

Progress in the diagnosis and treatment of fracture-dislocation of the coccyx (Review)

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Abstract. Coccyx fracture-dislocation is a common injury encountered in emergency trauma surgery, often resulting from direct impact. For the majority of patients, conservative treatment is recommended and can alleviate the pain associated with the injury. However, some patients respond poorly to conservative therapy and develop chronic, intractable sacrococcygeal pain. Advancements in clinical practice have resulted in the development of various treatment modalities for coccyx fracture-dislocation, including pulsed radiofrequency therapy, extracorporeal shockwave therapy, local drug injections, surgical treatments and conventional lateral recumbency combined with oral analgesia. The present review summarizes the literature on coccyx fracture-dislocation, including information on its epidemiology, anatomy, etiology, diagnosis and treatment. The aim of the review is to serve as a reference for the clinical diagnosis and treatment of coccyx fracture-dislocation.

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1. Introduction

The coccyx is located at the lowermost part of the spine, where it forms a pelvic tripod with the sciatic tuberosities to support sitting. The majority of coccyx fracture-dislocations are caused by direct trauma, such as falling vertically and landing on the buttocks, where the coccyx impacts a hard surface with sufficient force to create a fracture (1-3). Difficult labor and multiple deliveries are also important causes of coccyx fracture-dislocation (3,4).

Coccyx fracture-dislocations are typically treated conservatively, with most recommendations including the use of circular cushions and the adoption of a side-lying position to avoid placing weight on the injury site. This is often followed by oral anti-inflammatory analgesics, topical medications, local injections, radiofrequency therapy and other therapies with the ability to reduce pain in the sacrococcygeal region. In general, 90% of coccyx fracture-dislocations heal successfully with conservative treatment (5,6). However, if symptoms are not alleviated after 6 months of conservative treatment, surgical treatment may be considered. Surgical options include coccygeoplasty, coccygectomy and internal fixation of the coccygeal fracture by incision and reduction (7). Due to the continuous development of treatment methods for coccyx fracture-dislocation, the success rate of the management of this condition has gradually improved over time.

The present review summarizes the treatment methods of coccyx fracture-dislocation, aiming to serve as a reference for the treatment of patients with coccyx fracture-dislocation. In particular, it summarizes the characteristics and treatment methods of coccyx fracture-dislocation (Fig. 1).

2. Epidemiology

A study of data published by the Korean Health Insurance Review and Assessment Service revealed that a total of 26,545 coccyx fractures occurred in South Korea between 2010 and 2018, with a male-to-female ratio of 1:2.6. The annual incidence rate of coccyx fracture was 119.75 per 100,000 individuals overall, with a rate of 33.44 per 100,000 in male patients and 86.30 per 100,000 in female patients. Furthermore, the incidence rate was highest among males during puberty (age, 10-14 years) and among females during menopause (age, 50-54 years). The study also found that

coccyx fractures occur more frequently during the winter and less frequently in the summer (8). The higher incidence of coccyx fractures in women, with the highest incidence in menopause, suggests that coccyx fractures may be associated with osteoporosis (9). Another reason may be related to the morphological differences in the coccyx. Compared with men, women have a straighter coccyx and are more likely to have coccyx fractures after falling backward (10,11). The high incidence in adolescence can be explained by two factors: i) In contrast to the rapid growth of bone, mineralization of bone is relatively delayed, leading to increased bone fragility; and ii) intense physical activity in this age group (12). A study investigating hip, distal radius, proximal humerus and ankle fractures in individuals aged ≥ 65 years revealed that incidence rates peaked during winter months and reached their lowest levels in summer, suggesting that colder temperatures may increase fracture susceptibility (13).

3. Anatomy

The word coccyx is derived from the ancient Greek word for cuckoo, as its shape is similar to that of the cuckoo's curved beak (14). The coccyx is approximately triangular in shape and formed from 3-5 fused coccyx vertebrae. The first coccygeal vertebra which forms the base of the triangle is the largest and is connected to the sacrum. The lower point of the upwardly extending coccygeal angle is formed by the superior articular process of the first coccygeal vertebra, which articulates with the sacrum. On either side of the coccygeal angle, a pair of outwardly projecting bony structures, or cusps, form the transverse processes of the coccyx. The transverse processes of the second coccygeal vertebra are relatively small, while the third and fourth vertebrae are even smaller, degenerating into small nodular bony masses. Woon *et al* (10) report that the first coccyx (Co1) is fused to the fifth sacral vertebra (S5) in 57% of normal individuals. As a result, the lower part of the sacrum is referred to as Co1 and the first free vertebra is known as Co2 (10). On the anterior surface of the sacrum, there are three transverse grooves that correspond to the lines of fusion between the segments. On either side of the posterior surface are the coccygeal angles, which meet the sacral angles to form the posterior foramen of the sacrum, where the posterior division of the fifth sacral nerve is situated. In addition, the flattened lateral edge of the first coccygeal segment meets the edge of the last sacral vertebra, forming the anterior foramen of S5, which houses the anterior branch of the fifth sacral nerve. The wafer-thin lateral edge of the coccyx serves as an attachment point for the sacrococcygeal ligament, as well as for the fibers of the coccygeal muscle anterior to the ligament and the gluteus maximus muscle posterior to it. By contrast, the sacrococcygeal tendon attaches to the tip of the coccyx, providing protection to the rectum and supporting it through the coccyx (15).

There are two current classifications of coccyx morphology, which categorize structural differences of the coccyx into specific types. The Postacchini classification (16) defines these types as follows: i) Type I is a slightly forward-curved coccyx; ii) type II has a more pronounced curvature, with the coccyx pointing forward; iii) type III is an anteriorly pointed angulation; and iv) type IV manifests as a semi-dislocation of the

sacrococcygeal joint or the intercoccygeal joint. An alternative classification of coccyx morphology describes the following three types of coccyges: i) Type I shows a forward curvature of $>25^\circ$; ii) type II has a displaced or posteriorly subluxated coccyx; and iii) type III comprises an immobile coccyx with spiculae. Spiculae are defined as morphological abnormalities in the form of small bony excrescences on the dorsal aspect of the tip of the coccyx (17).

4. Etiology

The coccyx is positioned at the extreme tail end of the spine and, in a sitting position, is the lowest point of the body. If an individual accidentally slips and lands directly on the buttocks, the impact of direct contact with the ground can fracture the coccyx. Additionally, in an automobile accident, sudden backward and forward impact can also lead to a coccyx fracture (18). The type of coccyx fracture-dislocation is dependent on the morphology of the coccyx; vertical varieties are more susceptible to damage from external forces due to their immediate proximity to the skin (19). By contrast, a curved or hooked tailbone provides protection against external damage. Direct impact has been documented as the main cause of coccyx fracture and dislocation, while childbirth is the second most frequent cause, with a ratio of 9:1 for these two causes (1,8).

During childbirth, the coccyx, as part of the birth canal, can move backward due to fetal compression to provide more space for the fetus to pass through. However, excessive compression by a large fetus or other factors can lead to coccyx fracture or dislocation. Childbirth-related fractures of the coccyx are rare and often overlooked, as its symptoms primarily manifest as localized pain when sitting on a hard surface, which can be relieved by standing or lying on the side (20-22). Maigne *et al* (4) analyzed 57 patients with postpartum coccydynia and found that coccygeal dislocation occurred in 17.0% of cases, whilst coccygeal fracture was observed in 5.3% of cases (4).

5. Diagnosis

Fracture-dislocations of the coccyx, like those in other parts of the body, typically result from physical trauma. However, in women, the presence of the vagina anterior to the coccyx introduces an additional risk during labor, as fetus-induced pressure on the coccyx from the inside out can lead to a coccyx fracture (5). On external palpation or intrarectal palpation of a fractured coccyx, increased mobility may be detected, and pain elicited at the site of the dislocation or fracture (23). A definitive diagnosis of coccyx fracture-dislocation is typically made using standard X-ray procedures or computed tomographs scans, with motion pictures being particularly useful for the assessment of trauma-induced coccyx fracture-dislocations (23,24). In addition, magnetic resonance imaging (MRI) scans are preferred for the diagnosis of coccyx fracture-dislocations in pregnant women and other patients for whom radiation exposure is contraindicated (25). MRI can also help to identify other organic abnormalities around the dislocated segment of the coccyx fracture, as well as bone marrow edema and effusion in the dislocated segment of the fracture.

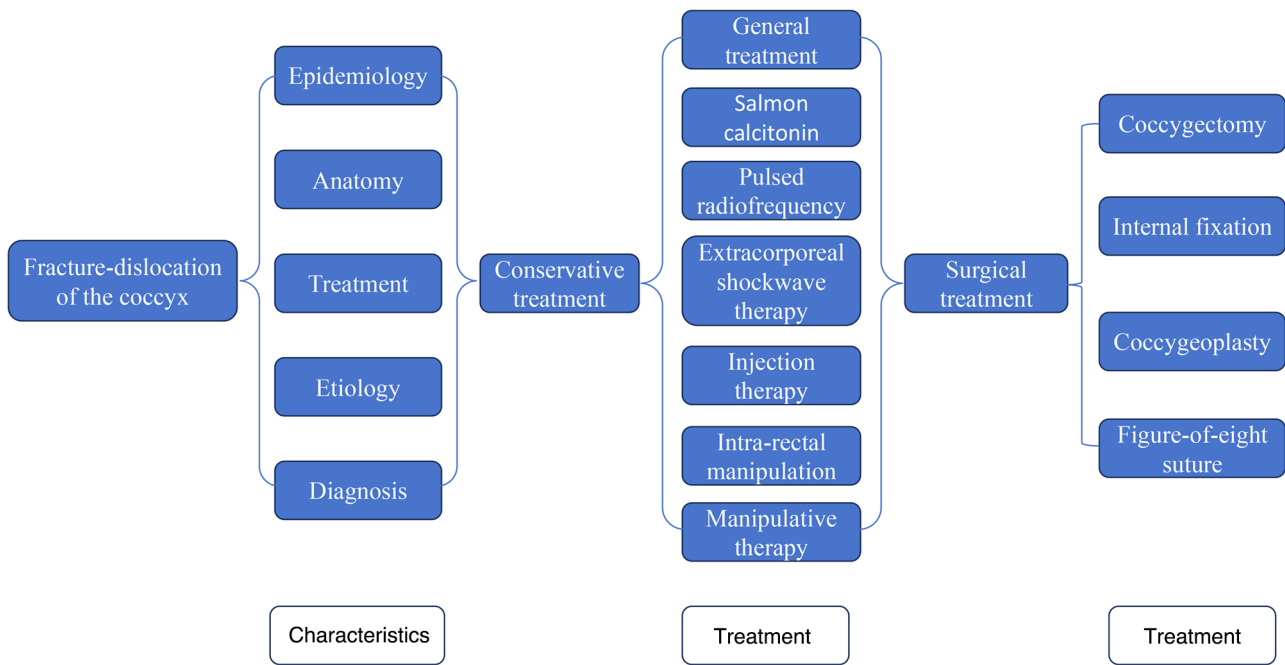


Figure 1. Characteristics and treatment of fracture-dislocation of the coccyx.

Coccyx fractures can be categorized into types I-III based on pathogenesis, namely flexion, compression and extension (25). Type I, a flexion fracture, occurs due to a fall or direct impact on the sacrococcygeal junction, typically resulting in a compression fracture of the lower sacral or upper coccygeal segments. Type II, a compression fracture, involves vertical fracture lines affecting the separate coccygeal vertebrae, namely Co2 or Co1, where they are compressed without fusion to S5. Type III, extension fractures, primarily occur as obstetric fractures with involvement of the lower coccyx, likely caused by forced extension of the coccyx during labor and delivery (25).

6. Treatment options

The treatment principles of fracture-dislocation involve reduction, immobilization and rehabilitation (26). Since the coccyx does not serve a primary motor or supportive function, a fracture-dislocation of the coccyx typically does not markedly impede the daily life of a patient, and anatomical or functional repositioning of the affected coccyx is not typically required. Located at the most distal end of the spine, the coccyx forms a pelvic tripod with the sciatic tuberosities to support the sitting posture. Following a fracture, the fractured end is subjected to downwards compression during sitting movements. In addition, due to its location relative to the rectum, the coccyx is subjected to backward pressure during defecation. These forces can destabilize the fracture site, potentially prolonging healing time. The treatment of coccyx fracture-dislocation is mainly focused on restoring the shape of the coccyx promptly after diagnosis, reducing pressure on the coccyx, restricting movement of the fracture site, minimizing pain and promoting healing. Management strategies are generally categorized into conservative and surgical treatments.

Conservative treatment. Conservative treatment of coccyx fracture-dislocation mainly entails non-surgical treatment to reduce the pressure on the sacrococcygeal region. This often includes the use of medication to promote fracture healing and relieve pain. It has been reported that 90% of coccyx fracture-dislocations recover fully following conservative treatment (6,15).

General treatment. The most common treatment approach involves the reduction of pressure on the fracture site, which mainly comprises advising the patient to lie on their side, sit on a hollow cushion and regulate their diet. These measures help to reduce the pressure of body weight and rectal defecation on the fracture site, reduce the mobility of the coccyx and provide optimal conditions for the fracture to heal (6). For localized pain due to trauma, oral medications are commonly used. Various medications, such as nonsteroidal anti-inflammatory drugs and opioid analgesics, can alleviate pain associated with fracture-dislocation of the coccyx (6).

Salmon calcitonin (SCT). SCT has been approved by the US Food and Drug Administration for the treatment of postmenopausal osteoporosis and has been shown to be effective in alleviating the pain resulting from various neurological and musculoskeletal disorders in numerous studies (27). In a rat model, fracture healing was found to be improved in rats treated with intramuscular calcitonin compared with that in the placebo-treated controls (28). In addition, in a study of patients who underwent the internal fixation of acute hip fractures, intranasal calcitonin was reported to promote fracture healing compared with that in patients treated with a placebo (29). Furthermore, Foye *et al* (30) found that intranasal SCT significantly reduced pain in patients with acute coccyx fractures. However, as the study was a case series and no control group was included, further studies are necessary to determine the role of intranasal SCT in the treatment of acute coccyx fractures (30).

Pulsed radiofrequency (PRF) therapy. PRF therapy is a neuromodulation technique that has been widely used for the treatment of neuropathic pain, sensory injury pain and cancer-related pain, without causing permanent nerve damage. In PRF therapy, a discontinuous, pulsed electric current is generated that creates a field around neural tissues to achieve an analgesic effect. It is commonly used in the treatment of chronic pain associated with nerves, joints, intervertebral discs and soft tissues (31). Although PRF therapy has been suggested for the treatment of sacrococcygeal pain, information on its use specifically for this condition is limited (32). However, Adas *et al* (33) treated a total of 41 cases of chronic intractable coccydynia between January 1, 2010, and December 31, 2012, and an evaluation performed after 6 months of treatment revealed treatment success in 90.2% of the patients and failure in the remaining 9.8%.

Shockwave therapy. A shockwave is an acoustic wave that generates energy through high-speed mechanical vibrations, leading to rapid compression and the concentration of energy in the medium it passes through (34). Extracorporeal shockwave therapy (ESWT) was first reported for the treatment of kidney stones by Chaussy *et al* (35) in 1980. Since then, the scope of application of ESWT has gradually broadened and it is now applied for the treatment of chronic soft tissue pain, muscle spasms, osteoarthritis, and acute and chronic skin injuries (31,36). While the mechanism of action of ESWT remains to be fully elucidated, it has been reported to have a wide range of therapeutic effects on musculoskeletal conditions, including the promotion of tissue regeneration, wound healing, angiogenesis and bone remodeling, and the inhibition of inflammation (37). Notably, Ahadi *et al* (38) found that ESWT provided stronger and longer-lasting relief of coccygeal pain compared with steroidal injection therapy in a randomized controlled trial (38).

Injection therapy. Local anesthesia combined with glucocorticoid injections have been reported to be effective in 60% of patients with sacrococcygeal pain (39). Local anesthetics are a class of drugs that reversibly block the initiation and transmission of sensory nerve impulses at the local level, leading to a reversible loss of nociception in the affected tissue (40). Glucocorticoids act by increasing vascular tone, reducing congestion, decreasing capillary permeability and minimizing exudation and edema. They achieve this by inhibiting the aggregation of inflammatory cells at the site of inflammation, thereby preventing complement activation in the inflammatory response. In addition, glucocorticoids block the synthesis and release of chemical mediators of inflammation, which relieves symptoms such as redness, swelling, heat and pain (41,42). The combination of local anesthetics and glucocorticosteroids effectively alleviates the inflammation and pain associated with coccyx fracture-dislocation. The injection is typically administered around the fracture-dislocation site and can be performed under fluoroscopic or ultrasound guidance for precise injection (41,43,44). Wray *et al* (39) conducted a study in which local injections of methylprednisolone acetate (40 mg) in combination with bupivacaine (10 ml) were administered to 50 patients with coccygeal pain. All patients were followed up for ≥ 1 year, with a mean follow-up of 2 years and 9 months. This treatment was found to be successful in 60% of the patients.

Intra-rectal manipulation. For patients with obvious displacement of a coccyx fracture-dislocation, intra-rectal manipulation can be used to restore the anatomical alignment of the coccyx. This technique helps to reset the fracture-dislocation, reduce the occurrence of deformity during healing and facilitate the healing of the fracture. During the operation, the patient is placed in the left lateral decubitus position with hip and knee flexion as far as possible, and the operator wears sterile gloves and stands behind the patient. The patient is asked to breathe deeply to relax the muscles around the anus. The operator then slowly inserts their right-hand index finger into the rectum to access the fracture site, where the patient is likely to feel pain upon contact. The right thumb of the operator is placed behind the coccyx, at the back of the buttocks, and the coccyx is gently pinched between the thumb and index finger. The index finger is then pressed against the displaced coccyx and a backward push is performed, being careful not to apply excessive force to avoid damage to the rectum. If the reset is successful, the operator feels a sliding or popping sensation, indicating proper realignment. The index finger is then moved along the coccyx in the anal canal to restore the physiological curvature of the coccyx (45,46). If the displacement is corrected, the pain typically disappears immediately (47). Fang *et al* (47) treated 29 patients with caudal fracture-dislocations using endorectal manipulative repositioning, and 20 patients were considered cured, 4 reported 'remarkable' effects, 4 reported being 'better' and 1 reported an ineffective outcome (47). Intra-rectal manipulative reduction is one of the more frequently used methods of treating coccyx fracture-dislocation in China, as it can restore the anatomical structure of the coccyx and aligns with the treatment principles of fracture-dislocation (26). The simple endorectal reduction of dislocated coccyx fractures restores the anatomical structure of the fracture site, which promotes the healing of fresh fractures. However, in older fractures, closure of the marrow cavity and sclerosis at the fracture ends create a mechanically unfavorable environment that substantially impairs new bone formation and connectivity (48).

Manipulative therapy. Manipulative therapy uses manual manipulation to relax the sacrococcygeal muscles and adjust the position of a stiff coccyx. Common manipulation techniques include the following: i) Massage of the levator ani, coccygeus and pectineus muscles; ii) repetitive joint mobilization around the coccyx; and iii) mobilization of the coccyx in a stretched position with vigorous stretching of the levator ani muscles (44,49). A randomized controlled study performed by Maigne *et al* (49) reported a success rate for coccyx manipulation in the treatment of coccydynia of only ~25%. Recent-onset traumatic coccyx pain with a stable coccyx and no interfering psychosocial factors are proposed to serve as indications for coccyx manipulation. The effectiveness of manipulation may be improved by the concurrent administration of steroid injections (50).

Surgical treatment. In certain patients undergoing conservative treatment, the fracture site does not heal, resulting in recurrent pain in the sacrococcygeal area. In such cases, surgery may be performed to relieve the pain. The surgical treatment of coccyx fracture-dislocation can be divided into four main methods: Polymethyl methacrylate (PMMA) coccygeoplasty,

resection of the fractured segments or coccyx, internal fixation of the fracture-dislocation by incision and reduction, and modified figure-of-eight minimally invasive suture. Among surgical treatment options, surgical resection of the coccyx for refractory sacrococcygeal pain has the highest improvement rate of 79% (51). There have been few studies on the surgical treatment of coccygeal fracture and dislocation as it is restricted to the sacrococcygeal region and does not affect patient survival. Previous studies on the surgical treatment of coccygeal fracture and dislocation have primarily focused on the impact of surgery, with a few reports of surgical complications, the main complication being surgical site infection, with an incidence of 2.6-26% (51-53).

Coccygectomy. In 1937, Key (54) first described a surgical procedure to remove the mobile fractured portion of the coccyx. The extent of resection remains a controversial issue, as evidence suggests that total resection of the coccyx and partial resection of the distal fracture achieve similar results (23,55,56). Despite this, total removal of the coccyx is generally regarded as the optimal surgical option (57,58). The inclusion criteria for this procedure are as follows: i) Confirmed history of trauma with imaging evidence of coccyx fracture-dislocation; ii) persistent or intractable sacrococcygeal pain, paroxysmal or persistent perianal discomfort, or dyspareunia; and iii) failure of non-surgical treatment for ≥ 6 months (23,53).

The surgical method begins with a preoperative enema and urinary catheterization. The patient is placed in knee-chest position, with a soft pillow for abdominal cushioning. Saddle or local anesthesia is then applied, after which a posterior median incision is made to expose the sacrococcygeal joints. The joint capsule is incised, and scarf pincers are used to clamp the upper end of the coccyx and pull it backwards. A sharp knife is then employed to cut through muscles attached to the coccyx, including the anus-lift and coccygeal muscles, and the surrounding ligaments. If the coccyx is heavily displaced forward or there is overlap between dislocated coccygeal joints, an assistant can insert an index finger into the anus and press the coccyx backward to facilitate the surgery. Care must be taken to avoid injury to the middle sacral, sacral lumbar and subsacral arterial branches and the sacrococcygeal nerve joint branch during dissection. The sacrococcygeal intervertebral discs and coccygeal ligaments are then separated and the coccyx resected from the proximal to the distal end. The residual ligament is then closed with sutures. Postoperatively, laxatives are prescribed for 5 days to avoid constipation, as this could exacerbate pain at the surgical site (44,53).

Mouhsine *et al* (23) performed coccygectomy in 15 patients with post-traumatic coccyx instability, which yielded 'excellent' outcomes in 11 cases, 'good' in 3 and 'fair' in 1. They also reported significant improvements in another 14 patients who underwent partial coccygectomy. In another study, Ramieri *et al* (54) performed resection of the coccyx fracture-dislocation site in 28 cases of coccyx fracture-dislocation and followed up the patients for 24-70 months. Visual analog scale (VAS) scores were 0-1 at the end of follow-up. In addition, 21 patients were satisfied with the outcome of the procedure, 4 were dissatisfied with the outcome, and 3 had missing follow-up data (54). In another study, Perna *et al* (44) performed caudal osteotomy on 21 patients with chronic

pain in the coccyx, which was due to trauma in 10 cases. The numerical rating scores decreased from 9.4 ± 3.1 preoperatively to 5.2 ± 2.3 at 1 month after surgery and 1.8 ± 1.1 at 1 year after surgery. All patients with chronic pain in the coccyx who were treated with coccygectomy exhibited a significant improvement (44). In another study, with a follow-up time of up to 29 years after coccygectomy, Hochgatterer *et al* (53) concluded that coccygectomy is a safe therapeutic option for patients with coccygeal pain and yields favorable long-term outcomes. In addition, the study recommended coccygectomy if a patient fails to respond to conservative treatment for 6 months. Kalstad *et al* (59) found that coccygectomy is a generally acceptable to patients, with outpatient and inpatient surgeries resulting in the same level of patient satisfaction (59).

Incision and internal fixation of coccyx fracture-dislocation. Restoration of the anatomical structure of the coccyx through surgical incision, repositioning and internal fixation is another procedure for the treatment of coccyx fracture-dislocation. Internal fixation promotes healing of the fracture while preserving the structure of the coccyx and the muscles and tendons attached to it. However, this procedure is more complex and costly compared with coccygectomy, and the recovery time is longer. The surgical approach involves preoperative bowel preparation, followed by the creation of an S-shaped incision in the sacrococcygeal region, where the skin, subcutaneous tissue and fascia are incised sequentially. The dorsal sacrococcygeal ligament, coccygeal muscle and part of the sacrospinous ligament are then incised to reveal the coccyx. Subsequently, cartilage and blood clots between the sacrum and coccyx are removed using a small spatula, and the anococcygeal ligament and part of the sacral muscular ligament are peeled off under the periosteum for anatomical repositioning. Based on the diameter of the coccyx measured by preoperative imaging, a depth limiter is used, and a small T-shaped plate is applied for internal fixation. Bone is then taken from the posterior superior iliac spine for bone grafting between the fracture-dislocations and both sides of the coccyx. After satisfactory restoration, the dorsal sacrococcygeal ligaments are tightly closed, followed by internal fixation under fluoroscopy using a C-arm machine (47). Fang *et al* (47) treated 27 patients with coccyx fracture-dislocations using an internal fixation procedure with microplates. Of these, 26 patients healed and 1 patient showed a significant improvement (47). A coccygectomy clearly affects the stability of the muscles, ligaments and musculature attached to the coccyx. In addition, the coccyx serves as one of the pelvic tripods, along with the sciatic tuberosity, which provides weight-bearing support for sitting. To the best of our knowledge, the clinical issues associated with coccygectomy have not been studied in detail, and sufficiently robust clinical trials are lacking. However, coccygectomy is a simpler procedure than the open reduction and internal fixation of coccygeal fractures and is preferred by both physicians and patients (59). Therefore, additional clinical data are required to demonstrate the efficacy of the two procedures and provide a valid reference for treatment.

PMMA coccygeoplasty. Coccygeoplasty is a treatment for coccyx fracture-dislocation that does not require incisional exposure and, in comparison with coccygeal fracture incision and internal fixation, is less invasive with a shorter recovery time. In this procedure, the patient typically adopts a prone

position on the operating table and is anesthetized and sedated. The pelvis and abdomen are supported with rolls and pads. With the assistance of C-arm fluoroscopy, the point of entry is determined based on orthostasis and laterality. Then, 2.5-3 ml PMMA is administered by injection (60). Postoperatively, patients are allowed to move on the day of the procedure, and do not require any analgesia (60). Manfre *et al* (61) performed coccygeoplasty in 12 patients with coccyx subluxation, and found that VAS scores decreased significantly in 75% of the patients during 3- and 12-month follow-ups. In addition, various case reports have indicated that coccygeoplasty is superior compared with other surgical treatments in terms of surgical difficulty, cost, length of hospitalization and patient satisfaction (62). However, due to the small number of reported cases of coccygeoplasty, it is challenging to evaluate the indications, contraindications and long-term efficacy of this treatment, although it remains viable as a treatment option.

Modified figure-of-eight minimally invasive suture. For coccyx fracture-dislocations with small distal coccyx fragments, a figure-of-eight suture can be used to fix the broken ends. A small local incision is made to expose the fracture site and non-absorbable sutures are used to fix the mobile fragments (45). Deviandri *et al* (45) treated a patient with a distal coccyx fracture conservatively for 1 month. As the pain associated with the fracture persisted, immobilization of the fracture was performed via a small incision with a figure-of-eight suture. The Oswestry Disability Index score of the patient, which was initially 16, decreased to 3 after 6 months of follow-up, and the sacrococcygeal pain caused by fracture-dislocation of the coccyx was significantly alleviated (47).

7. Conclusion

The diagnosis of coccyx fracture-dislocation is relatively straightforward and can be confirmed by medical history and imaging. However, the treatment of this injury varies as it is often considered to be self-healing through conservative treatment. The function of the coccyx is frequently overlooked, leading to the treatment of patients with coccyx fractures and dislocations being influenced by factors such as economic status, cognitive level, the treatment approach of the physician and the overall medical condition of the patient. Andersen *et al* (6) performed a systematic review of the therapeutic effects of different treatment measures on coccyx pain, which included a total of 1,980 patients from 64 studies, including 5 randomized controlled trials, 1 experimental study, 1 quasi-experimental study, 11 prospective observational studies, 45 retrospective studies and unpublished data from the DaneSpine registry. In patients receiving radiofrequency therapy, the mean VAS was decreased by 5.11 points, which was the greatest improvement in pain among all the treatments tested. By contrast, the VAS decreased by 5.06 points in patients receiving ESWT, 4.86 points in patients treated with coccygectomy, 4.22 points in patients treated with injectable therapies, 2.19 points in patients receiving manipulative therapies and 1.69 points in patients treated with conservative therapy (6). In China, the treatment of coccyx fracture-dislocation is typically applied in a combined and gradual manner. Oral medication or injection therapy is used alongside conservative treatment. As the treatment time extends, the VAS pain score tends to gradually

decrease, although this can be influenced by the uneven distribution of medical resources, with radiofrequency treatment or suitable surgical conditions being unavailable in certain areas. Therefore, these treatment strategies should be considered as a reference and applied in a personalized manner.

Coccyx fracture-dislocation is a common condition in trauma surgery due to the anatomical location of the coccyx. In addition, its limited physiological function in the body often results in insufficient medical care, leading to delayed healing, deformities and bone non-union, which may further result in complications such as old fractures, pseudo joints and osteoarthritis. Compression of the rectum can also lead to difficulties with defecation, blood in the stool and other symptoms, causing further pain to the patient. As some patients with coccyx fracture-dislocation experience localized chronic intractable pain, which can seriously affect their quality of life, coccygeal fracture and dislocation warrants further research attention (63).

The treatment of coccyx fracture-dislocation aims to relieve pain, promote the healing of the fracture and ultimately improve the quality of life of the patient. Treatment methods can include the following: i) Reducing the pressure on the site of the coccyx fracture, restricting its movement and promoting healing; ii) local administration of anti-inflammatory agents with analgesic or local anesthetic drugs to relieve pain; iii) physical therapy to relieve the pain of the fracture and promote healing; iv) endorectal manipulation and restoration to restore the anatomical structure of the coccyx; v) resection of the dislocated end of the coccyx, coccydotomy and incision of the coccyx for internal fixation; and vi) coccyoplasty to restore the structure of the coccyx. The treatment of coccyx fracture should follow a step-wise approach as 90% of patients can be successfully treated by conservative treatment. However, surgical treatment may be recommended for patients with persistent sacrococcygeal pain that is not significantly relieved by >6 months of conservative treatment or in cases of recurrent episodes. Patients undergoing conservative treatment are frequently required to restrict certain physically intensive activities for long periods of time, which may be inconvenient. If the patient is unable to accept the restrictions of conservative treatment, then early surgical treatment can be considered. The clinical management of coccyx fracture-dislocation should follow the principle of individualized treatment, taking into account several multidimensional factors, including differences in pathogenic mechanisms, disease course characteristics, healthcare resources, the pain tolerance of the patient and their quality of life. Notably, the choice of treatment strategy should be dynamic and adaptive, rather than limited to a single approach. Instead, treatment is often characterized by the synergistic effect of two or more interventions. Typical treatment protocols may include the use of a hollow decompression cushion combined with a baseline oral analgesic regimen. Local injections may be applied to enhance efficacy, with surgical intervention as the final treatment option in cases with marked displacement or nerve compression. Such a stepwise treatment model can effectively improve clinical outcomes through the combined effects of different mechanisms of action.

In general, the number of studies on the treatment of coccygeal fracture and dislocation, particularly surgical treatment, is insufficient and further research is necessary. In addition,

it is recommended that education on coccyx fracture and dislocation should be improved to help patients and medical staff fully understand this injury, and ultimately improve the quality of life of patients.

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Authors' contributions

YZ and GG established the background of the study, analyzed and interpreted the literature, and drafted, wrote, substantially revised and critically reviewed the manuscript. Both authors read and approved the final version of the manuscript. Data authentication is not applicable.

Ethics approval and consent to participate

Not applicable.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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