London College of Animal Osteopathy

CLINICAL SIGNS OF LONG-TERM COMPLICATIONS AFTER CASTRATION AND THEIR OSTEOPATHIC RELEVANCE

P. Bürgermeister

Abstract

Castration is one of the most common equine surgical procedures, yet its long-term musculoskeletal consequences remain poorly understood. This study aimed to investigate whether clinical signs adjacent to equine castration scars are associated with objectively measured locomotor asymmetry. Twenty-five geldings, including Standardbred trotters and riding horses, were examined through palpation and inspection of the castration site and scored for Depression, Fibrotic scarring, Pain, Discharge, and Edema on a 1–5 scale. Gait symmetry was evaluated using Sleip AI, a markerless motion analysis system, with a focus on Head, Pelvic, and combined Total asymmetry. Spearman's rank correlation was used to assess associations between clinical and motion variables. The composite clinical score showed a strong positive correlation with pelvic asymmetry ($\rho = 0.71$, $p < 0.001$) and a moderate correlation with total asymmetry ($\rho = 0.53$, $p = 0.007$), while no association was found with head asymmetry. Depression, Fibrotic scarring, and Edema were the most influential individual signs. These findings suggest that inadequately healed castration scars may contribute to pelvic dysfunction.

Foreword

This work was born out of stubborn curiosity. For a long time, I have wondered if, and to what extent, castration scars might contribute to movement asymmetries in horses. The question has followed me through encounters with numerous horses, wondering if I read too much into it or if there is actually something there. Although castration is among the most frequently performed surgical procedures, there is limited research examining its long-term effects.

This study is my way of starting to fill that gap. It is not only aimed at researchers, but above all at osteopaths, massage therapists, and other manual practitioners who meet horses in their daily work. My goal is to provide you with a new perspective, a new tool, a way to recognize castration-related issues, in milder forms that fall below the radar of veterinary medicine.

I want this text to serve as a push forward. An invitation to raise the bar together, sharpen our awareness, and dare to think differently about what shapes equine movement and wellbeing, and above all, be willing to put our hypothesis to the test.

I would like to express my sincere gratitude to the owners and trainers who graciously allowed me to borrow their horses for this study, as well as to Atilia and Patrik for their invaluable practical support throughout this process.

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Pauline Bürgermeister

Introduction

Equine osteopaths frequently encounter instances in which gelding scars may contribute to dysfunctional movement patterns. This study aims to investigate whether there is a correlation between diagnostic indicators of the long-term effects of inadequately healed castration scars and asymmetrical movement.

Although bilateral orchiectomy (castration) is one of the most commonly performed equine surgical procedures (Baldwin, 2024), the long-term effects of this surgery, particularly the development of gelding scars, remain poorly researched. In fact, no study to date has quantified correlations between scar-related clinical signs and objective gait asymmetry. These scars are often dismissed as benign but can contribute to a range of musculoskeletal issues that impact the horse's overall well-being and performance. By examining the osteopathic implications and pinpointing the signs of problematic scars, we can better understand the subtle yet significant changes they impose on the equine anatomy, potentially leading to innovative therapeutic approaches aimed at mitigating adverse outcomes and enhancing the quality of life for gelded horses.

The Educational Council on Osteopathic Principles (ECOP) identifies five parts of the osteopathic model:

Biomechanical Model - Physiological function of posture and movement

Respiratory/ Circulatory Model - Respiration, circulation, venous, and lymphatic drainage

Metabolic/ Energy Model - Metabolic process, reproduction, energy balance, immunological processes such as inflammation and repair. Absorption of nutrients and removal of waste

Neurological Model - Integration of bodily functions, control and sensations. Protective mechanisms

Behavioural Model – Psychosocial activities such as anxiety, sexual activities, stress, work, family, etc.

Although there is certainly a case to be made that castration of a stallion will affect all five parts of the osteopathic model, this study will mainly focus on the Biomechanical, Circulatory, and Neurological model.

Biomechanical Model

Several anatomical structures are affected during equine castration, any of which might be subject to poor healing and subsequent dysfunction. The **scrotal skin,** thin elastic skin covering the dermis and epidermis, and the **tunica dartos**, a smooth muscle layer embedded within subcutaneous tissue which plays a crucial role in thermoregulation, are incised vertically over each testicle to begin the procedure. The **superficial fascia**, loose connective tissue between dartos and the external spermatic fascia or **tunica vaginalis**, is dissected to allow access to the spermatic cord.

The **cremaster muscle** is a striated skeletal muscle derived from the caudal fibers of the internal abdominal oblique muscle. It originates along the caudoventral margin of this muscle and descends through the inguinal canal, accompanying the spermatic cord. Although it is a skeletal muscle in structure, its function is largely reflexive rather than voluntary. In the stallion, the cremaster muscle envelops the spermatic cord and inserts upon the parietal layer of the tunica vaginalis, where it exerts its primary physiological role: the elevation of the testis in response to cold temperatures or tactile stimulation of the inner thigh (the cremasteric reflex). This mechanism aids in thermoregulation, which is critical for normal spermatogenesis.

During castration procedures, the cremaster muscle may be transacted or included within the emasculation site. Improper handling or failure to adequately crush or ligate this muscle has been associated with an increased risk of postoperative complications, such as scrotal

hematoma or prolonged swelling (Auer & Stick, 2019; Budras, Sack, & Röck, 2012; Dyce, Sack, & Wensing, 2017).
In the 2020 research by M.P. Robert et al, it was reported that hind limb lameness, back pain, and jumping issues emerged as post-castration complications in a limited study of twenty horses. Roberts observed a funnel-like appearance to the scrotal region, a tight fibrous band running from the scrotum to the inguinal ring. In three horses, palpation of the fibrous band elicited a pain response. Following surgical intervention to remove adhesions and minimize scar tissue, improvement was observed within one week to six months. Client satisfaction was generally positive, with an overall rate of 83%.
This observation aligns with the findings of Echte et al (2006), who reported instances of back pain and hindlimb lameness in horses. The lameness was often inexplicable and prolonged over several months, sometimes intermittent and occasionally shifting sides. Horses exhibited a stringhalt-like gait or lameness during the swing phase of movement. These affected horses experienced difficulty in changing leads during canter.
Clinical evaluations revealed an easily palpable spermatic cord that elicited a pain response when pressed. Provocation tests for hindlimb lameness yielded negative results. Eighteen horses were non-lame following surgical intervention. Two horses exhibited reduced lameness after surgery, while one horse showed no improvement.
It is important to note that the lameness first presented several months post castration.

Circulatory Model

The **testicular artery**, a direct branch of the **abdominal aorta**, enters the spermatic cord and is closely associated with the **pampiniform plexus. These** vessels are severed and ligated during castration to prevent haemorrhage (Auer & Stick, 2019; Dyce et al. , 2017). Currently, there is little research on the long-term recanalization of testicular vessels after horse castration.
In a study of the long- and short-term complications of castrations with primary wound closure, Robert et al. (2017)found that in 105 horses owners reported the long-term complication of slight edema in fifteen (14,3%) of the cases and in nine horses (8,6%) moderate to severe edema was reported which would hint at the potential for circulatory complications post-castration. This edema can impede the lymphatic drainage and affect overall circulation within the affected regions. In 2018, Roberts et al. also reported edema as a common occurrence post-castration, further emphasizing that edema should be considered a significant postoperative issue.

The intricate interplay of biomechanical and circulatory disruptions can also influence the neurological aspects of a gelded horse's health. Nerve irritation or damage, as evidenced by the presence of neuromas, can lead to chronic pain and altered neurophysiological responses, complicating the gelding's movement and behaviour.

No studies were found that map specific lymphatic vessels disrupted by equine castration. Standard anatomical sources describe testicular lymphatic drainage to the **lumbar aortic** and **medial iliac** lymph nodes, and scrotal drainage to the **superficial inguinal** nodes. Post-operative swelling reported in clinical references likely reflects temporary or persistent impairment of these drainage pathways (Dyce et al. , 2017; Budras et al. , 2012).

Neurological Model

In the first study of its kind, Bengtsdotter, V, Ekman, and Andersen (2019) documented the occurrence of neuromas in connection with remnants of the spermatic cord after castration in horses. Neuromas were found in 54% of the spermatic cords, belonging to 65% of the 20 geldings. These neuromas were bilateral in 40% of the horses.

All castrations involve the compression or crushing of the spermatic cord tissue, severing the testicular nerves. These nerves are innervated by autonomic sympathetic nerve fibres that originate from the aortic plexus and extend to the caudal mesenteric plexus through the **Splanchnic lumbar nerve S2-4**, subsequently accompanying the testicular vessels within the spermatic cord.

In addition, most castration techniques involve tearing, crushing, and severing of the peripheral nerves of the cremaster muscle, scrotal skin, and tunica vaginalis. These structures are innervated by the genital branch of the Genitofemoral nerve, the Pudendal, and the Ilioinguinal nerves. The **Genitofemoral nerve**, branches of the second Lumbar nerve **L2-3,** has a motoric function on the cremaster muscle and a sensory function on the scrotal skin and the tunica vaginalis.

The **Pudendal nerve,** consisting of sensory nerves, originates at **S1-4** from where it takes an oblique course through the pelvis to innervate the scrotal skin.

The **Ilioinguinal nerve** is a mixed nerve and, as such, it contains both sensory and motor nerves, originates at **L2,** and also innervates the scrotal skin (Dyce et al. , 2017; Budras et al. , 2012).

Although it is yet to be proven that neuromas provoke pain in a horse, it is reasonable to assume so based on a number of studies conducted on humans, dogs, pigs, and sheep, showing that even though many neuromas are asymptomatic, they can become painful if the nerve endings are irritated or constantly stimulated.

Method

The subjects included in the study (N25) were selected based on convenience sampling, with ages ranging from 3 to 23 years (mean age: 11.2 years; median: 12 years). The sample was mainly made up of two primary groups: trotters undergoing training and racing (n10) and horses from a riding school, representing a wide range of sizes and breeds (n15).

Testing was performed following turnout and prior to more intensive training. The horses were taken from their stalls and filmed using Sleip, after which clinical evaluations were conducted to avoid triggering or exacerbating any pain before analysis. Only after assessing the clinical signs were the Sleip analyses reviewed so as not to influence the clinical evaluation.

The clinical signs assessed in relation to Sleip AI comprised visible **depression** adjacent to the castration scar, resulting in a funnel-shaped appearance; palpable **fibrous** scarring; **pain** response upon palpation; scar **discharge**; and **edema**. These were scored on an ordinal scale from 1 to 5, where 1 indicated the absence of pathology and 5 represented the most severe manifestation of the condition. Each sign was evaluated for correlation with asymmetry, as well as with the aggregate clinical score.

The horses selected for this study, to the best of their owners' or trainers' knowledge, had not previously undergone veterinary treatment specifically for castration-related complications. However, many had received management for distal joint inflammations. Of these, 23 horses had never been treated for issues related to castration, while 2 may have undergone some form of scar manipulation, though not within recent months.

Sleip AI, an AI-based markerless motion analysis system developed for equine gait assessment, was used to evaluate horse locomotion in this study (Meistro, Ralletti, Rinnovati, & Spadari, 2025; Sleip AI, n.d.). The outputs from Sleip were interpreted based on anatomical regions: the variable labelled **"Head"** indicates asymmetry detected in the forehand, while **"Pelvis"** represents asymmetry in the hindquarters. A combined score from all four limbs was termed **"Total score."** These terms were chosen to establish a direct anatomical connection between the objective motion data and the clinical assessments obtained through palpation and inspection.

All data were entered into a spreadsheet and analysed using descriptive and correlational statistics. For each group (Standardbred trotters, riding horses, and all horses combined), descriptive statistics (mean, standard deviation, and median) were calculated for age, Clinical sum, and Sleip variables (Head, Pelvis, Total score).

To investigate associations between clinical findings and objective motion asymmetry, Spearman's rank correlation coefficient (ρ) was used, as the clinical scores were based on ordinal scales. Correlation analyses were performed for the overall Clinical sum as well as for each individual clinical variable (Depression, Fibrosis, Pain, Discharge, and Edema) against all Sleip variables.

In addition, sensitivity analyses were conducted to assess the robustness of the Clinical sum. The composite score was recalculated after excluding individual items (*Pain* and *Discharge*), and correlations with Sleip variables were repeated to evaluate whether specific variables strengthened or weakened the overall associations.

Statistical significance was set at $p < 0.05$, with stronger significance levels indicated as $p < 0.01$ and $p < 0.001$.

Table 1. Overview of the methodological workflow.

Step	Key details
Sampling	Convenience sampling of 25 geldings (10 Standardbred trotters, 15 riding horses)
Clinical examination	Palpation and inspection of castration scars; scoring of depression, fibrosis, pain, discharge, and edema (1–5 scale)
Sleip AI analysis	Markerless motion capture of head, pelvic, and total gait asymmetry
Statistical analysis	Descriptive statistics and Spearman's rank correlation between clinical and motion variables

Results

The analysis revealed a strong positive correlation between the Clinical sum and Sleip Pelvis ($\rho = 0.71$, $p < 0.001$), and a moderate positive correlation with Sleip Total score ($\rho = 0.53$, $p = 0.007$). No significant association was found with Sleip Head ($\rho = –0.08$, $p = 0.70$).

When each clinical variable was analysed separately, significant positive correlations were found for Depression (Pelvis $\rho = 0.53$, $p = 0.007$; Total score $\rho = 0.54$, $p = 0.006$), Fibrose (Pelvis $\rho = 0.55$, $p = 0.005$), and Edema (Pelvis $\rho = 0.51$, $p = 0.009$; Total score $\rho = 0.45$, $p = 0.03$). No significant correlations were observed for Pain or Discharge with any Sleip variable.

Taken together, the clearest pattern was that clinical signs adjacent to castration scars were most consistently reflected in pelvic asymmetry. While Head showed no meaningful associations, Pelvis demonstrated moderate to strong correlations with both the composite Clinical sum and individual signs such as Depression, Fibrosis, and Edema. Total score also captured some of these relationships, though with weaker effect sizes, suggesting that the pelvic measure was the most sensitive to clinical dysfunction.

Sensitivity analyses confirmed the robustness of the findings. Excluding Pain slightly reduced the strength of the Pelvis correlation ($\rho = 0.65$, $p < 0.001$), indicating that even weaker variables may add value when combined. By contrast, excluding Discharge increased the Total score correlation ($\rho = 0.57$, $p = 0.003$).

Table 2. Correlation between Clinical sum and Sleip variables (Spearman's rho)

Sleip variable	ρ (rho)	p-value
Head	–0.08	0.70
Pelvis	0.71	<0.001
Total score	0.53	0.007

Table 3. Correlations between clinical variables and Sleip variables (Spearman's rho).

Clinical variable	Head	Pelvis	Total
Depression	0.07	0.53**	0.54**
Fibrosis	–0.04	0.55**	0.38
Pain	–0.12	0.17	0.11
Discharge	–0.20	0.11	–0.16
Edema	0.09	0.51**	0.45*

(*p < 0.05, **p < 0.01, ***p < 0.001)

Table 4. Descriptive statistics for standardbred trotters and riding horses

Variable	Trotters (n=10)	Riding horses (n=15)	All horses (n=25)
Age (years)	6.2 ± 2.0 (median 6)	15.0 ± 3.9 (median 14)	11.2 ± 5.3 (median 12)
Clinical sum	13.7 ± 2.4 (median 15)	12.7 ± 3.6 (median 13)	13.1 ± 3.1 (median 13)
Sleip Head	0.7 ± 0.7 (median 0.5)	0.3 ± 0.1 (median 0.3)	0.5 ± 0.5 (median 0.4)
Sleip Pelvis	0.6 ± 0.4 (median 0.5)	0.5 ± 0.3 (median 0.3)	0.5 ± 0.4 (median 0.4)
Sleip Total S.	1.2 ± 0.7 (median 1.0)	0.8 ± 0.3 (median 0.8)	0.9 ± 0.6 (median 0.9)

Discussion

The sensitivity analyses demonstrated that the composite Clinical sum is robust, but the contribution of individual items varies. Pain did not show a significant association with Sleip variables when analysed separately yet including it in the Clinical sum slightly strengthened the correlation with Pelvis ($\rho = 0.71$ vs. $\rho = 0.65$ without Pain). In contrast, Discharge appeared to dilute the overall association, as removing it increased the correlation with Total score ($\rho = 0.57$ vs. $\rho = 0.53$). These findings suggest that while certain weak variables may add cumulative value to the score (compound effect), others may introduce noise and reduce its precision.

It is important to emphasize that correlation does not imply causation; therefore, we cannot conclude that castration scarring leads to asymmetry. Considerable research is still required in this area, but I remain hopeful that actors with greater resources will pursue further investigation.

The findings of this study suggest that clinical signs adjacent to castration scars are most consistently associated with pelvic asymmetry. The strong correlation between the Clinical sum and Pelvis supports the hypothesis that inadequately healed castration scars may contribute to long-term biomechanical dysfunction. This aligns with earlier clinical observations by Robert et al. (2018) and Echte et al. (2006), who both reported hindlimb lameness, back pain, and abnormal gait patterns that were not explained by conventional diagnostics but were linked to palpable changes in the spermatic cord or surrounding tissues. While the present study did not directly examine scar histology, the correlations with Depression, Fibrotic scarring, and Edema indicate that structural alterations in the castration region may influence locomotor symmetry.

Interestingly, Pain and Discharge did not demonstrate significant associations with Sleip variables, whereas Depression, Fibrosis, and Edema did. A plausible explanation is that pain and discharge are more acute indicators, whereas depression and fibrotic scarring may indicate chronic and persistent changes that are more likely to affect long-term biomechanics. Nevertheless, the sensitivity analyses showed that Pain contributed additively to the composite Clinical sum, suggesting that even weaker individual variables may enhance the robustness of a cumulative score. In contrast, Discharge appeared to dilute the strength of the associations, highlighting the need for refinement in how clinical variables are weighted or combined in future research.

From an osteopathic perspective, the results strengthen the relevance of the biomechanical, circulatory, and neurological models outlined by the Educational Council on Osteopathic Principles (ECOP). Fibrotic tissue may restrict the mobility of surrounding structures, edema can impair lymphatic drainage and circulation, and nerve involvement, including the neuromas described by Bengtsdotter et al. (2019), may contribute to altered neurosensory signalling. Even if neuromas in horses have not yet been conclusively shown to cause pain, evidence from other species strongly supports this possibility. The combination of these mechanisms offers a plausible explanation for why asymmetry was most strongly expressed in the pelvic region.

Clinically, the results underline the importance of including castration scars in routine evaluations of unexplained movement asymmetries. Although castration is often considered a benign and routine procedure, the findings of this study suggest that its long-term consequences may be under-recognized. For practitioners such as osteopaths, equine therapists, and veterinarians, the palpation and assessment of castration scars may serve as a valuable screening tool, particularly when conventional lameness diagnostics fail to provide clear answers. The practical implication is that scar tissue should not be dismissed as incidental but evaluated as a potential contributor to dysfunction.

At the same time, several limitations must be acknowledged. The study was based on a relatively small convenience sample (n=25), with heterogeneity in age, breed, and training status. No blinded assessments were performed, and no objective measures for confirmation of scar quality were available. The absence of significant findings for the Head variable may indicate that castration-related dysfunction primarily affects the hindquarters, but it may also reflect the limited statistical power of this sample. These factors limit the generalizability of the results and highlight the need for larger and more controlled studies.

Future research should aim to expand the sample size and include longitudinal designs, following horses from castration through training to monitor when and how asymmetries develop. In addition, integrating behavioural observations may further illuminate whether scar-related dysfunction also influences the psychosocial and stress-related dimensions described in the osteopathic model.

In conclusion, this study provides preliminary evidence that long-term sequelae of equine castration can be associated with measurable pelvic asymmetry. While correlation does not establish causation, the findings invite a re-examination of castration scars as clinically relevant structures rather than benign remnants. For the field of equine osteopathy, the results offer both a new perspective and a call for further investigation, with the ultimate aim of improving equine health, welfare, and performance.

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