ Ble oppringt, men husker ikke

2. Type bedøvelse (Svar enten for spinal eller narkose):

☐ Jeg fikk spinal

Spinalbedøvelsen fungerte bra ☐ Ja ☐ Nei

Jeg hadde følgende problemer:

☐ Kvalme

☐ Mye smerter

☐ Svimmelhet

☐ Hodepine

☐ Jeg angrer på spinal og hadde heller foretrukket narkose

☐ Jeg fikk narkose

Narkosen fungerte bra ☐ Ja ☐ Nei

Jeg hadde følgende problemer:

☐ Kvalme

☐ Mye smerter

☐ Svimmelhet

☐ Hodepine

☐ Jeg angrer på narkose og hadde heller foretrukket spinal

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SPINE

Corticosteroid injection for coccydynia

A REVIEW OF 241 PATIENTS

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Aims

We aimed to establish the short- and long-term efficacy of corticosteroid injection for coccydynia, and to determine if betamethasone or triamcinolone has the best effect.

Methods

During 2009 to 2016, we treated 277 patients with chronic coccydynia with either one 6 mg betamethasone or one 20 mg triamcinolone cortisone injection. A susequent injection was given to 62 (26%) of the patients. All were reviewed three to four months after injection, and 241 replied to a questionnaire a mean of 36 months (12 to 88) after the last injection. No pain at the early review was considered early success. When the patient had not been subsequently operated on, and indicated on the questionnaire that they were either well or much better, it was considered a long-term success.

Results

At the three- to four-month review, 22 (9%) reported that they had no pain. The long-term success of one injection was 15% and rose to 29% after a second injection. Logistic regression tests showed that both early success (odds ratio (OR) 5.5, 95% confidence interval (CI) 2.1 to 14.4; p = 0.001) and late success (OR 3.7, 95% CI 1.7 to 8.3; p = 0.001) was greater with triamcinolone than with betamethasone. Late success was greater for patients with symptoms for less than 12 months (OR 3.0, 95% CI 1.4 to 6.7; p = 0.006). We saw no complications of the injections.

Conclusion

We conclude that the effect of corticosteroid injection for coccygodynia is moderate, possibly because we used modest doses of the drugs. Even so, they seem worthwhile as they are easily and quickly performed, and complications are rare. If the choice is between injections of betamethasone or triamcinolone, the latter should be selected.

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Keywords: Coccyx, Coccygodynia, Coccydynia, Pain, Corticosteroid injection, Triamcinolone, Betamethasone, Tailbone

Introduction

The tailbone was named coccyx (the Greek word for cuckoo) by the physician Herophilus, who was active in Alexandria around 300 BC, presumably because he felt it looked like the head and beak of a cuckoo when seen from the side.[1] In 1859, Simpson[2] first applied the term coccygodynia, or contracted to coccydynia, to non-radiating pain at the distal end of the spine, characteristically induced by sitting. The aetiology is unclear and probably multifactorial, but a high proportion is attributed to trauma and childbirth.[3-5]

Despite numerous studies on aetiology and treatment, a sceptical sentiment seems common among physicians. Hourigan et al[6] surveyed 200 GPs in Devon, UK, and found that 39% believed the condition to be associated with an underlying psychological disorder, 52% believed there was no proven treatment for the condition, and only 22% would consider referring the patient to a secondary care service.

Although the causes of coccydynia are often unclear, patients frequently relate it to a trauma, and it has been reported that successful treatment is more likely if this is the aetiology.[3,5,7] Mitra et al[8] reported that

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Table I. Number of results at late review among the 114 patients who had only had injection treatment.

Pain on	Before injection	Completely well	Much better	Someone better	Unchanged	Worse	Success, %*
Sitting	110	17	40	17	30	6	52
Rising	80	23	23	9	22	3	58
Defecation	33	11	8	2	11	1	58
Walking/jogging	51	16	12	4	17	2	55
Public transport	101	10	33	21	25	12	43
Sex (female)§	32/87	11	7	3	11	0	56%
	Before injection	**Never**	**Much less**	**Somewhat less**	**Unchanged**	**More often**	**Success, %†**
Use of a sitting ring/cushion	72	40	8	4	14	6	67
	Respondents	**Unlimited**	**Much longer**	**Somewhat longer**	**Unchanged**	**Shorter**	**Success, %‡**
Duration of pain-free sitting	113	3	49	15 29	29	7	55

*Proportion of patients who reported to be completely well or much better.
†Proportion of patients who reported that they never or much less often used a sitting ring.
‡Proportion of patients who reported that pain-free sitting time was unlimited or much longer.
§Pain among females on sexual intercourse.

success is more likely if symptoms have been present for less than six months.

A multitude of treatments have been suggested. Some recent review papers[9,10] agree that if conservative measures fail, patients may benefit from a local corticosteroid injection. The purpose of this study was to evaluate the efficacity of corticosteroid injection as a treatment for coccydynia in the short- and long-term and to compare the effects of triamcinolone and betamethasone.

Methods

In all, 277 patients with chronic coccydynia were treated with corticosteroid injection for coccydynia in our department during 2009 to 2016. The diagnosis of coccydynia was made by a senior spinal surgical consultant (RGK) based on a thorough medical history, clinical examination, and imaging with either radiographs, magnetic resonance imaging (MRI), or both of the coccyx.

Betamethasone 1 ml (Celeston Chronodose 6 mg; Schering-Plough, Kenilworth, New Jersey, USA) was used during the first part of the study period and mainly triamcinolone 1 ml (Lederspan 20 mg; Meda, Solna, Sweden) during the latter. The corticosteroid used was thus not random. Both were mixed with 1 ml 1% lignocaine before injection. We used the method described by Kersey[11] of direct injection in the most painful level of the coccyx, usually the sacrococcygeal or Co1 to Co2 level, under digital intrarectal control without fluoroscopic imaging (Figure 1).

Patients were first reviewed three to four months after injection, and we recorded the effect of the injections. Those who had improved partially or temporarily were offered a second injection. This was given to 69 (25%) patients, and a third injection to ten (4%).

Patients who still complained of severe symptoms at the end of the course of injections were offered operative coccygectomy. The follow-up with regard to surgery was extended to the present with the aid of the hospital records. For geographical reasons, as our hospital is the only one in a large area that performs this type of surgery, it is highly unlikely that they would have been operated elsewhere. All those who eventually were operated were automatically considered failures of injection therapy.

All patients were followed up with mailed questionnaires a minimum of 12 months after the last injection. Those who had not responded to the questionnaires after six weeks were contacted by telephone as a reminder and received new questionnaires if they wished.

At this late review, general coccydynia symptoms and symptoms in various aspects of daily life (Table I) were scored as completely well, much better, somewhat better, unchanged, or worse. We regarded the patients who reported that they were completely well, or much better, at late follow-up as successfully treated. If the patients were either somewhat better, unchanged, or worse, they were regarded as treatment failures.

Overall, 250 patients (90%) responded to the follow-up questionnaire. In nine cases, the type of corticosteroid used had not been recorded and these patients were excluded from further consideration. There were 196 (81%) women among the remaining 241 patients. Their mean age at the first outpatient visit was 40 years (11 to 75). At the time of referral, they reported to have had symptoms of coccydynia for a mean of 37 months (2 to 348). A total of 144 (59%) ascribed their condition to a trauma, 42 (17%) to childbirth, ten (4%) to pronounced weight loss, while 50 (21%) knew of no cause. A few gave more than one reason.

Table II. General results of one injection with either betamethasone or triamcinolone.

Variable	Betamethasone	Triamcinolone	p-value*
Number of patients	173	68	
Pain free three to four months after injection, n (%)	8 (5)	14 (21)	0.000
Subsequent injection, n (%)	51 (29)	11 (16)	0.033
Number operated, n (%)	103 (61)	29 (44)	0.018
Success of one injection, n (%)	17 (10)	18 (26)	0.001

Success was defined as those who had not been operated and replied at late review that they were well or much better.
*Chi squared test.

The time between last injection and the questionnaire at late follow-up was 39 months (12 to 88) for the 173 patients who had had a betamethasone injection as their first injection, and 28 months (14 to 53) among the 68 where triamcinolone had been given as the first injection. With regard to surgery, this was extended by use of the hospital records to 82 months (42 to 139) for the former group of patients, and to 72 months (44 to 103) for the latter.

Statistical analysis. The statistical evaluation of the data was with the chi squared test and stepwise logistic regression. The study protocol was considered by the regional committee for medical and health research ethics (2016/460), who found that it did not need their approval.

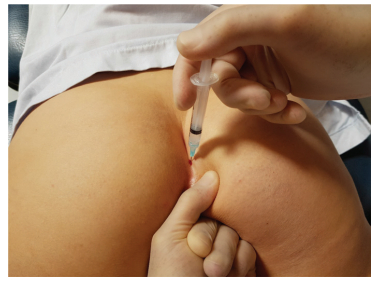

Fig. 1
Method of corticosteroid injection.

Results

At the time of the early review at three to four months after the first injection, 22 (9%) of the patients reported that they were pain-free, and 56 (23%) that they were improved. The patients with one triamcinolone injection significantly more often reported that they were well at this early review, compared to patients injected with betamethasone (Table II). They were also significantly less likely to need a subsequent injection or surgery.

A total of 136 patients went on to surgery. At late review, 35 of the non-operated patients who had only had one injection reported that they were well or much better, indicating a long-term success rate of one injection of 15%.

In all, 62 patients had a subsequent injection. There were 51 among those who had originally had a betamethasone injection, and 11 who had had a triamcinolone injection, as their first injection (p = 0.033, chi squared test; Table II). This second injection increased the overall late success rate (not subsequently operated and well or much better at late review) to 29%.

Among the 114 patients who had only received injection treatment the mean pain scale rating for pain (0 to 10) during the last week before late review was 3.6 (standard deviation (SD) 2.7). The rate of late success among these patients was 53% and fairly evenly distributed among the various domains of daily activities investigated (Table I).

When patients were divided according to duration of symptoms for less or more than 12 months, it was found that the outcome after one injection was significantly better among those who had had symptoms for the shorter period (Table III). The need for surgery was also lower in this group of patients. Both observations were mainly due to a particularly favourable outcome among those who had received a triamcinolone injection.

There was a trend towards less surgery among patients who felt that the reason for their coccydynia was either a trauma or childbirth than among those who cited pronounced weight loss or did not know of any reason (p = 0.094, chi squared test). This applied to both the group as a whole and to those who had received a triamcinolone injection.

Logistic regression with early success (pain free at the three- to four-month review) after one injection as the dependent variable and sex, age, traumatic aetiology, type of corticosteroid injection, and duration of symptoms for more or less than 12 months as independent variables, showed that only the type of corticosteroid used was significant. The odds ratio (OR) for triamcinolone to be better than betamethasone at this point was 5.5 (95% confidence interval (CI) 2.1 to 14.4; p = 0.001, logistic regression).

The same test with late success (not operated and well or much better at late review) as the dependent variable showed that sex and age were without significance and that trauma was borderline. However, the OR for a better outcome with triamcinolone and with symptoms for less than one year were both more than three (Table IV).

Table III. Results when duration of symptoms had been less or more than one year on success of treatment (not operated and well or much better at late review) of the first injection and on the need for surgery.

Variable	Number	Success, n (%)	Surgery, n (%)
Betamethasone			
Less than one year	63	10 (16)	33 (52)
More than one year	110	8 (7), p = 0.074*	72 (65), p = 0.090*
Triamcinolone			
Less than one year	18	9 (50)	3 (15)
More than one year	50	9 (18), p = 0.008*	27 (54), p = 0.006*
All patients			
Less than one year	81	19 (23)	36 (44)
More than one year	160	17 (11), p = 0.008*	99 (62), p = 0.010*

*Chi squared test.

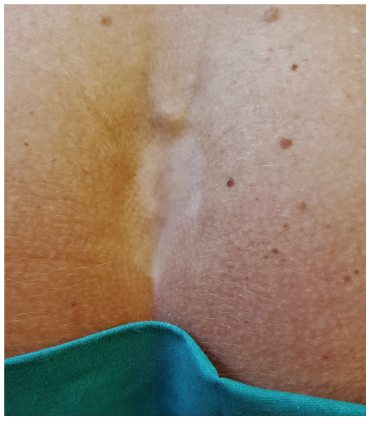

Fig. 2

Skin atrophy after corticosteroid injection of a patient not included in the present series.

No patient reported spontaneously that they had noticed any lasting discomfort or blanching of the skin in the injected area.

Discussion

Traditionally, injection therapy has been aimed at the most painful points on the patients' coccyx, often the sacrococcygeal or Co1 to Co2 levels. However, an increasing number of papers report on injection with corticosteroid and local anaesthetic into the ganglion impar, also known as the ganglion of Walther, which is located in the midline anterior to the sacrococcygeal junction.[12,13] Others have reported on prolotherapy where a larger volume of liquid is injected around the dorsal aspect of the coccyx with the aim of causing fibrosis of the soft tissues.[14] We do not have any experience of either of these treatment methods.

Although traditional corticosteroid injection seems to have become an established therapeutic option among those who treat coccydynia,[9,15,16] we have been able to identify only a few papers that describe first-hand experiences with its use. This contrasts with the considerable number of papers reporting on the more controversial coccygectomy. Wray et al,[17] in their seminal prospective study of 120 patients, found that 17 of the 29 patients (60%) who had only had an injection were improved after injection with 40 mg methylprednisolone and local anaesthetic. The follow-up period was on average two years and nine months. Perkins et al[18] reported that 62 of 77 patients had been successfully treated with injection with long acting corticosteroid and local anesthetic. The remainder were operated on. Mitra et al[8] reported on 14 patients injected with 80 mg triamcinolone and a local anesthetic and found that seven were improved at follow-up after three weeks. Yaganeh et al[19] treated 30 patients with an injection of 40 mg methylprednisolone and local anesthetic. The mean pain scores were 5.9 before injection and 2.1 after two months. Kodumuri et al[5] injected 201 coccydynia patients with 40 mg triamcinolone and local anesthetic, and found that 80% were cured at the six-week review.

Table IV. Results of stepwise logistic regression analysis of late success (not operated and well, or much better at late review) after one corticosteroid injection.

Variable	p-value*	Odds ratio	95% CI
Traumatic aetiology	0.076	0.48	0.22 to 1.08
Triamcinolone	0.001	3.74	1.70 to 8.25
Symptoms < 12 months	0.006	3.03	1.37 to 6.71

*Logistic regression test.
CI, confidence interval.

Our own overall results are not nearly as good as in these studies. Some of them are small, however, and it is also unclear what these authors consider "improvement", "cured" or a "satisfactory result". We have defined our successful outcome of injection therapy stringently and found that 15% of patients have a successful long-term outcome after one injection and around twice that number after two injections. Furthermore, in most of the cited studies the observation period was extremely short. It seems possible that their results would not have been as good in the longer term. Finally, it is perhaps noteworthy that we have used a relatively small dose of corticosteroid; it is possible that our results would have been better with a higher dosage.

We have performed the injections in the manner described by Kersey[11] with the patient lying in the right lateral or prone position and the physician's left index finger palpating the front of the coccyx from the rectum (Figure 1). We have had no difficulties injecting the sacrococcygeal joint or any other particularly painful area as determined by the clinical examination. We have not found any need for fluoroscopic control or radiograph guidance in order to avoid perforating the rectum.[5,8,14]

Mitra et al[8] reported that those who had had symptoms for less than six months responded better to treatment than those with a longer duration of symptoms. We had very few patients with a duration of symptoms as short as this and chose 12 months as the cut-off point. Results were significantly better in those with the shorter duration of symptoms. It is not certain that this is due to the injection. Some with short duration of symptoms may have improved spontaneously. Lirette et al[10] point out that many cases of coccydynia resolve without medical treatment.

Some authors[3,5,7] report that traumatic aetiology indicated a more favourable result of coccygectomy, while Trollegaard et al[4] found that the outcome was similar whether the symptoms were traumatically induced or idiopathic in origin. There was a trend for a better result after trauma or parturition among our injected patients, but the difference did not reach statistical significance.

The beneficial action of corticosteroids is presumed to be due to its anti-inflammatory effect. Betamethasone is around five-times as potent in this respect as triamcinolone. Even when the smaller dose of betamethasone is taken into account, our betamethasone injection is around 50% more potent than our dose of triamcinolone. It is therefore somewhat surprising that triamcinolone should prove to be significantly more effective than betamethasone with regard to early results, late results, and the need for surgery.

However, triamcinolone is reported to have led to local calcification after injection into a lumbar disc,[20,21] and Maigne[15] reported calcifications in four patients injected with cortivazol into a coccygeal disk. We did not observe this complication in any of our patients, but we rarely obtained radiographs or MRI studies after the original work-up.

Skin and soft tissue atrophy at the site of injection may occur occasionally with long-acting corticosteroids such as triamcinolone (Figure 2).[22,23] This is noted as a painless blanching of the skin and usually resolves after some months.[22] We did not record this systematically, and none of our patients reported it spontaneously, possibly because it is difficult to inspect one's own coccyx area. Brinks et al[23] reviewed the literature from 1956 to 2010 and found 87 papers reporting on complications after extra-articular injection of corticosteroid. They concluded that major complications, including skin atrophy, are "relatively rare" and that these injections are "relatively safe".

An additional benefit from injections with local anesthetics is that they may help to confirm the diagnosis. Although we did not record this systematically, we found that very many patients experienced relief from their symptoms for the few hours that the 1 ml of local analgesic was active, thus confirming the diagnosis of coccydynia.[9,19]

Although far from all coccydynia patients benefit substantially from corticosteroid injections, we still feel that they are well worth performing. The procedure is easy, takes little time, and has few complications. Other non-operative treatment methods do not seem as well supported by evidence of efficacy.

We conclude that around 15% of coccydynia patients are satisfied in the long-term with one corticosteroid injection. This rises to around 29% after a second injection. Duration of symptoms of less than one year increases the rate of success. If the choice is between injections of betamethasone or triamcinolone in the treatment of coccydynia, the latter should be selected. Improvement is earlier, fewer patients will need a second injection, and fewer patients will need surgery.

Take home message

- In the long-term, 15% of patients are relieved of symptoms after one injetion and 29% after two injections.
- Duration of symptoms of less than one year increases the rate of success of injections.
- Triamcinolone injections work better than betamethasone for coccydynia.

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Author contributions:

- V. Finsen: Planned the study, Analyzed the data, Wrote the manuscript.
- A. M. Kalstad: Planning the study, Collected and analyzed the data, Wrote the manuscript.
- R. G. Knobloch: Planned the study, Collected the data, Reviewed the manuscript.

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Paper III

Paper IV

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GENERAL ORTHOPAEDICS

The treatment of coccydynia in adolescents

A CASE-CONTROL STUDY

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Aims

To determine if the results of treatment of adolescents with coccydynia are similar to those found in adults. Adult patients with coccydynia may benefit from injection therapy or operative treatment. There is little data evaluating treatment results in adolescents. We have treated adolescent patients similarly to adults and compared the outcomes.

Methods

Overall, 32 adolescents with coccydynia were treated at our institution during a seven-year period; 28 responded to final follow-up questionnaires after a minimum of one year, 14 had been treated with only injection therapy, and 14 had been operated with coccygectomy. We collected data with regards to pain while sitting, leaning forward, rising from a sitting position, during defecation, while walking or jogging, and while travelling in trains, planes, or automobiles. Pain at follow-up was registered on a numeric pain scale. Each adolescent was then matched to adult patients, and results compared in a case control fashion. The treatment was considered successful if respondents were either completely well or much better at final follow-up after one to seven years.

Results

Out of the 28 treated adolescents, 14 were regarded as successfully treated. Seven were somewhat better, and the remaining seven were unchanged. In the adult control group the corresponding number was 15 successfully treated, eight patients were somewhat better, and five were unchanged. Six of the 14 successfully treated adolescents had been operated. There were no significant differences between the groups in the various registered domains, or on numeric pain scale.

Conclusion

Treatment results in adolescent patients seem similar to those in adults. The long-term success rate of injection therapy is low. In case of injection treatment failure, operation may be considered, also in adolescents.

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Keywords: Coccyx, Coccydynia, Adolescent, Coccygectomy

Introduction

Coccydynia is a condition associated with pain around the lower end of the spine, particularly when sitting. The exact prevalence of this condition is not known,[1] but Ghormley in 1958 found that it encompassed 2.7% of all hospital presentations with back pain.[2]

Most review papers on coccydynia conclude that both corticosteroid injections and surgery can be beneficial.[3-7] However, published papers also indicate a seeming reluctance to employing these methods in young patients. This is particularly noticeable with regard to surgery. We have found 24 relevant papers on coccygectomy in the literature.[8-31] Although coccydynia may certainly affect adolescents, only seven of these included patients under the age of 18 years.[25-31]

We have treated our patients without regard to age. Coccydynia in adolescents has

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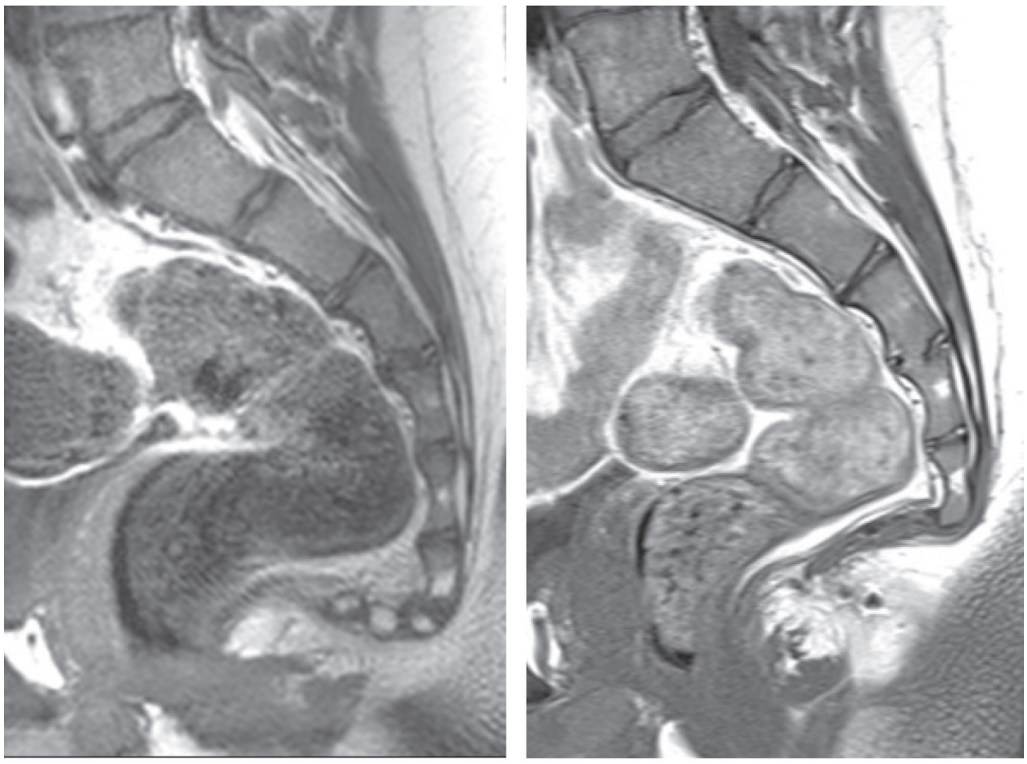

a b

Fig. 1

a) 13-year-old boy at referral. b) After surgery.

a serious impact on daily social activities, sports and, most importantly, on their school education which usually involves long periods of sitting. We have reviewed our own patients in order to compare our results in adolescents to those in adult patients in a case-control fashion.

Methods

In all, 358 patients with chronic coccydynia were referred to our institution during the period 2009 to 2016. A total of 43 (12%) of these were adolescents with a mean age of 15 years (11 to 17). There were 36 girls and seven boys.

The patients were referred to our institution by general practitioners and other hospitals after having failed conservative therapy. All adolescent patients were investigated, diagnosed and treated in a similar manner to adults.

The diagnosis of coccydynia was made by a senior spinal surgical consultant (RGK) based on a thorough medical history, clinical examination and imaging with either coccygeal radiographs, MRI, or both (Figures 1 and 2).

Patient characteristics were recorded, including the aetiology of the coccygeal pain and the history of onset (Table I). A total of 31 (72%) had experienced a trauma, while one girl had coccydynia after giving birth at age of 15 years. The remaining 11 did not know the cause of their pain. The condition was regarded as chronic if patients had been symptomatic for more than two months.

We recorded the presence of pain in the following domains: sitting, leaning forward, rising from a sitting position, during defecation, while walking or jogging, and while travelling in trains, planes, or automobiles.

Rectal examination was feasible in most cases, usually with a parent alongside the patient. On this examination, we noted the presence of pain from local pressure, reproduction of pain by manipulation of the coccyx, and coccygeal hypermobility.

Almost all patients had been advised some form of conservative treatment during the months between referral and out-patient examination. All patients were therefore offered a targeted lidocaine/corticosteroid

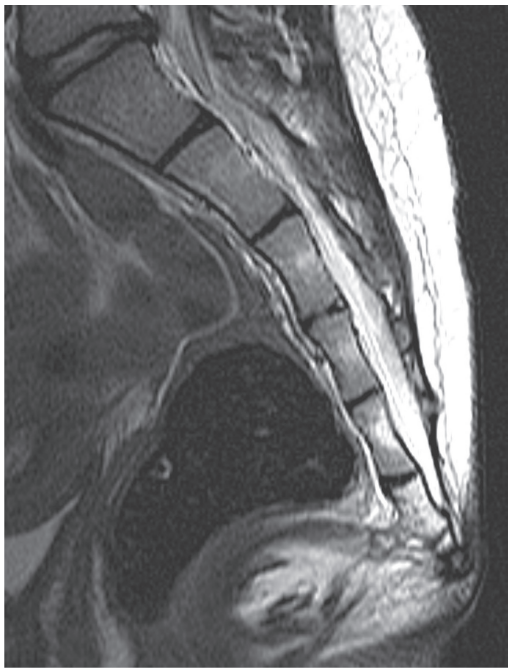

Fig. 2
MRI of 15-year-old boy with bony spicula from coccyx.

Table I. Causes of coccydynia in adolescents.

Cause	n
Fall	10
Winter sport	5
Bicycle/skating/horse riding	3
Gym/sports/play	11
Other trauma	2
Birth-related	1
Not known	11
Total	43

injection either at the first or a subsequent out-patient visit. In all, 11 adolescents received no treatment and were excluded from further consideration. We used a standardized method of direct injection in the most painful level of the coccyx, usually the sacrococcygeal or Co1-Co2 level, under digital intrarectal control without fluoroscopic imaging as described by Kersey[32] and Finsen.[33] A total of 21 had one injection, four had two injections, and two had three injections. Patients who were afraid of possible injection pain and refused treatment were offered injection during a short intravenous anaesthesia.

In case of treatment failure with injection therapy, patients were offered surgery with partial or total coccygectomy, with the technique described by Key.[34] Surgery was performed in 12 such adolescents. In addition, five were operated without previous injection.

All treated patients were reviewed clinically three months after the last injection or surgery. At a minimum of 12 months after treatment, the patients were further followed-up with mailed questionnaires. Patients who had not responded to the questionnaires were contacted by telephone after six weeks as a reminder. They received new questionnaires if they wished. The mean time to final follow-up was 34 months (12 to 86).

Pain in the previously registered domains and overall result were at follow-up scored in the following fashion: completely well, much better, somewhat better, unchanged, or worse. Patients who were completely well or much better at final follow-up were regarded as successfully treated. If the patients were either somewhat better, unchanged, or worse we regarded them as treatment failures. Patients who were not satisfied with the results of injection therapy and therefore continued to operative treatment were automatically regarded as failures of injection therapy.

In addition, patients scored pain during the last week on numeric pain scales from 0 to 10. The operated patients were also asked whether they would have consented to the operation if they had known the outcome in advance.

Overall, 28 treated adolescents (88%) responded to our final follow-up and constitute the index patients of our review (Figure 3). The four who were lost to follow-up were equally distributed between the operative and non-operative groups. Of the index patients, 14 received only injection therapy, with a mean follow-up of 37 months (18 to 66), and 14 were operated upon, with a mean follow-up of 35 months (14 to 64).

Each adolescent was then matched to adult controls who had undergone the same treatment for coccydynia during the same time-period. The matching was done for sex, number of injections given, whether they were subsequently operated, and duration of follow-up (± six months) after final injection or operation. When there were multiple available matches, median results were recorded. No match was available for one child and the follow-up duration had to be extended by two extra months in order to find a match.

The results were then analyzed, comparing the index patients to adult controls with chi-square testing of dichotomous results, non-parametric testing for all functional domains and independent samples *t*-tests to compare numeric pain scores. The study protocol was reviewed by the regional committee for medical and health research ethics in central Norway who found that it did not need their approval.

Results

Out of the 28 treated adolescents, 14 were regarded as successfully treated (seven completely well and seven

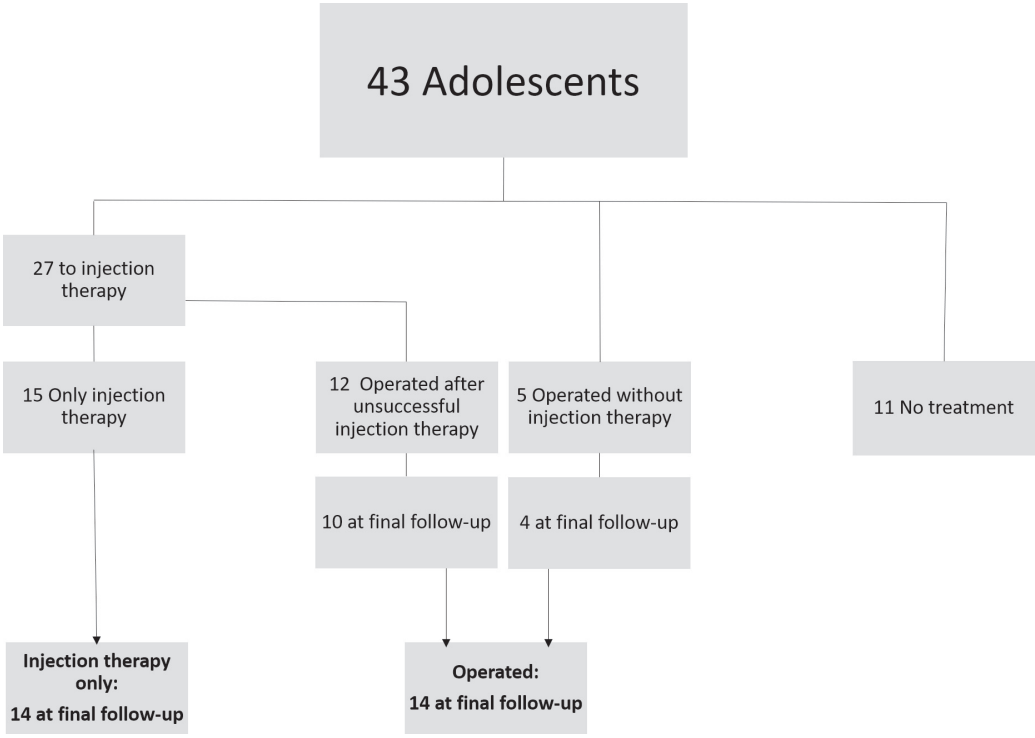

Fig. 3
Flowchart of patients included in study.

much better at final follow-up). Seven were somewhat better and the remaining seven were unchanged. For the adult controls, 15 were regarded as successfully treated (four completely well and 11 much better), eight were somewhat better, and the remaining five were unchanged.

The average 0 to 10 pain score among all treated adolescents at final follow-up was 3.4, while it was 3.3 in the adult control group.

Injection therapy. In our short-term results (three months after final injection), we found that seven of the 24 patients were completely well, seven were somewhat better, five had experienced a temporary period of relief before relapsing, and five had no improvement. At the final follow-up, injection therapy was successful in eight injected index patients (completely well or much better).

In the adult control group, four were completely well at the short-term follow-up, seven were somewhat better, five had temporary relief followed by a relapse, and eight had not experienced any improvement. At the final follow-up five adults were found to be successfully treated by injection therapy. There were no adverse events from the injections.

Operative treatment. Operative treatment was successful in six out of 14 adolescents. In the adult control group, nine out of 14 were considered a success. On a scale from 0 to 10, the operated adolescents had a mean pain score of 3.9 at final follow-up, while it was 2.6 in the adult control group. When asked whether they would have consented to the operation if they had known the result in advance ten out of the 14 operated adolescents, answered yes. In the adult control group 13 answered yes.

Operative treatment was complicated by two deep infections in the adolescent group, requiring surgical debridement. This was also the case in the adult control group.

On statistical testing we found no significant differences between the adolescents and the adult controls, regardless of which treatment modality had been used, with regard to both numeric pain scores or the various pain domains (Table II).

Table II. Results among operated adolescents.

	Number before operation	At review				
		No pain	Much better	A bit better	No change	Worse
Pain on symmetrical sitting	14	3	2	6	2	1
Adult controls	*14*	*3*	*6*	*3*	*1*	*1*
Pain on rising	11	3	2	2	4	1
Adult controls	*11*	*7*	*2*	*0*	*2*	*0*
Pain on defecation	11	8	2	2	0	0
Adult controls	*11*	*9*	*1*	*1*	*0*	*0*
Pain on walking	13	6	4	1	2	0
Adult controls	*13*	*5*	*4*	*3*	*0*	*1*
Pain in public transport	14	1	1	6	2	2
Adult controls	*14*	*2*	*7*	*2*	*3*	*0*

Discussion

As this review did not involve randomized control groups, there is a potential for selection bias despite systematic matching. Adult patients may be more positive towards undergoing both injection therapy and operative treatment than adolescents, which could influence the choice of treatment. In addition, as this is a relatively uncommon condition the number of index patients is low. Furthermore, we did not match the patients and controls with regard to aetiology as this would have left many adolescents without controls.

Like in all studies of adults, there was a strong preponderance of females. It is unlikely that girls are more physically active than boys at this age and injure themselves more often. We presume therefore, like others authors, that the reason for the sex ratio of 5:1 may be due to anatomical differences in the shape of the pelvis.[3] Woon found that female coccyges were shorter and straighter and may be more prone to retroversion.[35]

We have found only one paper where the focus is on the treatment of adolescents.[36] It reported on a retrospective follow-up of 53 adolescent patients, which comprised 7% of their total coccydynia population. We found that 12% of our patient population with coccygeal pain were adolescents. The authors, Maigne et al, included patients below 17 years of age, whereas we have included patients below 18 years, which harmonizes with the definition of childhood in most countries, and this may explain a higher prevalence.

In Maigne and co-workers' study, only three patients had surgery, although not before turning 18 years, when they were no longer adolescents. They investigated 47 adolescents who received injection therapy. At two-month follow-up 19 (40%) had an excellent result, ten (21%) had partial relief or relapse, and there was insufficient or no benefit in 18 (38%). At their final follow-up, one to four years from initial presentation, they did not specify the results of the injected patients, but in their total patient cohort 32 of 53 (60%) patients were reported as totally or almost pain free, 12 (23%) had moderate pain, and nine (17%) had severe pain and major functional impairment.

Our results were not as good. In our short-term results (three months after final injection), we found that only 7/24 were completely well, 12/24 had partial relief or relapse, and 5/24 had no improvement. In our long-term results, injection therapy was rated as successful (completely well or much better) in 8/24 of injected adolescents.

Our long-term results of injection therapy indicate that such injections are unlikely to provide lasting results in most patients. Only one-third of our injected adolescents and around one-fifth of their adult controls were completely well or much better from this modality. We do, however, regard it as a safer option than operative treatment in terms of adverse events and believe that injection therapy should still be tried before operative treatment.

The discussion whether to operate on adolescents or wait until skeletal maturity is challenging, and very little literature on this topic exists. The fact that juveniles seem to make up 7% to 12% of the patient populations, but only a few are reported in the literature to have been operated, seems to indicate a reluctance to submit them to surgery.

Reviewing the published evidence, we found seven papers presenting operative treatment that included adolescents, but none reported the specific results of the adolescents.[25-31] Only Margo[26] reported results of four operated adolescents, but only included results after one to two months' follow-up.

There is thus no comparative literature available, but our long-term results show that less than half of our operated adolescents can be regarded as successfully treated, compared to around two thirds in the adult control group. However, our definition of success only included patients who were found to be completely well or much better at final follow-up. Seven of the operated adolescents that we classified as failures at final follow-up still reported that they were somewhat better. This may explain why

as many as ten out of 14 adolescents reported that they would have consented to the operation if they had known the result in advanced.

The operative results seem better than our results of injection therapy, but since surgical coccygectomy involves a higher risk of complications, we believe that it is reasonable to reserve surgery for the most severe cases.

This is by far the greatest number of operated adolescents with coccydynia reported in the literature, but the number is still small and unlikely to reveal statistically significant differences. Even so, our results do give the general impression that, seen together, results are similar to those obtained among adults. We shall therefore continue to offer our adolescent patients cortisone injections and to consider the possibility of surgery when neither sitting aids, painkillers, or repeated injection therapy has had sufficient effect.

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Paper V

Resection of the coccyx as an outpatient procedure

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Abstract

We wished to determine if coccygectomy as an outpatient procedure is a safe alternative to inpatient treatment. 68 patients were treated at our institution with coccygectomy as an outpatient procedure during a seven-year period. Out of these 61 (90%) responded to final follow-up questionnaires after a minimum of one year. We recorded satisfaction with the outpatient modality, and compared postoperative complications and long-term satisfaction with patients who had been operated as inpatients during the same period. Out of the 61 patients who responded to final follow up, 39 (64%) were satisfied with having the operation as an outpatient procedure. The patients who would have preferred overnight hospitalization generally felt that traveling home the same day was painful. There was significantly less pain on the journey home if the procedure had been performed under spinal anaesthesia. In terms of complications, there were 10% reoperations due to deep infection in the outpatient group, and 12% superficial wound infections treated with oral antibiotics. The corresponding numbers for the in-patient group were 8% and 14%. The long-term success rate was similar for both groups. 87% of outpatients and 89% of inpatients reported that they would have consented to the operation if they had known the result in advance. Coccygectomy as an outpatient procedure gives similar results to inpatient treatment and can be regarded as an acceptable alternative. Spinal anaesthesia reduces postoperative pain on the journey home.

Introduction

Chronic coccydynia, or tailbone pain, may be severe and resistant to conservative treatment. In cases where conservative treatment and injection therapy have failed patients can be treated surgically with coccygectomy.[1,2]

Traditionally, coccygectomy patients spend several days in hospital after their operation. In the 1990s, the average stay after this procedure was 7-10 days.[3]

Outpatient surgery (also known as day surgery, same-day surgery or ambulatory surgery) refers to surgical procedures that are performed without staying overnight in the hospital. Following advances in peri- and postoperative pain control regimens and early rehabilitation protocols there has been a trend in other areas of surgery towards performing more outpatient procedures. In recent years, this has included procedures such as unicompartmental knee arthroplasty, and even total hip arthroplasty,[4] commonly regarded as an inpatient procedure. This development has the benefit of reducing costs and instigating early rehabilitation, without compromising results or patient satisfaction.[5,6]

In line with this trend, we have performed coccygectomy as an outpatient procedure in selected patients and now wished to review our results.

The purpose of this study was to determine if outpatient surgery of the coccyx is a safe alternative to hospitalization.

Materials and Methods

Patients were referred to us by general practitioners and other hospitals when non-invasive treatment had failed. All diagnoses were confirmed by a senior spinal surgical consultant (RGK) based on a thorough medical history, clinical examination and imaging with either coccygeal radiographs, MRI, or both.

In case of severe symptoms, patients were initially offered targeted injections with a mixture of lidocaine and corticosteroid. If this treatment failed to give lasting results, patients were offered surgery.

A total of 184 patients were operated in our department for coccydynia between 2009 and 2016. A total of 68 were operated as outpatients while 116 were admitted to the ward until the day after surgery. Selection was mainly on geographic grounds. Those who had less than two hour's travel to their home were treated as outpatients provided they were classified as ASA 1 or 2 on the American Society of Anesthesiologists classification. These patients were discharged from the hospital after a 3-6 hour postoperative observation period with prescriptions for oral pain medication and follow-up instructions.

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The standard pain prescription was paracetamol, tramadol, and diclofenac, although some individualization was performed as needed.

Out of the 68 outpatients, 52 had undergone a course of one to three corticosteroid injections (42 had one injection, 9 had two injections, and one had three injections) without a lasting satisfactory result.

Surgery was performed under either spinal or general anesthesia with antibiotic prophylaxis started preoperatively (Cephalotin 2g intravenously every 90 minutes, 4 doses in total, and one oral dose of Metronidazole 1g). Resection of the coccyx was done at the most proximal mobile segment, with the technique described by Key,[7] through a 4-5 cm midline incision and subperiosteal removal of the coccyx with monopolar and bipolar diathermy. Before closure, 20 ml of Ropivacaine 7.5 mg/mL was infiltrated into the area.

Outpatients were telephoned by an orthopedic nurse on the day after surgery to inquire about how they were doing and address any postoperative concerns.

Traditional physician-led morning rounds were performed for inpatients.

All patients were reviewed clinically 3-4 months after their operation and were followed up with a questionnaire at a minimum of 12 months after treatment. If the operation had been performed as an outpatient procedure, we included a separate questionnaire to evaluate satisfaction with this modality. Patients who had not responded to the questionnaires were reminded by telephone after 6 weeks and received new questionnaires if they wished.

A total of 171 (92%) operated patients responded to the final follow-up. We have, however, included all patients when recording postoperative complications during the first three months after surgery.

The mean follow-up was 39 (range 12-85) months. In the outpatient group there were 9 males and 59 females. Their mean age at referral was 40 (17-70) years. In the hospitalized group there were 19 males and 97 females. Their mean age was 37 (11-75) years.

Out of the 68 outpatients, 61 (90%) responded to our final follow-up. They had had symptoms of coccydynia for a mean of 36 (4-252) months before presentation.

There were six patients who were intended as outpatients but converted to inpatients. Four were due to insufficient postoperative pain relief, one to dizziness, and one to delayed start of surgery.

We also recorded the time it had taken for patients to travel home after surgery. There were 34 patients residing in the same municipality as our hospital, and therefore assumed to have less than 30 minutes travel time home, and 27 patients who lived in surrounding municipalities and were assumed to need between 30 and 120 minutes to get home.

Statistical testing of categorical data was done with the chi-square test.

The study was reviewed by the Regional committee for medical and health research ethics in Central Norway (2016/460) who found that it did not need their approval.

Results

Satisfaction

In the outpatient procedure group 53 (87%) reported that they would have consented to the operation if they had known the outcome in advance, compared to 98 (89%) of the inpatients.

Out of the 22 patients who had been operated under spinal anaesthesia, 20 were satisfied with this, while two stated that they would have preferred a general anaesthetic. The remaining 39 were operated under a general anaesthetic, and all were satisfied with this. Of the 61 outpatients at final follow-up, 39 were satisfied with having the operation as an outpatient procedure, while 18 explained that completing the journey home the same day had been more painful than anticipated. The remaining four patients would have preferred overnight hospitalization for other practical reasons. 15 (83%) of the patients who felt the journey home had been too painful had been operated under a general anaesthetic, while only 3 (17%) patients had had a spinal anaesthetic (p=0,048). Out of the 34 patients with less than 30 minutes travel time home, 10 (29%) reported dissatisfaction because their journey was too painful. Among the 27 patients with 30-120 minutes travel time, eight (30%) reported the same. With regards to the first day follow-up call by a nurse, only one was dissatisfied with this.

Complications

None of our outpatients were re-hospitalized for postoperative pain management after their initial discharge.

Seven patients (10%) in the outpatient group developed deep postoperative infection requiring operative debridement. They were re-operated 3-5 weeks after their initial surgery and went on to subsequent healing. There were a further eight patients (12%) with spots of serous drainage from the wounds persisting beyond the first 1-2 weeks. As there were no other infective signs, they were regarded as superficial wound infections, and resolved with a course of oral antibiotics.

In comparison, out of the 116 patients who were operated as inpatients, nine (8%) were subsequently re-operated due to infection, while 16 (14%) were treated with antibiotics for superficial wound infections.

There were no significant differences in either postoperative infections or long-term satisfaction between the groups, nor any difference in satisfaction between patients with short or long journeys home after surgery.

Discussion

About one third of our outpatients stated that they would have preferred to stay at the hospital post-operatively, mainly because the journey home had been painful. A limitation of this study was that we did not have comparable data for the inpatients with regard to discomfort at the time of discharge. It is likely that a considerable proportion of the inpatients may also have had enough pain at the time of discharge to have preferred a longer hospital stay.

Others have found that there is less postoperative pain in outpatient procedures such as knee arthroscopy and lower abdominal surgery when performed under spinal anaesthesia, rather than a general anaesthetic.[8] Our findings show that the patients who were operated under spinal anaesthesia had significantly less pain on their journey home. As a consequence, we are now performing most coccygectomies under spinal anaesthesia.

Reviewing our data, we have nevertheless been compelled to explore more effective pain treatment protocols to make the journey home more tolerable. The addition of pre-operative gabapentin as an adjunct in multimodal pain management has been advocated for several procedures[9] and has now been added to our protocol. Only one patient was dissatisfied with having a nurse telephone for the first-day follow-up. This is an established method of follow-up for other types of outpatient surgery[10] and seems applicable to this procedure as well.

Coccygectomy as an outpatient procedure has to our knowledge not previously been described in the literature. There is however considerable literature about other procedures that have recently been transformed to outpatient procedures.[5,6,11] One of the key components to this is patient selection. We have limited our patient selection to postoperative travel distances within 2 hours, granted that the patients are medically fit, with an ASA score of <2. We had expected increasing travel time home after surgery to correlate with more pain. Surprisingly, a similar proportion of patients reported undue pain on their journey home, regardless of how close to the hospital they lived. Two of our outpatients were adolescents (17 years) at the time of the operation. We have not performed this procedure as an outpatient procedure in younger patients than 17 years, but have previously found that adolescent coccygectomy patients in general have similar results to adults.[12] There is comparable literature available on other orthopaedic outpatient procedures in adolescent populations,[13] which would suggest that this could also be an acceptable treatment option. Our number of infections leading to re-operations were 10% and 8% for the out- and inpatient groups, but when counting superficial wound problems treated with antibiotics, the total number of infections were found to be 22% for both groups. Coccygectomy traditionally carries a high rate of postoperative infection and wound dehiscence. The rates are variable in the published literature. There have been published series reporting infection rates

requiring reoperation as low as 0-3,5%,[14,15] although most authors report rates of infection between 7-27% when also including superficial wound problems, treated with antibiotic therapy alone.[16-20]

Conclusions

Coccygectomy as an outpatient procedure seems to have comparable outcomes to in-hospital management in terms of patient safety. The number of postoperative complications is similar to that for inpatient management. In the longer follow-up, we found that patients treated as outpatients were just as likely to have consented to the operation if they had known the result in advance. The main disadvantage is that about one third of outpatients complain of pain from the journey home, regardless of how short their journey is. This can be improved by operating under spinal anaesthesia.

This treatment has the benefit of reducing hospital costs, as one night hospitalized for this condition according to the financial department at our hospital has an average added cost of 11.000 Norwegian kroner (approximately US$ 1.200). Another benefit is the reduction in the orthopedic ward occupancy, which at peak times may be very limited. In light of this, we shall continue to offer coccygectomy as an outpatient procedure to patients who qualify for this treatment.

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