Investigative Study

THE APPLICATION OF INTERSPINOUS SPACERS IN CONJUNCTION WITH SPINOPLASTY TREATMENT: INSIGHTS FROM OUR EXPERIENCE

L. Manfrè[1*], A. E. De Vivo[1], H. Al Qatami[2], A. Own[3], F. Ventura[1], K. Zhou[4], R. V Chandra[5], J. A Hirsch[6], M. Frigerio[7] and M. Bonetti[7]

[1]Department of Radiology, IOM Mediterranean Oncology Institute, Viagrande, Sicily, Italy;
[2]Neuroradiology, Hamad Medical Corporation, Doha, Ad Dawhah, Qatar;
[3]Neuroradiology, Hamad General Hospital, Academic Health System, Doha, Qatar;
[4]Interventional Neuroradiology, Monash Health, Clayton, Victoria, Australia;
[5]Monash University Faculty of Medicine Nursing and Health Sciences, Clayton, Victoria, Australia;
[6]Neurointerventional Radiology, Massachusetts General Hospital, Boston, Massachusetts, USA;
[7]Department of Neuroradiology, Istituto Clinico Città di Brescia, Brescia, Italy

Correspondence to:
Luigi Manfrè, MD
Minimal Invasive Spine Therapy Department,
Mediterranean Institute for Oncology,
Corso Italia 10,
Catania, Italy
e-mail: lmanfre@me.com

ABSTRACT

Lumbar spinal canal stenosis and foraminal stenosis of the lumbar spine are widespread degenerative conditions that may lead to neurogenic claudication, significantly affecting patients' functionality and overall quality of life. Recently, percutaneous interspinous devices (PIDs) have surfaced as a minimally invasive substitute treatment option. This study outlines a twenty-year experience at a singular center with PIDs and evaluates the adjunctive use of spinous process augmentation (spinoplasty) to enhance clinical outcomes. The cases included were collected up to 2023. A retrospective cohort study was executed involving 900 consecutive patients who sought treatment at a specialized spine clinic, with 788 ultimately undergoing intervention. Inclusion criteria encompassed substantial stenosis, failure of conservative management approaches, and electromyographic verification. Within this cohort, 288 individuals received a PID alone, while 500 underwent concurrent polymethyl methacrylate (PMMA) augmentation of the adjoining spinous processes. Follow-up evaluations were conducted at 3 and 12 months utilizing the Zurich Claudication Questionnaire (ZCQ) and the Oswestry Disability Index (ODI). Results: both groups demonstrated considerable improvements in ZCQ scores (from 3.2 to 1.3) and ODI metrics (from 32 to 21), in addition to high levels of patient satisfaction (mean score of 1.7). The incidence of symptom recurrence due to complications was significantly lower in the cohort receiving spinous process augmentation compared to the group treated exclusively with PIDs (<1% vs 10,76%). The results of this investigation underscore the effectiveness of percutaneous interspinous devices in the management of lumbar spinal stenosis. Furthermore, the findings indicate that the combination of spinous process augmentation with PID treatment reduces the likelihood of symptom recurrence.

KEYWORDS: *spine, lumbar spinal canal stenosis, LSCS, lumbar foraminal stenosis, LSFS, neurogenic claudication, spinous process augmentation, spinoplasty*

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INTRODUCTION

Lumbar spinal canal stenosis (LSCS) and lumbar foraminal stenosis (LSFS) are degenerative disorders associated with aging, capable of inducing neurogenic claudication that severely compromises the functional status of afflicted patients (1). These conditions are prevalent, with estimates suggesting that as many as 47% of individuals over the age of 60 may experience some form of symptoms. Given the aging demographic, it is anticipated that this issue will intensify in forthcoming years (1).

The primary driver of these diseases involves constriction of the central spinal canal or neural foramina in the lumbar region. Numerous concurrent pathologies frequently exacerbate this narrowing, such as disc herniations, facet joint arthropathy, and thickening of the ligamentum flavum. Additionally, venous ischemia resulting from compression of blood vessels surrounding the spinal nerves has been documented (1). Such narrowing is often aggravated by trunk extension, which amplifies the natural lordosis of the lumbar spine, while flexion tends to alleviate the condition by promoting a more kyphotic posture. This pathophysiological mechanism is at the core of the classic symptomatology associated with lumbar spinal stenosis (LSS): progressive pain in the back, buttocks, and lower extremities, which intensifies with ambulation (typically when the individual is in an extended posture) and is relieved through sitting or lying down (in a flexed position). Dynamic MRI studies have visually substantiated these alterations in the spinal canal (1-4).

Initial management is commonly conservative, incorporating physical therapy, analgesics, and local interventions like epidural or foraminal injections of anesthetics and corticosteroids. If conservative strategies fail, standard surgical interventions for LSS involve decompression through either laminectomy or laminotomy, with or without posterior fusion. Interspinous spacers or percutaneous interspinous devices (PIDs) have been developed as a less invasive treatment alternative for this condition. These devices are intended for placement between adjacent spinous processes, utilizing minimally invasive surgical techniques or percutaneous guidance by imaging (5, 6). They function alongside intact interspinous ligaments and paravertebral muscles to prevent excessive lordosis of the spine, mimicking the way patients alleviate their symptoms through forced flexion. Evidence supports their superiority over conservative treatment methods, as well as their non-inferiority compared to traditional decompression surgeries. Furthermore, there is documentation of symptomatic relief and improvement in conditions associated with LSCS and LSFS (7). However, a significant drawback in comparison to conventional surgical options is the incidence of device malfunction, symptomatic recurrence, and the necessity for subsequent surgeries, often connected to issues like bony remodeling or fractures of spinous processes (8-10).

Osteoporosis contributes to both the fragility and height reduction of vertebral bodies and spinous processes (11-12). The positioning of a PID increases the load borne by the spinous processes, rendering them susceptible to fractures (11-15). To mitigate this risk, augmenting the spinous processes using PMMA is employed to enhance the structural integrity of the underlying bone. Preliminary clinical and cadaveric studies have suggested that prophylactic spinoplasty can diminish the failure rate of PIDs. This investigation aims to retrospectively assess nearly twenty years of experience with PIDs and to contrast the device failure rates between patients who underwent preventive spinoplasty and those who received PIDs alone.

PATIENTS AND METHODS

Patient selection

A retrospective review of cases was performed for patients between January 2009 and December 2023. Nine hundred consecutive patients presenting chronic neurogenic claudication, with or without radicular symptoms, were assessed at a specialized spine facility for the potential of percutaneous interventions. Institutional review board approval was secured for data collection and publication.

Baseline assessment

Pain severity was assessed using the Zurich Claudication Questionnaire (ZCQ), well-regarded for its accuracy in gauging LSS (16). Disability levels were quantified through the Oswestry Disability Index (ODI) (17). All participants underwent lumbar MRI using a 1.5 T scanner (Intera, Philips, Erlagen, Germany) in accordance with established protocols. Sagittal T1-weighted spin-echo, T2-weighted fast spin-echo, and T2-STIR sequences were obtained, with a 2-3 mm section thickness and a 0.3 mm intersection gap, in addition to axial T2-weighted fast spin-echo sequences. Assessment of LSS was conducted based on the qualitative grading system proposed by Schizas (18), which is considered to reflect the clinical severity of the condition more accurately than traditional measurements, as it incorporates the actual morphology of the dural sac (Fig. 1) (19).

Fig. 1. *A): Preoperative sagittal MRI in supine position showing segmental canal stenosis L4-L5 in 1st-degree listhesis according to Meyerding; B): Preoperative sagittal MRI under load confirming Meyerding grade I listhesis of L4 compared to L5 with segmental canal stenosis.*

Inclusion criteria

Eligible patients were individuals with grade C or D stenosis or grade B who had not experienced improvement through conservative measures. These patients subsequently underwent a non-contrast CT scan of the lumbar spine (General Electric, Milwaukee, WI, USA) with a section thickness of 1.2 mm and underwent additional preoperative electromyography of the lower extremities to confirm at least moderate nerve conduction impairment.

Exclusion criteria

Patients presenting stenosis attributable to bony spurs, ossification of the ligamentum flavum, or facet joint hypertrophy were excluded from the study. Other exclusion factors included severe contact or subluxation of adjacent spinous processes, obesity (with a BMI >30 kg/m²), spondylolysis, and prior surgeries on the lumbar spine.

Treatment

Six-hundred-eighty-eight patients qualified for treatment based on predefined criteria and provided standard informed consent. A combined CT/fluoroscopy-guided approach was applied per local institutional protocols. Patients were positioned prone, and mild intravenous sedation (fentanyl 1-3 µg/kg/hour) was utilized. A preprocedural CT scan validated the targeted anatomical level, followed by the infiltration of 5 to 10 mL of 2% lidocaine into the deep paraspinal musculature and adjacent periarticular region for local anesthesia. A small incision (5-10 mm) was made to insert a 6 mm K-wire into the interspinous space via a posterolateral approach, subsequently confirmed with low-dose CT scans. Incremental dilatation of the soft tissues was performed, maintaining a 12 mm dilator in place. Using fluoroscopic guidance, various-sized probes were introduced into the interspinous space to release the interspinous ligament and determine the ideal size for the PID. Once sufficient measurements were obtained, the selected PID was deployed within the interspinous space. The wire, dilator, and holder were removed, and the incision was sutured. A follow-up CT scan was conducted postoperatively to ensure correct PID placement and to evaluate for any immediate complications (Fig. 2).

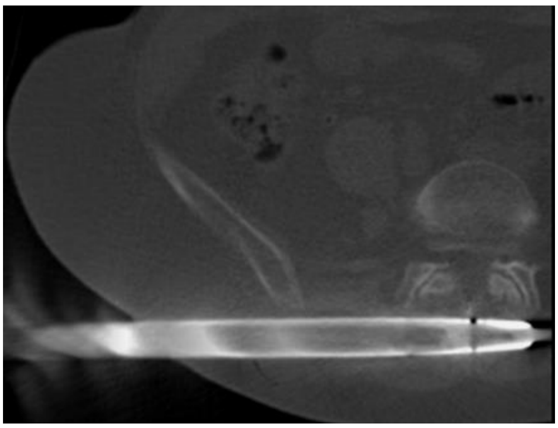

Fig. 2. *Intraoperative control CT scan.*

Three types of PIDs were utilized: the In-space (Depuy Synthes, MA, USA), a PEEK-covered spacer with metallic wings; the Helifix (ATEC Spine, CA, USA), a fully PEEK spiral body; and the Lobster (Techlamed, Italy), a titanium device covered in PEEK. The sizes of PIDs ranged from 8 to 14 mm. Starting in January 2011, prophylactic augmentation of the posterior arch with PMMA was performed before all PID implantations based on promising outcomes reported in earlier studies (Fig. 3 A-C). This procedure was conducted in a similar CT-guided manner, with a 13 G needle inserted into the superior and inferior spinous processes through either a midline sagittal or parasagittal approach. A volume of 1-2.5 mL of PMMA was injected into the spinous processes. The PID was placed immediately afterward or within a month depending on the clinician's preference to optimize patient comfort or to allow for some natural reactive sclerosis to develop as desired (Fig. 4 A-C).

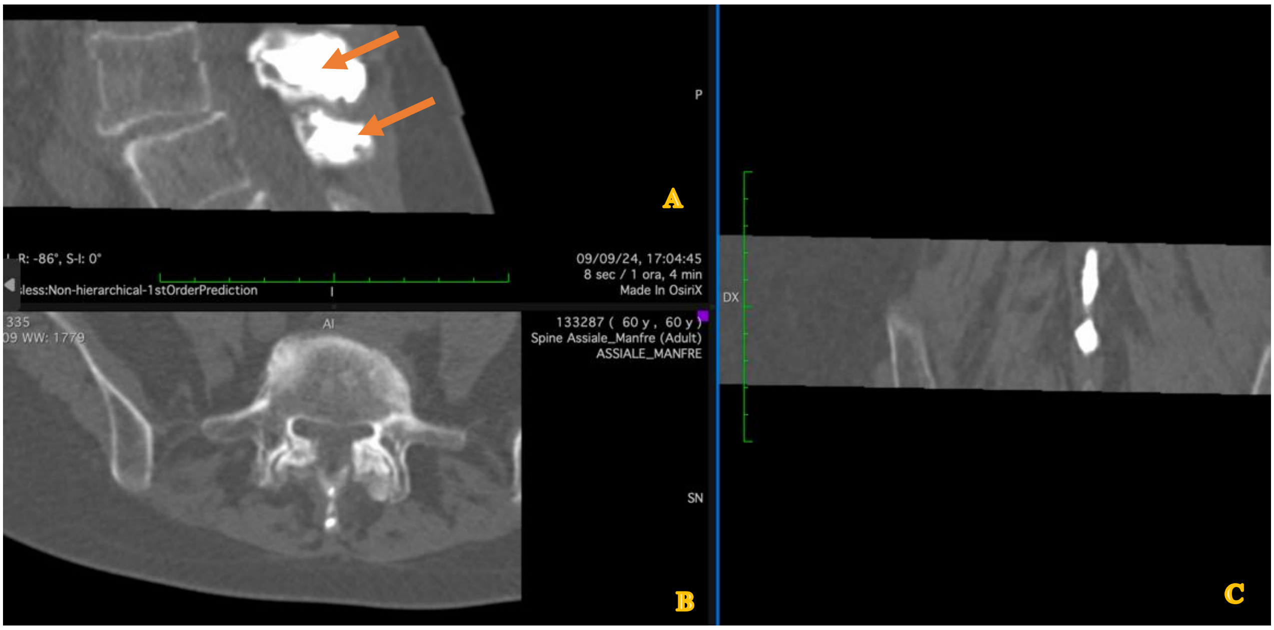

Fig 3. *A-C): PMMA injection control (**arrows**).*

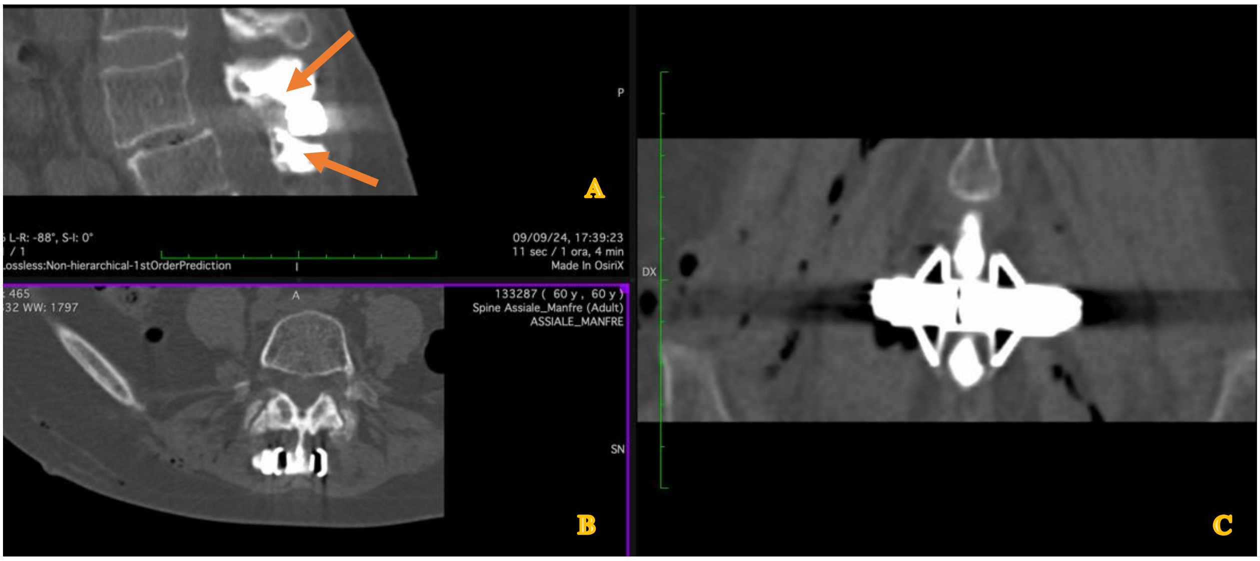

Fig 4. *A-C): PMMA injection control (**arrows**).*

Outcomes

Clinically meaningful improvement was defined as achieving at least a 0.5-point increase in ZCQ domains, a ZCQ patient satisfaction score of ≤2.5, and a minimum 10-point decrease in ODI. Follow-up assessments were performed at 3 and 12 months. Demographics and baseline characteristics of the patient population are summarized in Table I. The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines were adhered to as much as possible during the reporting of this observational study.

Table I. *Demographics and baseline characteristics of the patient population*.

Characteristics	Total	Group A n = 288	Group B n = 500
Median age and range (years)	72 (56-82)	72 (56-82)	72 (59-83)
Gender ratio (male: female)	1.31	1.30	1.31
Mean baseline ZCQ: Symptom score ±SD	3.2	3.2±0.4	3.2±0.6
Mean baseline ZCQ: Function score ±SD	2.2	2.2±0.3	2.1±0.4
Mean baseline ODI score ±SD	32	31±3.6	32±4.1
Schizas grading			
B	57	20	37
C	264	88	176
D	467	180	287
Level treated			
L2/3	16	7	9
L3/4	35	15	20
L4/5	639	237	392
L5/S1	98	39	59

RESULTS

Of the 788 patients treated, 288 were exclusively managed with PIDs (group A), while 500 received both spinoplasty and PID (group B). The majority of patients in both groups presented with Schizas grade D LSS, indicative of advanced disease. All individuals reported functional impairment and symptomatology, with the most common surgical level being L4/5.

The procedure was classified as technically successful if the spacer was accurately positioned, confirmed by radiological imaging demonstrating enlargement of the spinal canal and local foramina, as well as a reduction in ligamentum flavum hypertrophy. In some patients with grade I spondylolisthesis, improvements in spinal alignment were also noted, although this was not a primary objective. At the 3-month follow-up, the findings illustrated a significant reduction in the ZCQ symptom score (from 3.2 to 1.3) and the function score (from 2.2 to 1.4), with an average patient satisfaction score of 1.7, and the ODI decreased from 32 to 21. These results were consistent across both patient cohorts, with minimal changes observed at the 12-month follow-up. No patients were lost to follow-up.

Complications

Within group A, 31 patients (10,76%) encountered a return of their original symptoms following initial improvement. Repeat CT scans indicated either fracture of the spinous processes or bony remodeling encircling the PID, resulting in a recurrence of original LSS symptoms. Fifteen of these patients chose to undergo another PID procedure with concurrent spinoplasty, of which twelve achieved complete symptom resolution and remained pain-free at the 12-month mark. The other three continued experiencing persistent symptoms and subsequently underwent traditional open-surgical decompression and posterior fusion.

In group B, one patient suffered a spinous process fracture necessitating surgical posterior decompression. Furthermore, one other patient experienced device migration, requiring surgical removal and re-implantation of a new device. This incident represented the only major device-related adverse event reported in either group. No other patients in group B reported a recurrence of symptoms at the 12-month evaluation. A Chi-square statistical analysis revealed a significant difference ($p<0.05$) in the occurrence of complications between the two groups. Despite the higher complication rate observed in group A, the overall occurrence remained low, and the quantitative impact on outcome measures was minimal. No immediate complications post-procedure was noted in either group, and no patient required additional conservative management such as epidural injections or nerve blocks following the procedure.

DISCUSSION

Lumbar spinal stenosis has been managed for years through open surgical decompression; however, it comes with inherent risks such as blood loss, general anesthesia complications, and prolonged recovery times—all of which are particularly relevant for an older patient demographic that carries additional anesthetic risks. Minimally invasive interspinous spacers have proven to be non-inferior in terms of patient outcomes, and they provide distinct benefits regarding operational duration and reduced blood loss (2-26). This extensive cohort study corroborates existing literature, highlighting improvements in patient symptoms and functionality following interspinous spacer insertion, thereby reinforcing the safety profile of PIDs, with no immediate post-procedural complications recorded (24). Nevertheless, the most consistently reported negative outcome associated with interspinous devices is the elevated rate of required reoperations, particularly when compared to decompression surgery (23-25). The current study demonstrates a 10,76% recurrence rate of symptoms specifically in the PID-only subgroup.

The theories surrounding PID failure emphasize the role of osseous remodeling surrounding the spacer over time. This encompasses a degree of bone resorption, encasement, and erosion, alongside spinous process fractures. Previous literature has indicated an overall spinous process fracture rate of approximately 2.4%. Furthermore, finite element analysis has indicated that the PID, which is designed to support the vertebral structures during flexion and extension, fails to bear load effectively during lateral flexion, thereby increasing pressure on the spinous process.

Prior investigations into the optimal use of combined vertebral body augmentation and interspinous spacers have been documented in scenarios involving both compression fractures and LSS. The potential biomechanical advantages of PMMA augmentation of spinous processes were first theoretically demonstrated in cadaveric studies. Subsequently, investigations have illustrated in smaller cohorts the efficacy of spinoplasty, revealing fewer spinous process fractures in the augmented subgroup compared to those who did not receive this preventative measure.

This study showcases, on a significantly larger scale, that prophylactic augmentation of the spinous processes can substantially decrease both the rates of symptom recurrence and the need for reoperations. Only two patients in the spinoplasty group experienced repeated symptoms, both relating to either a spinous process fracture or device migration, contrasting with the 31 (10,76%) in the PID-only cohort. Notably, these two procedures can be performed concurrently, requiring only a minimal quantity of PMMA. However, despite several advantages, there appears to be no enhanced symptom relief resulting from the addition of spinoplasty. Currently, no study has conducted a direct comparison between traditional decompression approaches and PID plus spinoplasty. Such a comparison demonstrating similar reoperation rates would effectively address one of the primary barriers to the incorporation of PIDs in practice (23-39).

A primary limitation of this investigation involves the non-randomized, sequential distribution of patients, contrasting two groups across different time spans rather than concurrently. While baseline clinical and demographic characteristics are shown to be similar, there are no assurances that systemic differences in selection, procedural techniques, devices, or operator experience did not impact the results over time. Additionally, the single-center design of the study restricts the generalizability of the findings. Finally, given that some of the devices utilized may not be available universally or may have been superseded by more advanced models, practitioners should take this into account, albeit comparable results are anticipated with predicate devices.

CONCLUSIONS

This research highlights the safety and efficacy of percutaneously inserted interspinous spacers for managing LSS within the largest single cohort reported to date. Furthermore, it suggests that preventive PMMA augmentation of the spinous processes in the vicinity of the insertion point may lead to reduced rates of device failure and reoperation. Future direct comparisons between conventional decompression techniques and integrated PID plus spinoplasty will offer greater clarity on the optimal utilization of PIDs in the treatment of LSS.

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Comparative study

THE ROLE OF CORE TRAINING DURING THE REHABILITATION OF CHRONIC LOW BACK PAIN IN FOOTBALL PLAYERS

E. Rexha and K. Kapedani

[1]Sports University of Tirana, Albanian University, Tirana, Albania

Correspondence to:
Ergys Rexha, PhD
Sports University of Tirana,
Albanian University,
Tirana, Albania
e-mail: kujtimkapedani@yahoo.com

ABSTRACT

Management of Chronic Low Back Pain (CLBP) is often multidisciplinary and involves a combination of treatments, including instrumental physiotherapy and therapeutic exercises. Core stability exercises aim to improve pain and disability in CLBP by enhancing spinal stability, neuromuscular control, and preventing shear forces that cause damage to the lumbar spine. The objective of this study was to evaluate the effectiveness of combining instrumental physiotherapy with core stability exercises in order to reduce pain and improve limited functional capacity. This study was conducted at the "Orthomed Sport" physiotherapy clinic between January and July 2024. The participants were professional football players diagnosed with chronic lumbago, who had been prescribed instrumental physiotherapy by an orthopedic doctor for a two-week period. The participants were divided into two groups: group A and group B. Participants in group A underwent only the instrumental physiotherapy prescribed by the doctor for a two-week period. Participants in group B, in addition to the instrumental therapy, also performed core stability exercises three times a week for a period of 6 weeks. Following the study, core stability was found to be effective in improving outcomes after re-evaluation through physiotherapy. This study highlighted the reduction in CLBP in patients who incorporated core training exercises into their rehabilitation phase. This treatment effectively reduces the activation time of the stabilizing model that we aim for. Combining core stability exercises with other exercise modalities appears to lead to greater improvements in pain and disability compared to using any single treatment alone.

KEYWORDS: *core training, physiotherapy, prevention, rehabilitation, stability, posture*

INTRODUCTION

Lumbago (lower back pain) is a common neuromusculoskeletal problem affecting 40% of the global population at some point in their lives and causes significant disability in daily activities (1). The signs and symptoms include local or radicular pain, pain in the lumbar region, and spasms, which are aggravated by movement, leading to a loss of functionality (2). Physical or mechanical causes of lumbago include osteoarthritis, rheumatoid arthritis, degeneration of intervertebral discs or disc herniation, a vertebral fracture (e.g., from osteoporosis), or rarely, an infection or tumor (3).

Although the etiology of lumbago remains debated, pain is believed to arise from several factors, depending on whether they are specific or non-specific. Specific lumbago has a diagnosed pathology such as muscle strain, infection, fracture, or disease of the spinal column (4). On the other hand, non-specific lumbago does not have a clear pathology

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related to the cause of pain. Still, it is theorized to result from factors such as poor posture, reduced flexibility, previous injuries, heavy lifting, mental stress, and obesity (4, 5). Other possible causes of non-specific lumbago include common disorders identified in patients such as weakness of the deep trunk muscles, poor coordination, and muscle imbalance. The therapeutic approach to managing non-specific lumbago varies based on the tolerance of both the doctor and the patient (6). Common treatments aim to achieve similar goals, as massages are intended to promote muscle relaxation, while various modalities can be used to reduce pain levels.

Therapeutic approaches involving massage, medications, and modalities have demonstrated short-term effects in pain reduction (4, 7). Each of these management strategies requires specific equipment, repeated healthcare visits, or prescriptions.

It has been established that two-thirds of adults will be affected by or will experience non-specific lumbago at some point in their lives (8, 9). This condition limits their ability to maintain basic movement mechanics for optimal athletic performance. Lumbago can be defined as any painful stimulus in the region between the lower ribs and the gluteal areas, which can also cause muscle weakness with or without leg pain (10).

However, only about 10% of lumbago cases are specific and have a clear explanation for the pain, leaving 90% as non-specific lumbago (10).

Maintaining physical activity has positive effects on reducing non-specific lumbago (11). The use of exercises to activate and strengthen the core (i.e., Core Stability Exercises, CSE) has shown to be a promising method for treating chronic lumbago (5, 10, 12, 13). The goal of core strengthening is to improve and restore the ability to better control the spine (5). This approach focuses on re-educating the function of the deep trunk muscles and coordinating the deep and superficial trunk muscles during static and dynamic phases (10). A core program focuses on the central musculature, including the transverse and rectus abdominis, internal and external obliques, paraspinal, as well as the gluteal muscles, pelvic floor, and hip joint musculature. A core program can promote patient independence with a home exercise regimen.

Globally, lumbago is classified as the pathology with the greatest global disability, measured by Disability-Adjusted Life Years (DALY).

The diagnosis of chronic lumbago is usually made through a physical examination, physical tests, palpation, and imaging techniques such as X-rays, MRI, and CT scans. Treatment options include medication, physical therapy, and surgery, with physical therapy being tailored to the patient's condition. This includes modalities such as physical therapy, manual therapy, and patient education for home activities.

Chronic lumbago rehabilitation is carried out by a multidisciplinary team and involves a combination of physiotherapeutic treatments, pharmacological care (NSAIDs, muscle relaxants, glucocorticoids), massages, electrotherapy (laser therapy, TENS, Tecartherapy), acupuncture, and, in specific cases, the use of injections and surgical procedures (14).

The effectiveness of manual therapy and core stability exercises is evident in managing CLBP. Still, there are no single studies available in the literature on the combined effects of manual therapy and core stability exercises. Manual therapy is a common treatment for CLBP aimed at improving the mobility of the lumbar spine. These techniques involve passive mobilization performed by physiotherapists in a prone position.

Poor coordination and muscular strength (15, 16) can alter the normal stability of the spine in athletes with chronic lumbago (17, 18). The lumbar multifidus muscle is the primary stabilizer of the trunk and its effectiveness may be reduced 24 hours after the onset of acute lumbago. In patients with chronic lumbago, muscle compensation to alleviate pain may modify sensory function. Therefore, early initiation of core exercises is crucial for better recovery and prevention of chronic lumbago.

Core stability exercises strengthen the spinal muscles by improving their ability to maintain the spine in a neutral position using the abdominal, back, neck, and shoulder muscles as stabilizers rather than movers. There are two types of core stability exercises: static and dynamic exercises performed on the ground.Core stability has gained widespread popularity in recent years, with some studies observing a delayed or reduced activation of the lumbar multifidus and transversus abdominis in chronic lumbago. Dysfunction of these muscles can lead to loss of spinal stability, increased stress, and load on the spinal joints and ligaments.

The goal of core stability exercises is to establish normal muscle function to enhance spinal stability and neuromuscular control in the lumbopelvic region.

Core concept

The core concept has been a focal point in media and scientific literature since the end of the last decade (19). Core anatomy includes all structures between the scapula and gluteals. Core structures can be categorized into stabilizers, such as the internal and external oblique muscles, which control movement angles eccentrically, and mobilizers, such as the rectus abdominis and iliocostalis, which accelerate movement concentrically.

The muscles constituting the core are responsible for maintaining posture in various positions and facilitating safe and effective movement through different planes and directions. The core, represented by the coxo-lumbo-pelvic complex, is the center of the kinetic chains from which all upper and lower limb movements originate. An accurate anatomical understanding of the core region should also include the axial skeleton (coxofemoral and shoulder joints) and connective tissues (tendons, ligaments, fascia).

Researchers (20) have divided the core into three subsystems based on analogies with the "spinal stabilization system":

- passive: comprising vertebral ligaments, intervertebral discs, and articular fasciae;
- neural: this subsystem controls core muscle usage through feedforward and feedback mechanisms;
- active

The classification model proposed by researchers (21) is detailed in the following table (Table I).

Table I. *Classification of core muscles.*

LOCAL STABILIZER	GLOBAL STABILIZER	GLOBAL MOBILIZER
Transverse abdominal	External oblique muscle	Rectus abdominis
Interspinal	Internal oblique	Ileocostal
Psoas (posterior fascia)	Gluteus medius	Piriformis
Diaphragm	quadratus lumborum (deep bandage)	quadratus lumborum (ileo-costal bandage)
Pelvic muscles		Hip bi-articular muscles

The core muscles can be classified into various groups based on their anatomical location and function. The primary groups include:

1. abdominal and paraspinal muscles: these muscles are fundamental components of the core and have been extensively studied. They are divided into two main categories:
   - abdominal muscles: this group includes the rectus abdominis, external oblique, internal oblique, and transverse abdominis. These muscles are crucial for trunk flexion, rotation, and stabilization;
   - paraspinal muscles: this group consists of the spinal erectors (such as the iliocostalis and latissimus dorsi) and deeper trunk muscles like the rotatores, intertransversarii, and multifidus. These muscles are involved in extending and stabilizing the spine.

Particularly, the transverse abdominis is notable for its close anatomical relationship with the trunk and the thoracolumbar fascia. It has been the focus of many studies due to its role in core stability and is often targeted through specific exercises;

2. diaphragm: the diaphragm is considered the upper part of the core region. Its contraction, in synergy with the transverse abdominis and pelvic floor muscles, increases intra-abdominal pressure and enhances trunk stability, independent of its role in respiration;
3. coxofemoral joint and pelvic muscles: these structures form the base of support for the core. Key muscles in this region include the gluteal muscles. The gluteals are significant for stability and force production during specific sports movements. They help stabilize the trunk through closed kinetic chain movements and contribute to generating power and force for lower limb activities;
4. iliopsoas: the iliopsoas, a major muscle of the lumbar region, play a role in trunk flexion but do not contribute significantly to stabilization. Hypertonicity in this muscle can increase the load on the lumbar spine.

Methodology

This study was conducted at the “Orthomed Sport” physiotherapy clinic between January and July 2024. The participants were professional football players diagnosed with chronic lumbago who had been prescribed instrumental physiotherapy by an orthopedic doctor for a two-week period. The patients included in the study complained of back pain for 2 months and presented with a pain level of 3 or higher on the Visual Analog Scale (VAS, scale 0-10).

A total of 30 professional football players aged between 22 and 33 years were included in the study. The exclusion criteria included:

- history of spinal surgery;
- history of rheumatoid arthritis;
- spondylolisthesis or spondylolysis;
- history of pelvic fracture;
- inflammation or tumor of the spinal column;
- history of stroke;
- respiratory or cardiac pathology;
- athletes unwilling to complete the study.

The participants were divided into two groups: group A and group B. Participants in group A underwent only the instrumental physiotherapy prescribed by the doctor, which included TENS, Tecar therapy, and high-intensity laser therapy, for a two-week period. Participants in group B, in addition to the instrumental therapy, also performed core stability exercises three times a week for a period of 6 weeks. Before and after the experiment, the patients underwent the following tests:

1. measurement of pain intensity (VAS): patients were asked to indicate the subjective magnitude of their lumbar pain on a scale from 0 to 10, where 0 represents "no pain" and 10 represents "the worst possible pain” (Fig. 1);

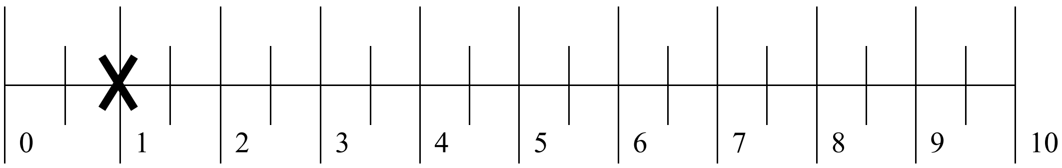

Fig. 1. *Measurement of pain intensity (VAS).*

2. measurement of hamstring flexibility: the toe-touch test was used to assess the flexibility of the posterior thigh muscles. The patient stands with both feet together and bends forward from the hips to touch their toes with their hands. Patients were instructed to bend forward as much as possible without bending their knees;
3. measurement of iliopsoas muscle flexibility: to assess iliopsoas muscle flexibility, the Modified Thomas Test (MTT) is utilized. The patient sits on the edge of a table and lies supine. They then pull their knees toward their chest while keeping the lower back pressed against the table (to prevent compensatory movement by extending the lower back). One leg is then slowly lowered below the table. The examiner observes and palpates the thigh to ensure it is completely relaxed;
4. internal rotation test in adduction and flexion: the internal rotation test in adduction and flexion was used to measure the flexibility of the piriformis muscle. The patient is positioned supine, with the hip joint flexed to 60° and the knee joint flexed to 90°. The physical therapist performs passive adduction and internal rotation of the hip joint. The range of motion is measured with a goniometer at the point of pain during the passive test. The pain point corresponds to the sciatic and gluteal regions;
5. measurement of disability level: the Oswestry Disability Index (ODI) was used to assess disability caused by CLBP. The ODI consists of 10 questions covering pain intensity, lifting, walking, sitting, standing, sleeping, sexual activity, social life, and travel;
6. one-Legged Stance test (OLST): the test was performed by standing on one leg to measure static balance. The time is recorded until the patient places their foot on the ground and the Trunk Stability Test (TST) (Fig. 2);

Fig. 2. *Trunk stability test (TST).*

7. The Y Balance Test: the YBT test is the sum of the 3 best distances achieved in the various directions divided by length of the limbs multiplied by 100 (Fig. 3);

Fig. 3. *Y-Balance test (YBT).*

8. McGill Core test (MCG): Isometric position hold and measurement of stance duration (Fig. 4).

Fig. 4. *Core endurance tests (sit up position, trunk extension, side bridge)*.

Participants in Group A and Group B underwent the aforementioned tests before the start of physiotherapy treatment. The results of these pre-treatment tests are presented in the table below (Table II).

Table II. *Initial tests before treatment.*

Patients	VAS	Flex Hams	Flex psoas	FAIRT	Trunk Stability Test (TST) left/right	MCG	YBT	OLST
Patient 1	2	7°	10°	30°	25/27 sec	20 sec	36.6 cm	1 min
Patient 2	2	8°	12°	31°	25/28 sec	18 sec	35 cm	50 sec
Patient 3	4	20°	15°	26°	18/20 sec	13 sec	26.7 cm	40 sec
Patient 4	6	22°	15°	18°	16/18 sec	10 sec	20.5 cm	35 sec
Patient 5	5	22°	18°	18°	17/20 sec	12 sec	22.6 cm	40 sec
Patient 6	5	25°	18°	19°	18/19 sec	13 sec	23 cm	40 sec
Patient 7	5	26°	18°	20°	16/21 sec	14 sec	24 cm	43 sec
Patient 8	8	30°	32°	10°	7/9 sec	6 sec	15.6 cm	10 sec
Patient 9	8	33°	34°	10°	8/10 sec	8 sec	17.3 cm	8 sec
Patient 10	5	20°	20°	15°	16/19 sec	12 sec	23 cm	37 sec
Patient 11	3	10°	31°	27°	18/21 sec	18 sec	35.3 cm	50 sec
Patient 12	3	11°	30°	26°	17/18 sec	18 sec	34 cm	47 sec
Patient 13	3	10°	32°	30°	16/16 sec	17 sec	36 cm	40 sec
Patient 14	3	8°	28°	25°	15/18 sec	16 sec	36 cm	49 sec
Patient 15	6	20°	20°	21°	13/15 sec	11 sec	21.3 cm	41 sec
Patient 16	6	20°	20°	20°	15/15 sec	10 sec	21.5 cm	40 sec
Patient 17	6	18°	22°	20°	16/17 sec	10 sec	21.5 cm	37 sec
Patient 18	7	17°	31°	22°	11/12 sec	9 sec	18.6 cm	25 sec
Patient 19	8	21°	29°	17°	10/10 sec	7 sec	15 cm	27 sec
Patient 20	7	18°	30°	20°	14/13 sec	8 sec	19.3 cm	27 sec
Patient 21	8	18°	31°	16°	11/12 sec	7 sec	14.7 cm	39 sec
Patient 22	8	20°	31°	14°	10/11 sec	6 sec	13.7 cm	38 sec
Patient 23	8	21°	32°	14°	10/14 sec	8 sec	14.8 cm	39 sec
Patient 24	8	18°	33°	15°	9/14 sec	8 sec	15.8 cm	40 sec
Patient 25	8	19°	32°	13°	10/13 sec	10 sec	15 cm	42 sec
Patient 26	7	28°	28°	17°	15/15 sec	13 sec	18.6 cm	32 sec
Patient 27	6	29°	29°	15°	16/17 sec	16 sec	22.5 cm	26 sec
Patient 28	4	24°	23°	24°	24/22 sec	18 sec	28.6 cm	47 sec
Patient 29	4	20°	25°	24°	22/21 sec	19 sec	27.8 cm	47 sec
Patient 30	9	37°	35°	8°	6/7 sec	4 sec	10 cm	6 sec

After the completion of the tests, patients in group A underwent instrumental physiotherapy for a two-week period. The procedures performed were: TENS for pain reduction=20 min, tecartherapy=25 min, high-intensity laser therapy=10 min.

Patients in group B received instrumental physiotherapy for a two-week period and, for an additional 6 weeks, performed core strengthening exercises with a frequency of three times per week. The main core exercises included:

- Push-Ups: 3 sets of 15 reps
- Dumbbell Rows: 3 sets of 10 reps (each arm)
- Overhead Press: 3 sets of 10 reps
- Plank: 3 sets of 1 minute
- Hanging Leg Raises**:** 3 sets of 10-15 reps
- Medicine Ball Slams: 3 sets of 15 reps
- Ab Wheel Rollouts: 3 sets of 10 reps
- Weighted Russian Twists: 3 sets of 20 reps on each side
- Cable Woodchoppers**:** 3 sets of 12 reps on each side
- Stability Ball Pike**:** 3 sets of 10 reps
- Russian Twists: 3 sets of 20 reps
- Leg Raises: 3 sets of 15 reps
- Bicycle Crunches: 3 sets of 20 reps. Squats: 3 sets of 10 reps
- Deadlifts: 3 sets of 8 reps
- Lunges: 3 sets of 12 reps
- TRX Body Saw: 3 sets of 15 reps
- Single-Leg Romanian Deadlift: 3 sets of 12 reps on each side
- Lateral Band Walk: 3 sets of 20 steps in each direction

Two months after the completion of treatment, patients were reassessed by the physical therapist and underwent follow-up tests. The results from the re-evaluation are presented in Table III.

Table III. *Tests after treatment.*

Patients	VAS	Flex Hams	Flex psoas	FAIR Test	TST left/right	MCG	YBT	OLST
Patient 1	0	0°	3°	40°	30/30 sec	40 sek	55 cm	2 min
Patient 2	0	0°	4°	39°	30/30 sec	38 sek	58 cm	1,7 min
Patient 3	0	1°	0°	36°	30/29 sec	31 sek	45.7 cm	1,7 min
Patient 4	1	1°	0°	30°	28/29 sec	26 sek	44.7 cm	1,2 min
Patient 5	1	1°	0°	32°	29/30 sec	28 sek	40.4 cm	1,6 min
Patient 6	1	0°	4°	31°	28/29 sec	30 sek	42 cm	1,4 min
Patient 7	1	0°	5°	33°	28/28 sec	32 sek	41 cm	1,4 min
Patient 8	2	10°	5°	27°	24/26 sec	21 sek	38.7 cm	1,8 min
Patient 9	2	8°	7°	26°	28/28 sec	20 sek	40.3 cm	48 sek
Patient 10	1	0°	0°	29°	29/29 sec	32 sek	46.5 cm	1,3 min
Patient 11	0	0°	0°	33°	30/30 sec	31 sek	56 cm	1,8 min
Patient 12	0	0°	0°	37°	30/30 sec	31 sek	57.5 cm	1;8 min
Patient 13	0	0°	0°	40°	28/29 sec	34 sek	55 cm	1,4 min
Patient 14	0	0°	2°	37°	27/28 sec	30 sek	54.6 cm	1,4 min
Patient 15	1	1°	0°	38°	27/28 sec	23 sek	46.7 cm	1,6 min
Patient 16	1	2°	0°	28°	27/29 sec	24 sek	45 cm	1,4 min
Patient 17	1	1°	0°	29°	26/30 sec	22 sek	48.5 cm	1,1 min
Patient 18	1	5°	0°	32°	27/27 sec	19 sek	43.8 cm	1,4 min
Patient 19	2	0°	5°	28°	20/20 sec	24 sek	42.3 cm	57 sek
Patient 20	2	0°	5°	32°	24/23 sec	18 sek	42.3 cm	57 sek
Patient 21	1	0°	0°	26°	25/24 sec	21 sek	46 cm	1,5 min
Patient 22	2	0°	0°	28°	20/23 sec	19 sek	40 cm	1,5 min
Patient 23	1	0°	0°	30°	30/30 sec	25 sek	50.1 cm	1,5 min
Patient 24	1	0°	0°	27°	28/29 sec	24 sek	50.3 cm	1,5 min
Patient 25	1	0°	2°	31°	26/28 sec	20 sek	49.3 cm	1,7 min
Patient 26	2	1°	0°	30°	30/29 sec	25 sek	48.5 cm	1 min
Patient 27	1	0°	5°	28°	28/28 sec	29 sek	49 cm	56 sek
Patient 28	0	0°	0°	40°	30/30 sec	38 sek	59 cm	1,7 min
Patient 29	0	0°	0°	39°	30/30 sec	37 sek	57.3 cm	1,6 min
Patient 30	2	3°	5°	26°	25/26 sec	18 sek	48 cm	45 sek

RESULTS

Core stability is closely related to the prevention and rehabilitation of lower limb injuries. The core is the primary point where the lower limbs generate or resist forces during movements. Authors have emphasized that core stability is vital for injury prevention (22). Reduced lumbo-pelvic stability has been shown to correlate with an increased risk of lower limb injuries, particularly in women. Beyond its stabilizing function and force generation, core functionality is integral to all sports involving extremities, such as athletics, football, swimming, and cycling.

Since the core connects the lower and upper limbs, controlling the strength, balance, and movement of the core can optimize the entire kinetic chain, including isolated athletic gestures of both the upper and lower limbs. Several studies have shown that excellent core stability is associated with improved physical performance in all sports. Precise transmission of forces from the lower to the upper limbs, along with good stabilization, provides a strong foundation for developing muscular strength, enhancing the effectiveness of athletic movements. A strong and stable core improves mobility, speed, and performance in athletes' lower extremities. Following the study, core stability was found to be effective in improving outcomes after re-evaluation through physiotherapy.

Two months after the completion of the therapeutic cycle, the patients were re-evaluated; from these evaluations, the following findings emerged:

- out of the 15 patients who underwent routine physiotherapeutic treatment with instrumental therapy, 8 experienced recurrent episodes of low back pain (lumbago);
- None of the 15 patients who received instrumental physiotherapeutic treatment combined with core stability exercises experienced further recurrent episodes.

This study highlighted reduced back pain from chronic lumbago in patients who incorporated core training exercises into their rehabilitation phase. This treatment effectively reduces the activation time of the stabilizing model we aim for.

DISCUSSION

In clinical practice, various therapeutic exercises are used for patients with chronic lumbago. Core stability exercises focus on activating the transverse abdominis and multifidus muscles. These muscles are connected to the thoracolumbar fascia and create a rigidity effect in the lumbar spine by increasing intra-abdominal pressure. Core stability exercises improve the muscular capacity of the local trunk muscles to achieve better neuromuscular control of spinal stability (23). These exercises can reduce pain and disability, improve proprioception, and enhance posture (24, 25).

Strength exercises are commonly used to treat patients with lumbago. Strength exercises activate the superficial trunk muscles that absorb load impacts and are suitable for patients with subacute or chronic lumbago. These exercises aim to increase the strength and control of the general trunk muscles to improve the overall stability of the vertebral column. They can reduce pain and physical disability and increase trunk muscle activity in patients with chronic lumbago.

Core strengthening through exercises can enhance the motor activity of the gamma system, improve central motor control mechanisms, or produce a combination of central and peripheral mechanisms. No previous studies have reported the effects of strengthening exercises on proprioception during subacute or chronic stages of lumbago.

In athletes with chronic lumbago, the posterior thigh muscles, iliopsoas, piriformis, and tensor fascia lata are hyperactive due to weakness in the abductors, extensors, and core muscles of the hip joint. Core stability is essential for proper pelvic, spinal, and kinetic chain balance.

CONCLUSIONS

The core is crucial in providing stability, force transmission, and preventing sports injuries. Through a comprehensive study of core anatomy, function, and clinical assessment techniques, this article provides insights for sports physical therapists. Implementing injury prevention programs for football players through core strengthening and core stability programs offers a clear, evidence-based framework for designing various effective programs. Results from several studies have shown that a single exercise is not sufficient to strengthen the entire core region; instead, a combination of exercises is needed to optimally strengthen the musculature.

Core stability can offer significant therapeutic benefits for patients with chronic non-specific low back pain. It helps reduce pain intensity and functional disability and improves quality of life by enhancing the activation and thickness of core muscles.

Core stability exercises are undeniably more effective than rest or minimal intervention. However, there is conflicting evidence regarding the superiority of core stability exercises compared to other exercises for managing chronic low back pain.

Combining core stability exercises with other exercise modalities appears to lead to greater improvements in pain and disability compared to using any single treatment alone.

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Retrospective Study

FEMOROACETABULAR IMPINGEMENT SYNDROME: CLINICAL OUTCOMES AND COMPLICATIONS OF THE ARTHROSCOPIC-ASSISTED MINI-OPEN SURGERY AT MID-TERM FOLLOW-UP

A. Russo[1], A. Clemente[1], A. Masotti[2], A. Battini[3], A. Massè[2] and A. Nicodemo[1]

[1]Humanitas Torino, Via Cellini 5, Turin, Italy;
[2]Department of Surgical Sciences, University of Turin, Turin, Italy;
[3]Azienda Ospedaliera di Alessandria, Alessandria, Italy

Correspondence to:
Antonio Russo, MD
Humanitas Torino,
Via Cellini 5,
Turin, Italy
e-mail: russo.antonio.92@gmail.com

ABSTRACT

Femoroacetabular impingement syndrome (FAI) is a painful condition derived from a complex of anatomical patterns involving the femoral neck-head junction and acetabulum. It is a well-established cause of early degenerative disease of the hip, and a prompt diagnosis is crucial to implement modifications of activities, physical therapy, and eventually to correct the deformity through surgery. The aim of this study was to report clinical-functional and radiographic outcomes of patients who underwent femoroacetabular impingement correction with a mini-open arthroscopic assisted direct anterior approach. A retrospective analysis of a prospectively collected database of patients operated for femoroacetabular impingement in a single center from 2012 to 2019 was performed. Harris Hip Score, the degree of hip internal rotation, and radiographic alpha angle were measured pre-operatively and compared to values registered at the latest follow-up. Operative times and intra-operative times of exposure to X-rays were also recorded. A total of 69 procedures on 64 patients were included. Of these, 46 were males (71.9%). The mean age was 34.4±6.6 years. The mean follow-up was 75.7±24.4 months. Mean values of Harris Hip Score, internal rotation of the hip, and alpha angle at the latest follow-up significantly improved from those registered preoperatively ($p<0.01$). Operative time significantly decreased after the first 34 procedures ($p<0.01$). One patient (1.4%) required conversion to total hip arthroplasty after 5 years of the index procedure. The arthroscopic-assisted mini-open technique showed good clinical outcomes with a low rate of complications and can be a reliable choice to treat FAI. This strategy may represent a suitable alternative to arthroscopy due to its low operating times, costs, short learning curve, and reduced total time of traction and X-ray exposure.

KEYWORDS: *femoroacetabular impingement syndrome, FAI, femoral head-neck junction, acetabular rim*

INTRODUCTION

Femoroacetabular impingement (FAI) is a syndrome characterized by abnormal biomechanics of the hip due to abnormal morphology of either the femoral head-neck junction or the acetabular rim, which cause pain, functional

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limitations, chondral and labral lesions and predispose to early hip osteoarthritis (OA) (1, 2). There are three different types of morphology related to FAI: cam, with decreased head-to-neck ratio, loss of sphericity of the femoral head, and femoral neck retroversion; pincer, which has abnormal acetabular morphology, such as anterosuperior acetabular rim overhang, acetabular retroversion, coxa profunda or protrusion acetabuli; mixed, which involves characteristics of the previous two types (3-6). Several hypotheses concerning FAI etiologies have been postulated, such as genetic factors, type of physical activity, history of pediatric hip disease, and previous hip fracture (7-8). The treatment should be tailored to the patient's symptoms, clinical presentation, and anatomical abnormalities. Behavioral and postural interventions, activity modification, physical therapy, and oral anti-inflammatory drugs are the first-line approach. In case of failure of conservative treatments, surgery is indicated, aiming at improving symptoms and quality of life, decreasing pain, and delaying the onset of OA.

Depending on the cases, surgery may involve femoral and acetabular osteochondroplasty and acetabular labral repair (3, 9). Several different surgical techniques have been described, and the first one was the surgical dislocation described by Ganz (10), which played an important role in the treatment of this condition and remains an excellent technique for the treatment of complex conditions. More recently, hip arthroscopy has been considered as the *gold standard* due to reduced surgical invasiveness and shorter return to physical activity (11-13). However, the arthroscopic approach has some limitations, such as inadequate bony correction, persistence of pain and subsequent revision, and neurovascular trauma due to long traction and operative time (14-16). In 2005, a combined arthroscopic and mini-open procedure was described by Ribas and colleagues, which is less invasive compared to open surgery and has a shorter operative time and learning curve compared to arthroscopy (15, 17, 18). The purpose of this study was to analyze arthroplasty-free survivorship, clinical outcomes, and complications of patients who had an arthroscopic assisted mini-open surgery to treat FAI syndrome.

MATERIAL AND METHODS

This is a retrospective analysis of a prospectively collected database of patients who underwent arthroscopic assisted mini-open direct anterior approach to treat FAI. All procedures were performed by a single surgeon (A.N.) between October 2012 and December 2019. The minimum follow-up was set at 36 months. Patients who underwent prior hip surgeries were excluded.

Outcome measures

Preoperative clinical evaluation included physical examination with measurement of the internal rotation and Harris Hip Score (HHS), which were recorded and tabulated in a dataset. All patients underwent preoperative X-rays (anteroposterior pelvis view and bilateral hip axial Dunn view) to assess osteoarthritis, Wiberg and alpha angles, and arthro-MRI to assess cartilage and labrum preoperatively. Radiographic parameters were evaluated independently by two different authors. The same clinical tests and imaging studies were conducted at the last follow-up. All possible complications and operative variables were recorded.

Surgical technique

All procedures were performed under general anesthesia. Patients were positioned supine on a regular table with a traction system extension (Advanced Supine Hip Positioning System - Smith & Nephew®) (Fig. 1A). All vulnerable body areas were protected to avoid pressure marks. Mini direct anterior approach was performed in all cases, 3 to 6 centimeters, depending on patient morphotype (Fig. 1B).

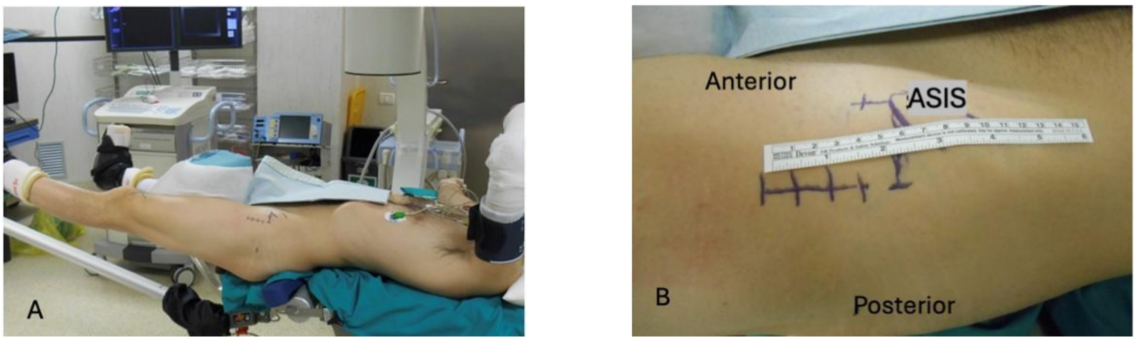

Fig. 1. *Setting in the operative theatre.* ***A****): patient positioning on the traction table;* ***B****): anatomical landmarks for skin incision.*

Three Homann retractors (medial and lateral to the neck and over the anterior acetabular wall) were placed to visualize the capsule. An H or inverted T-shape capsulotomy was performed, proximal to the circumflex artery avoiding coagulating it. Thereafter traction was applied to inspect the acetabulum and rim by a 70° arthroscope. Sutures were carried on with 1 to 3 bioabsorbable anchors (Osteoraptor 2.3 - Smith & Nephew®). Traction was applied to the operated limb only during central compartment inspection and labral suture. The femoral osteochondroplasty was carried out with a high-speed burr (Fig. 2).

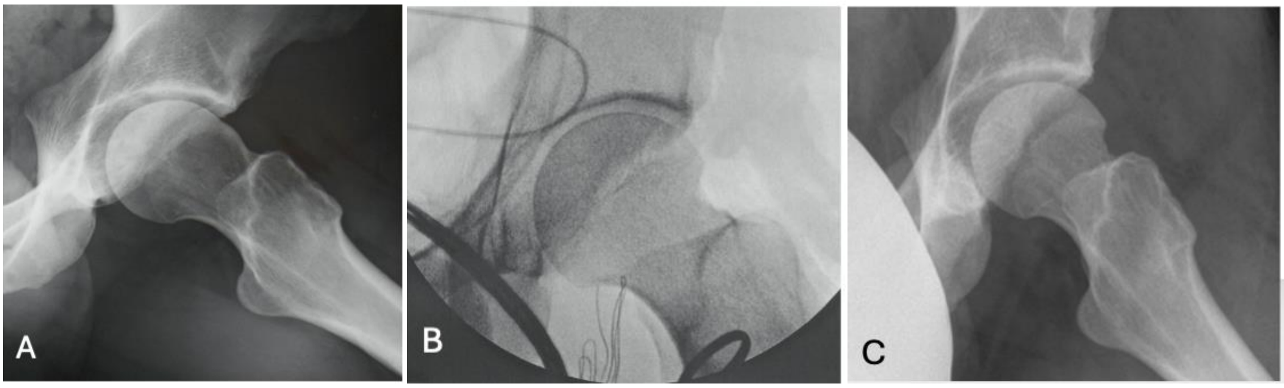

Fig. 2. *Radiographic images of 31 years old male patient.* ***A****): pre-operative CAM deformity.* ***B****): intraoperative fluoroscopy for assessment of CAM correction.* ***C****): X-ray of the hip at latest follow-up.*

Whether the labrum was not detached and the acetabular rim osteochondroplasty was not necessary, the labrum was not treated although were present degeneration signs, considering the spontaneous healing after the resolution of bony impingement demonstrated by Harris (19), even avoiding further joint instability. The accuracy of the correction was assessed under direct visualization, with an impingement test in flexion, adduction and internal rotation and a final fluoroscopy check in coronal and Dunn view. Fluoroscopy was used only to check the accuracy of CAM resection. At the end of the procedure, the capsule was repaired, and the skin was closed using staples or an intradermal absorbable running suture.

Postoperative care

The patients were discharged one or two days after surgery, depending on residual pain and general conditions. Postoperative rehabilitation protocol consisted of ambulation with crutches and partial weight bearing for 2-5 weeks depending on the amount of CAM resection and other procedures performed during surgery (labral suture or microfractures). Motion over maximum degrees of flexion and internal rotation were restricted for 3 weeks. Postoperatively all patients received 3 weeks treatment with nonsteroidal anti-inflammatory drugs (Celecoxib 200mg 2/die) for heterotopic ossification prophylaxis.

Data analysis

Continuous variables were presented as mean ± standard deviation. Categorical variables were reported as the total number of cases or percentage. Data distribution was assessed using the Shapiro-Wilk test. Continuous variables registered preoperatively were compared to those obtained at latest follow-up using paired t-test. Statistical significance was set at $P < 0.05$ for all the variables analyzed. Statistical analysis was conducted using IBM SPSS Statistics 26.0 (IBM Corp., Armonk, NY, USA).

RESULTS

A total of 69 procedures performed on 64 patients were included. Of these, 46 (71.9 %) were men. The mean age at the time of surgery was 34.4±6.6 years (range 18-45 years). No patient was lost at follow-up, and the mean follow-up time was 75.7±24.4 months (range 36-114 months) (Table I).

Table I. *Demographic data of patients.*

Variable		Number of cases (%)	Mean ± SD
Number of patients included		69 (100)	-
Sex	Male	46 (71.9)	-
	Female	18 (28.1)	-
Mean Age		69 (100)	34.4 ± 6.6
BMI, kg/m^2		69 (100)	23.4 ± 3.7
Operative Time		69 (100)	83.1 ± 22.3
Follow-up, mo		69 (100)	75.7 ± 24.4

BMI: Body Mass Index; mo: months.

The mean operative time (OT) was 83.1 minutes±22.3 (range 50-140). The mean OT of the first 34 procedures was 103.4 min±17.3 (range 75-140) while the OT of 35 last cases was 66.5 min±15.6 (range 50-110) ($p < 0.01$). Mean limb-traction time was 26.5±7.7 minutes (range 16-41). Thirty-nine patients (56.5%) presented labrum tears that required sutures, and in 23 cases (33.3%) an acetabular rim resection was performed. In 9 cases (13.0%) a resection of unstable chondral flap was conducted, and in 2 cases (2.9%) microfractures were performed to treat full-thickness cartilage tear. Mean total time of intraoperative X-ray exposure was 2.7±1.1 seconds (range, 1-5). Radiographic evaluation demonstrated Tönnis grade 0 in 31 hips (44.9%), grade 1 in 30 hips (43.5%), and grade 2 in 8 cases (11.6%).

Arthroplasty-free survivorship

One patient (1.4%) required conversion to total hip arthroplasty. This patient had Tönnis grade 1 osteoarthritis at the time of mini-open surgery and underwent replacement of the hip due to persistent hip pain five year after the index procedure. This patient was later found positive to HLA B-27 test.

Clinical outcomes

Internal rotation of the hip improved from mean preoperative value of 8.7°±9.0 to 21.7°± 6.6 ($p<0.01$) at last follow-up. The mean Harris Hip Score (HHS) increased significantly from preoperative value of 67.4±8.9 points to 87.7±7.9 points at final follow-up, with mean improvement of 20.3 points ($p <0.01$) (Table II).

Table II. *Clinical and Radiographic outcomes.*

Variable	Preoperative	Postoperative	p-value
Internal Rotation	8.7° ± 9.0	21.7°± 6.6	**<0.01**
Alpha Angle	66.0° ± 10.6	51.8° ± 6.5	**<0.01**
HHS	67.4° ± 8.9	87.7° ± 7.9	**<0.01**

HHS: Harris Hip Score; p-value is for paired t-test.

When stratifying patients based on age (< or ≥ 35 years) and Tönnis grade (< or ≥ grade 1): the mean post-operative HHS was 91.2 for group A (< 35y and Tönnis 0) and 87.2 for group B (≥ 35y and Tönnis 1 or 2). A total of 16 patients (25%) were semi-pro athletes (martial arts, basketball, and football) and the rate of return to the same level of competition was 81.3%.

Complications

Eleven cases (15.9%) of femoral cutaneous nerve and one case (1.5%) of pudendal nerve transient injuries were recorded; all of them were totally recovered at the final follow-up evaluation. No heterotypic ossifications, superficial or deep infection, or avascular necrosis of the femoral head were registered. There was no need for a blood transfusion during the hospital stay (Table III).

Table III. *Prevalence of potential complications associated with the procedure.*

Complications	Number of cases (%)
Neuroapraxia*	12 (17.3)
Heterotopic Ossification	0 (0)
Avascular Necrosis	0 (0)
Infection	0 (0)
THA conversion	1 (1.5)

*THA: Total hip arthroplasty; *11: transient lateral cutaneous nerve; 1: transient pudendal nerve.*

DISCUSSION

Clinical outcomes of the mini-open arthroscopic assisted approach are evaluated in a few articles, with a small number of subjects analyzed. In the present study, 69 consecutive procedures were analyzed, and a good HHS mean value of 87.7 points was found at the last follow-up. A recent literature review reported similar values (84.5 for arthroscopy and 88.1 in open surgery)(20). All the patients included reached a good restoration of the internal rotation, considering a mean value of 21.9 degrees at the last follow-up, values consistent with those encountered in the literature on patients treated with other techniques.(20, 21). No major complication was recorded, and the more common complication in the present case series was lateral femoral cutaneous nerve neuropraxia in 11 (15.9%) cases, which is similar to the mean values reported in the literature (22-25). The cases of neuroapraxia were all solved at the last follow-up without permanent consequences.

The overall reoperation rate was 1.4%, which is non-inferior compared to arthroscopy (26). The one patient who was reoperated was found positive for HLA-B27 associated spondyloarthropathy and underwent total hip arthroplasty 5 years after the indexed procedure due to progression of arthrosis and persistence of groin pain. The direct visualization of the surgical approach helps the surgeon to easily address the extent of the correction required, test the dynamic impingement intraoperatively, and then prevent inadequate osteochondroplasty that may lead to the persistence of pain and further surgical revision (11, 27) .

A recent review analyzed the cost-effectiveness of arthroscopic treatment of FAI, comparing it with non-operative treatment, concluding that the surgical approach is more expensive but led to a significant improvement in quality of life (28). Currently, the literature is missing a cost-effectiveness analysis that compares the arthroscopic technique with the mini-open arthroscopic-assisted technique. In the present study, the mean operative time was 88.1 minutes, reaching a mean of 66.5 minutes in the last 30 procedures. The mean operative time decreased by more than 20 minutes, suggesting a short learning curve of the mini-open approach. The reduced mean operative time, together with good to excellent clinical outcomes and the absence of major complications, make this procedure attractive and competitive with arthroscopy. Moreover, although several studies showed excellent outcomes together with a low complication rate of FAI correction through hip arthroscopy, these case series are performed by experienced surgeons with a high volume of procedures per year (22, 25). Furthermore, one of the most important drawbacks of arthroscopy is the long learning curve and the high cost of the procedure and instrumentation.

The arthroscopic-assisted mini-open approach is a reproducible technique with a shorter learning curve, especially for surgeons skilled in direct anterior approach for hip arthroplasty. This technique was analyzed by a few authors (11, 15, 17, 18) with a consequent small number of procedures and only a few studies comparing it to other techniques (20, 21, 25). The surgical procedure proposed in the present case series is a safe and effective treatment of FAI syndrome, providing good functional outcomes.

This study presents several limitations that should be considered when interpreting the results. First, the retrospective nature of the analysis with all the inherent issues typical of this level of evidence. For instance, the total number of complications reported could be lower than the real prevalence since minor complications could not have been registered. However, this study presents some strengths since all patients were treated by a single surgeon following a standardized protocol in a hip surgery unit, reducing the impact of potential variabilities.

CONCLUSIONS

The arthroscopic-assisted mini-open technique showed good clinical outcomes with a low rate of complications and can be a reliable choice to treat FAI. This strategy may represent a suitable alternative to arthroscopy due to its low operating times, costs, short learning curve, and reduced total time of traction and X-ray exposure.

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Case Report

A CASE OF MERALGIA PARESTHETICA TREATED WITH OZONE THERAPY

F. Albertini

Department of Neuroradiology, S. Anna Clinical Institute of Brescia (San Donato Group), Brescia, Italy

Correspondence to:
Filippo Albertini, MD
Department of Neuroradiology,
S. Anna Clinical Institute of Brescia (San Donato Group),
Brescia, Italy
e-mail: docalbertini66@gmail.com

ABSTRACT

Meralgia paresthetica (MP) is a clinical condition of growing interest, mainly because it can affect a wide range of patients and is associated with abdominal and pelvic surgeries. This neuropathy occurs due to compression or irritation of the Lateral Femoral Cutaneous Nerve (LFCN), which is responsible for sensitivity in the outer part of the thigh. Local infiltration treatments typically use anesthetics and corticosteroids. In the presented case, a mixture of oxygen-ozone (O_2-O_3) at 20 µg/ml was injected locally, with a total of 8 cc and a single treatment.

KEYWORDS: *meralgia paresthetica, neuropathy, abdominal and pelvic surgery, oxygen, ozone*

INTRODUCTION

Meralgia paresthetica (MP) is a rare neuropathy caused by the compression of the Lateral Femoral Cutaneous Nerve (LFCN), which occurs in the region where the nerve passes through the inguinal ligament on its way from the pelvis to the thigh. The specific anatomy of this region explains the clinical presentation characterized by sensitivity alterations, burning pain, and dysesthesias in the anterior and lateral aspects of the thigh (1-5).

The term "meralgia" comes from the combination of the Greek words “meros” (thigh) and “algos” (pain), reflecting the main symptomatology of this condition; it was first described in 1885 by Hager and subsequently by Bernhardt and Roth in 1895, from which the condition is sometimes referred to as Bernhardt-Roth syndrome or Roth syndrome (6, 7). These early studies highlighted the association of MP with the use of "binds" or bands for the confinement of inguinal hernias before the era of modern surgical techniques. These devices, which exerted pressure on the pelvis and thigh, were a common cause of nerve compression and contributed to the development of this neuropathy (8-22).

MP continues to be relevant primarily due to its association with abdominal and pelvic wall surgical procedures, as well as with medical conditions and risk factors such as obesity and diabetes. Therefore, understanding and managing MP is crucial to alleviating patient discomfort and improving postoperative and clinical outcomes.

Anatomy

The LFCN is a purely sensory nerve that provides innervation to the skin of the anterior and lateral aspects of the thigh. It originates from the anterior ramus of the second lumbar nerve (L2) of the lumbar plexus, with fibers also coming from the third lumbar nerve (L3). This nerve is characterized by its early autonomy, separating from other fibers of the lumbar plexus as it travels along the lateral margin of the psoas major muscle (Fig. 1).

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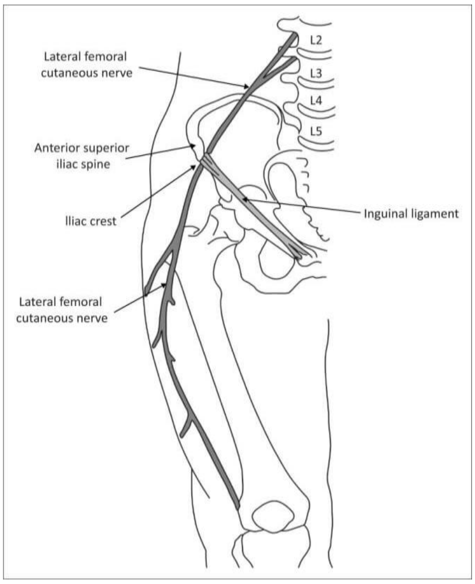
Fig. 1. *Anatomy of the lateral femoral cutaneous nerve*.



After crossing the iliac fossa, the LFCN exits the pelvis by piercing the lower abdominal fascia, located just below the Anterior Superior Iliac Spine (ASIS) and the Inguinal Ligament (IL), with which the nerve is often closely associated. In this region, the nerve comes into direct contact with the fascia of the sartorius muscle and divides into two branches: an anterior branch and a posterior branch. These branches innervate the anterior and lateral portions of the thigh, respectively.

It is important to note the anatomical variability of the nerve's course, with up to five documented variations (10). In the majority of cases (about 80%), the nerve emerges below the inguinal ligament and medially to the ASIS. This position is crucial for understanding the etiology of nerve injury, as any compression or irritation in this area can significantly affect the function of the LFCN and lead to the symptoms of MP (3).

ETIOLOGY

MP can arise from a variety of factors, which can be divided into two main categories: idiopathic and iatrogenic.

Idiopathic origin

The idiopathic causes are directly attributable to mechanical and metabolic factors that cause compression of the LFCN, such as:

- obesity: excess body weight can exert additional pressure on the nerve region, contributing to compression and associated symptoms (22);
- pregnancy: physiological and structural changes during pregnancy may predispose to nerve compression;
- constrictive clothing: prolonged use of tight clothing or uniforms can apply direct pressure on the nerve region (19), causing symptoms;
- anatomical and mechanical alterations: conditions such as scoliosis, lower limb discrepancies, and other spinning-pelvic mechanical anomalies can alter the normal course of the nerve, predisposing it to compression;
- metabolic factors: diseases such as diabetes mellitus and alcoholism, along with conditions like lead poisoning, can affect nerve functionality through metabolic and toxic mechanisms.

Iatrogenic origin

Iatrogenic causes are related to surgical procedures and medical practices that can cause compression or irritation of the nerve, such as:

- open or endoscopic abdominal surgery: procedures such as hernioplasty, laparotomy, and other abdominal operations can lead to compression of the lateral cutaneous nerve of the thigh, especially if excessive pressure is applied during the operation.

- orthopedic surgery: during anterior approach hip arthroplasty, the nerve may become compressed or irritated (2, 5, 11).
- spinal surgery: prolonged prone positioning of the patient during spinal surgery can exert pressure on the nerve. Additionally, procedures involving the iliac crest, such as bone graft harvesting, can contribute to nerve compression.

CLINICAL

MP presents with a series of characteristic symptoms primarily affecting the anterior and lateral regions of the thigh (12, 16). Diagnosis can be complex due to symptoms that overlap with other conditions. The main symptoms include burning pain, the most common symptom affecting the anterior and lateral thighs. This pain can be continuous or intermittent and tends to worsen with physical activity. There may be accompanying sensations of tingling, numbness, or altered sensitivity in the same area (dysesthesias).

Differential diagnosis

Diagnosis can be challenging due to symptoms similar to those of other medical conditions. Conditions that may present with similar symptoms include:

- spinal and radicular disorders: lumbar disc diseases and spinal stenosis may cause symptoms similar to those of meralgia paresthetica, such as pain and sensory changes in the thigh region;
- chronic neurological disorders: polyneuropathy may present with symptoms of tingling and pain in the thigh, necessitating accurate differentiation;
- hip joint disorders: MP may complicate or be confused with hip joint disorders, such as femoroacetabular impingement, trochanteric bursitis, and coxofemoral osteoarthritis.

Diagnosis

Diagnosis requires a comprehensive clinical evaluation that includes the following:

- history and physical examination*:* a detailed history and physical examination to identify the pattern of pain and dysesthesias and to exclude other conditions;
- diagnostic tests*:* in some cases, diagnostic tests such as nerve conduction studies or electromyography may be necessary to confirm the diagnosis and exclude other neuropathies;
- imaging*:* imaging techniques, such as ultrasound or magnetic resonance imaging (MRI), may be useful to exclude other conditions and visualize nerve compression if present.

Clinical-diagnostic tests for MP

Diagnosis of MP can be confirmed and differentiated from other conditions through various clinical-diagnostic tests; the three main tests used are:

- Pelvic compression test: the patient is positioned on the healthy side, and the examiner positions themselves on the symptomatic side and applies downward compression on the pelvis for at least 30 seconds.
  - Interpretation:
    - if the patient reports a reduction in symptoms during or immediately after the compression, the test is considered positive;
    - this result suggests that compression reduces tension on the inguinal ligament and, consequently, compression of the lateral cutaneous nerve of the thigh;
    - the sensitivity of this test is generally considered very high, making it useful for confirming the presence of MP.
- Tinel sign or percussion of the nerve: an orthopedic hammer is used to gently strike the area of compression of the lateral cutaneous nerve of the thigh.
  - Interpretation:
    - if the nerve is particularly inflamed, percussion may provoke a sensation of electric shock or sharp pain.

These clinical-diagnostic tests offer a practical approach to identify MP and guide therapeutic management.

Diagnostic exams

To confirm the diagnosis, conducting neurophysiological and imaging exams is essential.

- Neurophysiological exams:
  - Sensory neurography: this test measures the conduction velocity and amplitude of the potential evoked by the lateral cutaneous nerve of the thigh. It is useful for assessing nerve function and identifying signs of damage or compression. Sensory neurography can help confirm the diagnosis of MP and differentiate the condition from other neuropathies.
- Imaging exams:
  - pelvic X-ray: used to exclude the presence of bone neoplasms, calcifications of the inguinal ligament, or other bone abnormalities that could contribute to nerve compression.
  - ultrasound: ultrasound of the lateral cutaneous nerve of the thigh can provide detailed images of the nerve structure and identify signs of compression, inflammation, or injury (13).
  - Magnetic Resonance Imaging (MRI): MRI provides an excellent view of soft tissues (1) and can reveal compressions or abnormalities not visible on X-ray. MRI can be used to exclude other conditions and confirm the presence of nerve compression.

TREATMENT

The choice of treatment depends on the severity of symptoms, the underlying cause, and the response to initial therapies.

Non-invasive treatment

1. Lifestyle modifications:
   - avoid compression: identify and modify habits that may contribute to nerve compression, such as wearing tight clothing, carrying heavy backpacks, or improper positioning.
   - weight management: weight loss can reduce pressure on the nerve and alleviate symptoms.
2. Pharmacological approach:
   - neurotropic drugs: used to improve nerve function and reduce pain. Analgesics and non-steroidal anti-inflammatory drugs (NSAIDs) can be useful for managing pain.
3. Physical therapy and osteopathy:
   - manipulations and stretching of the muscles and tendons can help reduce compression and improve mobility, techniques to improve flexibility and reduce tension in skeletal and musculo-tendinous segments.

Pain therapies

1. Pulsed radiofrequency ablation:
   - technique: uses radiofrequency energy to heat and deactivate nerve tissue, reducing pain (17). The procedure is guided by ultrasound for greater precision and safety (18).
2. Nerve anesthetic block:
   - anesthetic injections: provide temporary relief from symptoms and can aid in diagnosis and treatment planning.

Surgical treatment

1. Nerve neurolysis:
   - the procedure includes abdominal fasciotomy and partial detachment of the inguinal ligament until complete release of the nerve and its branches. It aims to remove compression and restore nerve function (15, 18, 20). The possibility of recurrence is approximately 20%.
2. Neurectomy:
   - the procedure involves isolation and resection of the nerve for a segment of at least 3 cm (21). It is a more invasive solution that eliminates nerve function in the affected area and leads to permanent loss of sensitivity in the nerve's area of competence (4).

CASE REPORT

A case is described of an obese patient treated for MP through an O_2-O_3 guided by an X-ray. In June 2024, a 43-year-old obese male patient came to our clinic, reporting a loss of sensation on the lateral side of the thigh and painful "shock-like" dysesthesias on the anterior side of the right thigh. The symptoms began shortly after undergoing bariatric surgery, which ended with the temporary placement of an abdominal-pelvic containment belt. This belt was maintained in place with moderate compression for over three hours.

In the following months, the patient underwent osteopathic treatment, non-steroidal anti-inflammatory drugs (NSAIDs), and had a lumbar MRI and electromyography performed (Table II). The latter reported a diagnosis of injury to the saphenous nerve and, thus, possible meralgia paresthetica.

Table II. *Results of electronuromyography and electromyography performed on the patient, accompanied by clinical interpretation of the findings.*

ELECTRONEUROGRAPHY

Sensory conduction velocity

Nerve and Site	**Latency on Set** ms	**Peak latency** ms	**Width** µV	**Segment**	**Distance** mnt	**VDC** ms
Lateral femoral cutaneus. S						
Above inguinal ligam	1.9	2.6	2	Above inguinal ligament - Thigh	120	63
Lateral femoral cutaneous.D						
Above inguinal ligam	NR	NR	NR	Above inguinal ligament - Thigh		

ELECTROMYOGRAPHY

Muscle	Inserz	Fibril	Fasciculations	Other	Width	Duration	Polifasic	Rccl
Right Iliopsoas	0	0	0		Norm	Norm	No	Norm
Right rectus femoris	0	0	0		Norm	Norm	No	Norm
Right adductor magnus	0	0	0		Norm	Norm	No	Norm

CONCLUSIONS

Examination limited by adipose tissue. As far as assessable, there is present SAP of the left lateral femoral cutaneous nerve, while a clear and reproducible response from the right lateral femoral cutaneous nerve is absent. The musculature dependent on L3 is normal. Findings overall suggestive of meralgia paresthetica.

An L3-L4 protrusive discopathy with right L3 foraminal conflict was also present on the MRI. After clinical evaluation, the performance of some clinical tests, and the collection of medical history, the therapeutic choice was to perform an X-ray guided injection (fluoroscopy) with O_2-O_3 (20 µg/ml) in the inferomedial region at the Anterior Superior Iliac Spine (ASIS) (Fig. 3).

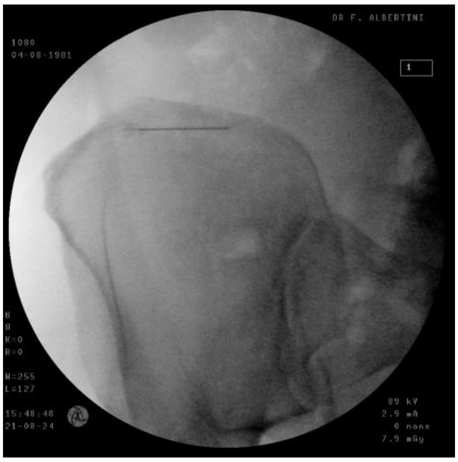


Fig. 3. *Scopic control of the O_2-O_3 injection.*

The patient experienced gradual improvement one week after the treatment, culminating in the complete disappearance of pain. By the twentieth day, there was also a partial reduction in the sensory deficit. The results were reassessed at 30, 60, and 90 days following the injection, consistently confirming the benefit.

DISCUSSION

Much of the therapeutic potential of O_2-O_3 therapy in pain management is attributed to its multimodal mechanism of action. The most fundamental mechanism involves the oxygenation of the treated tissue and the restoration of cellular redox balance. In addition, ozone regulates the local antioxidant system, thereby reducing the inflammatory response and improving the management of ischemia/reperfusion processes. Several studies have confirmed its anti-inflammatory properties, as well as its anti-edematous, regenerative effects on nerves, and analgesic effects (9, 22-25).

CONCLUSIONS

MP is a complex and multifactorial condition that requires particular attention both in the diagnostic and therapeutic phases. Local infiltrative therapy with O_2-O_3 should always be considered in cases that can avoid surgical treatment.

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Case Report

METASTATIC CANCER OF THE LUNG AND LUMBAR SPINE MIMICKING LOW BACK PAIN: A CASE REPORT

H. Sidita and T. Altin

Faculty of Medicine, Rehabilitation Sciences, The Catholic University "Our Lady of Good Counsel" Tirana, Albania

Correspondence to:
Haxolli Sidita, MD
Faculty of Medicine,
Rehabilitation Sciences,
The Catholic University "Our Lady of Good Counsel"
Tirana, Albania
e-mail: siditahaxholli@hotmail.com

ABSTRACT

The purpose of this case study is to describe the presentation of a patient with persistent back pain and leg pain with no prior diagnosis of cancer and to describe the clinical course of a patient referred to physiotherapy (PT) for treatment, which was subsequently diagnosed with metastatic cell carcinoma of the lung and bone. A 76-year-old woman was referred to PT for the evaluation and treatment of an insidious onset of low back and leg pain of 3-month duration. She had positive neurologic signs or symptoms suggestive of radiculopathy, recent weight changes, and general health concerns. She received mild relief during the first office visit, including manipulation, tecar therapy, moist heat, and electro-acupuncture stimulation. Although the patient experienced some pain relief after her physiotherapy treatment, she continued to have persistent mild pain in the lumbar area. The patient's history and physical examination were consistent with a mechanical neuromusculoskeletal dysfunction, and no red flag findings warranted immediate medical referral. Short-term symptomatic improvements were achieved using PT treatment. However, despite 5 PT sessions over 5 weeks, the patient did not experience long-term symptomatic improvement. On the fifth session, the patient reported a 7-day history of right hand and leg weakness and breathing problems. This prompted the physiotherapist to refer the patient to the emergency department. Abnormal examinations and radiographic findings were discovered. A subsequent computed tomography scan of the lumbar spine revealed marked metastatic changes to the lower thoracic and upper lumbar spine. The patient was immediately referred to the pulmonologist and oncologist. This case highlights the importance of patient health history and further investigation of the red flags of persistent pain in patients. Differential diagnosis is a key component of PT practice. Low back pain recurrence in an established patient should constitute a reevaluation of the problem. The cause cannot be assumed to be musculoskeletal in origin, even though this may have been the case with the initial complaint. Metastatic disease should be considered with any type of recurrent low back pain. The ability to reproduce symptoms or achieve short-term symptomatic gains is not sufficient to rule out threatening pathology.

KEYWORDS: *lung cancer, diagnostic imaging, metastatic carcinoma, differential diagnosis, low back pain*

INTRODUCTION

Cigarette smoking is the leading cause of lung cancer, but 15% of patients with the disease have never smoked (1-6). Thirteen to 15% of all lung cancers worldwide are small cell carcinomas. This type of cancer is aggressive, is usually central in location, and is associated with mediastinal involvement. This case study describes the management of a patient who complained of low back pain. Despite a similar presentation in this patient's history, recognizing a

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potentially different etiology led to the clinical decision to perform a reexamination. Lung carcinoma with metastasis in the spine was eventually diagnosed as a result of this examination.

Low back pain is a common condition, and physiotherapists (PT) routinely manage patients with this complaint. While the prevalence of severe medical pathology (i.e., cancer) causing low back pain is extremely low, it is the responsibility of the physiotherapist to screen and monitor for medical conditions and determine if referral to another health care practitioner is indicated. Lung cancer commonly metastasizes to the skeletal system, and when affecting the spine, it may initially be mistaken for a typical musculoskeletal source of back pain.

These screening strategies allow the physiotherapist to proceed with the patient's care and avoid unnecessary physician referrals. Some threatening pathology may present initially with musculoskeletal symptom patterns, including the ability to reproduce or reduce symptoms through mechanical means (7-9). Therefore, it is imperative for physiotherapists to frequently reevaluate their patient's response to intervention since signs and symptoms of severe underlying disease can develop at any point in the course of care. Evidence-based strategies can be utilized to screen for medical pathology that can mimic mechanical low back pain. If a red flag is present, evidence-based screening strategies suggest that lumbar spine radiographs and laboratory testing (erythrocyte sedimentation rate) are the next appropriate steps to rule out cancer as the cause of low back pain. However, suppose the concern persists without abnormal laboratories and/or radiographic findings. In that case, advanced diagnostic imaging should be used to screen for cancer as a source of the pain. This report describes the clinical course of a patient referred to physiotherapy for the treatment of low back pain, who was subsequently diagnosed with cell carcinoma of the lung with metastases in the spine.

CASE REPORT

Patient characteristic

The patient was a 76-year-old woman. She enjoyed occasional walking for physical activity daily. She was initially evaluated in the emergency department the day after the onset of low back pain symptoms. Lumbar radiographs were significant for degenerative changes at the L4- L5-S1 level. She was diagnosed with a lumbar strain, prescribed ibuprofen, and asked to follow up with her primary care physician if she did not improve. One month after symptom onset, there was no improvement when the patient was evaluated by her primary care physician. During this evaluation, the patient complained that her fatigue limited her daily activities.

The patient had a 5-year clinical history of fatigue but no associated depression. She also noted that the pain was unchanged with activity. At this visit, she was prescribed cyclobenzaprine, provided a general exercise handout, instructed in postural education, advised on activity modification, ordered to rest and use manipulation, diathermic heat electro-acupuncture, and referred to PT.

Examination

At the PT's initial evaluation, the patient's chief complaint was upper lumbar pain centered at L4-L5-S1 and described as an intermittent, variable, and dull ache with referral into the buttock or lower extremities. Aggravating factors included sitting and lifting objects while easing factors included standing and sleeping. The patient noted that her symptoms were most intense in the evening and that the pain occasionally caused her difficulty falling asleep. She reported that her symptoms were more intense in the afternoon and while taking medications prescribed for her pain. Her symptoms were insidious and began 5 weeks before the PT evaluation. There was no known cause for the pain.

At the time of the initial PT evaluation, the patient was only taking 500 mg of ibuprofen and aspirin twice daily and 10 mg of cyclobenzaprine three times daily. Despite her fatigue report to the primary care provider, she denied fatigue during her PT evaluation. She also denied fever/chills/sweats, shortness of breath, and upper/lower extremity weakness, but she suffers from high blood pressure. There was evidence of little weight change, and there was no history of cancer. The patient reported a recent onset of constipation and difficulty maintaining her balance while walking, which she felt was associated with the intake of ibuprofen and cyclobenzaprine. The physiotherapist recommended that the patient contact her physician for medical evaluation of these potential side effects of the cyclobenzaprine. She had a regular gait pattern, and transitional movements were normal without signs of guarding. Balance testing was not performed at the initial evaluation. Pelvic alignment was level in standing, and her thoracic kyphosis and lumbar lordosis were unremarkable.

No erythema, ecchymosis, or edema was seen in the thoracic, lumbar, or sacral regions. Lumbar active range of motion in standing was within normal limits with flexion and left lateral flexion, causing a slight increase in pain. The patient's passive range of motion was within normal limits bilaterally and did not reproduce her symptoms. With the patient in the prone position, central posterior to anterior pressures at the L4-S1 vertebral levels were hypo-mobile and reproduced concordant symptoms. The straight leg raise testing was sometimes done with paint.

Respiratory examination revealed increased respiratory effort, moderate right side, and percussive dullness postero medially and postero laterally. Palpation revealed severely decreased tactile fremitus on the right lower lateral and lower medial chest wall and moderately reduced breath sounds on the right posterolateral and posterior medial chest wall. No lymphadenopathy was noted. A mildly abnormal finger-to-nose test result was also present. Radiographic images were ordered and displayed evidence of a lung mass. The patient was informed of the findings and immediately referred to a computed tomography (CT) of the lungs and to see a pulmonary specialist. The CT confirmed the right upper lobe mass. The patient was subsequently under the care of the pulmonary specialist and oncologist. Magnetic resonance imaging of the head and whole-body positron emission tomographic scan and a biopsy taken by the pulmonary specialist were ordered. The patient was subsequently found to have metastatic lung carcinoma and was treated with chemotherapy and radiation treatment.

Clinical impression

Red flags for threatening pathology were not present at the initial evaluation but were of minimal concern when coupled with the patient's history and physical exam. More specifically, the patient had recently reported fatigue but also had a known 5-year history of fatigue associated with her back pain. She reported recent episodes of constipation, but she associated this with a recent change in her medications. The pain was in the upper lumbar region, which was of concern given her previous history of a herniated disc; however, her kidney function tests had returned normal, and she reported that the current symptoms did not feel similar to those of her previous. Even though the patient had no prior cancer history, the common indicators of cancer (i.e., age >50, intermittent symptoms, and the physical exam) mimicked what one would expect of a patient with a malign musculoskeletal condition.

The most pertinent exam findings were:

1. pain primarily in lumbar flexion positions (sitting);
2. pain relieved by lumbar extension positions (standing);
3. active lumbar flexion and left-side bending reproduced her symptoms;
4. L4-S1 was tender to palpation and hypomobile on spring testing.

Intervention

The intervention focused on increasing postural awareness to avoid lumbar flexed positions while increasing L4-S1 mobility and thus reducing pain. The patient's positive response to an extension-based exercise indicated the best treatment approach was likely specific exercise. A home exercise program was provided, including continuing her walking program and performing 10-15 repetitions 2 times per day. For this reason, a PT follow-up was scheduled for 1 week. At the time of the PT follow-up visit 2 weeks later, the patient reported no change in her symptoms per the global rating of change scale score=0 despite reported compliance with the home exercise program. The patient reported 4/10 resting pain in sitting, which was unchanged by standing. Her lumbar active range of motion was slightly decreased in flexion and left lateral flexion. Lumbar flexion increased the patient's upper lumbar pain to 6/10. Meanwhile, left lateral flexion induced right-sided upper lumbar paraspinal pain. The physical examination was otherwise unchanged from the initial evaluation.

The patient was treated with a neutral-gap lumbar thrust mobilization-targeted at L4-S1. We put electro-acupuncture and tecar therapy in the lumbar region. After the lumbar thrust mobilization and electrotherapy, her lumbar flexion and left lateral flexion range of motion improved to within normal limits, and her pain was reduced. She was asked to continue her initial home exercise program for another week. At her second follow-up visit with the physiotherapist 3 weeks following her initial evaluation, the patient reported that her symptoms were a little worse. She stated that her symptoms worsened 12 days after initiating PT and that her symptoms were no longer relieved with her medications. She reported compliance with her home exercise program but no longer felt pain relief from the exercises. Her pain during rest had increased to 7/10 while sitting, which was reduced with standing and supine manual lumbar traction. Lumbar extension was standard, and the pain was unchanged compared to resting. Lumbar forward flexion range of motion was decreased and continued to be the most provocative active motion.

Outcome

The patient completed two manipulation treatments, although afterward, the patient did not experience any lasting improvement in symptoms. On arrival for her fifth appointment, she complained of a headache, right-sided leg extremity numbness and tingling, dropping items, and feeling unbalanced for the previous 2 days. She was escorted to the emergency department for immediate medical evaluation. A computed tomography scan of the lung was completed in the emergency department. Chest, abdominal, and pelvic MR demonstrated a 3.8 cm left cancer mass and osseous lesions involving L4 and S1. A computed tomography-guided biopsy of the left lingular mass led to a diagnosis of cell carcinoma of the lung with metastases to the spine. Spinal magnetic resonance imaging showed diffuse lesions throughout the vertebral bodies consistent with metastatic disease, with the largest lesion at L4-L5-S1. Despite radiation therapy and chemotherapy, the patient succumbed to cancer 6 months after she was first seen in PT (Fig. 1-3).

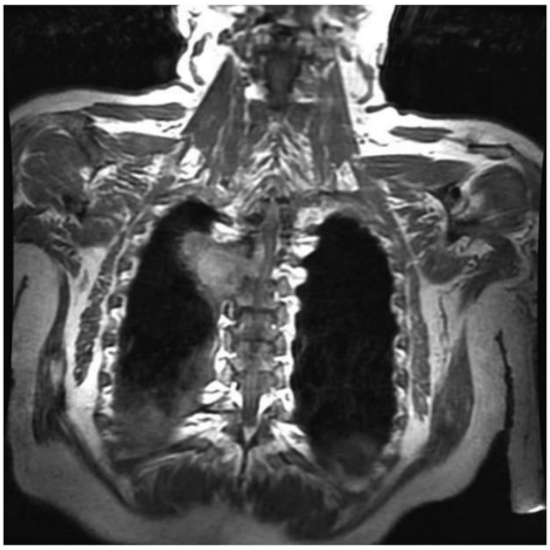

Fig. 1. *MRI lung cell carcinoma.*

Fig. 2. *MRI Metastatic carcinoma of the spine.*

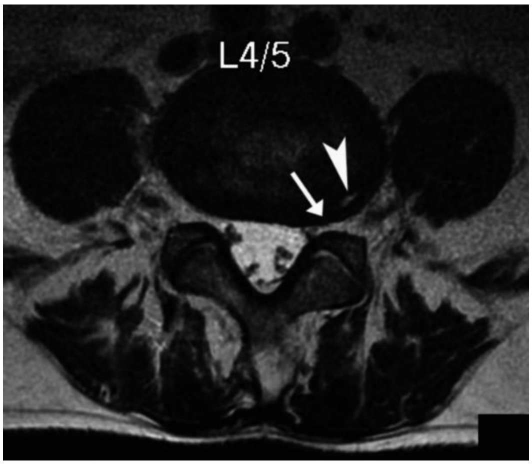

Fig. 3. *Axial lumbar MRI image at the level of the L4-S1 intervertebral disc.*

DISCUSSION

This case was an unusual presentation of metastatic disease that onset as mechanical low back pain and leg pain. In many instances, a patient with metastatic disease complains of night pain, intense pain at rest, and unexplained weight loss.

The case is an example of the “red flags” that are sometimes not acknowledged. This patient's “red flags” were considerable weight loss in a short time, sweating, and fatigue. However, magnetic resonance of the cervical, thoracic, and lumbar spine revealed no central nervous system lesions. Lung cancers usually present symptoms resulting from the primary tumor or metastatic disease or the effects of unusual hormone production, with symptoms depending on the location of the disease. In stage 4, cell carcinoma of the left upper lobe, as found in this case after biopsy, the clinical presentation due to the primary tumor might include signs of respiratory distress, superior vena cava obstruction, and recurrent. The 4 most common sites of metastasis from primary lung malignancy are the bone, brain, liver, and adrenal glands. Hematuria and pyuria may also occur. The patient discussed here did not report any symptoms that directed the PT to a primary diagnosis of metastatic cancer. The PT was concerned due to the patient’s age, lack of a significant mechanism of injury, and the chronic, recurrent symptom presentation. The PT opted for lumbar spine radiographs before proceeding with treatment.

The spine accounts for 83% of bone metastatic lesions and is one of the most common sites for the early presentation of metastases (1-9). Cancer of the breast, lung, and prostate are the most commonly associated with bone metastases, and up to 50% of patients with these types of cancer develop bone metastases. Approximately 60% of bone metastases are found in the axial skeleton. Studies have shown that the majority of skeletal metastases can be asymptomatic, with cervical and lumbar metastases tending to be more symptomatic than those in the thoracic spine. Unfortunately, metastatic disease is typically widespread by the time patients present symptomatically to the clinic.

Once symptoms are present, delays in diagnosis can be significant. Studies have shown symptom-to-diagnosis delay in lung cancer to be approximately 1-3 months. Misdiagnosis and misinterpretation of tests are two factors contributing to practitioner delay. The inherently poor sensitivity of radiographs in detecting metastatic lesions can lead to misdiagnosis, adding to practitioner delay. More specifically, 30-50% bony destruction is necessary for a lytic lesion to appear on radiographs, suggesting that some metastatic lesions may go undetected by radiographs for a considerable time. In our case, total diagnostic delay was approximately 90 days, with 40 days attributed to practitioner delay. Notably, the patient had received conventional radiographs of the lumbar spine at her initial presentation to the emergency department, which showed no signs of metastatic disease.

Considering the advanced stage of our patient’s cancer, it is unlikely that the outcome would have changed dramatically with a more suitable diagnosis. However, a timely diagnosis may have provided a psychosocial benefit to the patient and her family. Studies have shown that preparation for death is a key factor in making the dying process more favorable for patients and their families (6-9). Our patient survived approximately 6 months after diagnosis. It is worth noting that our patient did not initially exhibit the typical characteristics of threatening pathology. Several factors emerged throughout treatment, which indicated that her symptoms were not solely of musculoskeletal origin. More specifically, the patient’s initial report of fatigue affecting her activities of daily living, her lack of response to treatment with gradually worsening symptoms, and the location of her symptoms in the upper lumbar spine were concerning.

While several components of this patient’s history and physical examination were consistent with a mechanical musculoskeletal dysfunction, the location of the patient’s symptoms (upper lumbar spine) was concerning. Upper lumbar pain has been associated with visceral referral from the kidneys. In addition, the upper lumbar spine is one of the most common sites for vertebral compression fractures. Most non-musculoskeletal causes of back pain do not specifically target the upper lumbar spine. Threatening pathologies propagating through hematogenous seeding can be spread throughout the body, with areas near the venous/lymphatic drainage being the most highly affected. In the case of lung cancer, the thoracic spine is the most common region for spinal metastases. The upper lumbar spine only accounts for 2-5% of lumbar disc herniations, 30% of central canal stenosis, and 9-12% of lumbar degenerative disc disease (DDD).

Threatening pathology is commonly thought to present as constant, unwavering pain that is unchanged by joint movement or altering body positioning and may become worse at night. However, metastatic lesions of the spine may mimic musculoskeletal pathology, as symptoms are often reproducible by active/passive movement and can ease with position change or rest. During the PT evaluation, the patient exhibited intermittent symptoms that were changed with position and mechanical intervention and were subjectively eased by sleep. The patient experienced short-term gains with both manual intervention electrotherapy and a directional preference exercise but lacked any sustained improvements.

While intersession gains with manual intervention have been shown to be an indicator of favorable prognosis, it is pertinent to note that intersession or short-term symptomatic improvements did not sufficiently rule out threatening pathology.

As treatment ensued, the patient began to complain of intractable pain that was unchanged by either mechanical or pharmaceutical interventions. Also of concern were her new development of headaches, right-sided upper extremity numbness and tingling, dropping items, and a decreased sense of balance. Lack of improvement with conservative therapy after a one-month period has been shown to be an indicator of underlying a threatening pathology.

CONCLUSIONS

This case outlines the need for clinicians specializing in musculoskeletal disease to consider visceral sources of pathology in returning cases, especially if findings are inconsistent with musculoskeletal findings. Low back pain recurrence in an established patient should constitute a reevaluation of the problem. The cause cannot be assumed to be musculoskeletal in origin, even though this may have been the case with the initial complaint. Metastatic disease should be considered, along with any type of recurrent lower back pain.

While the prevalence of serious medical pathology causing low back pain is low, it is the responsibility of the physiotherapist to screen for serious medical conditions and continuously monitor the development of those conditions throughout the course of care. PT treats musculoskeletal complaints such as low back pain daily. In some instances, visceral problems can be presented as mechanical low-back conditions. When a patient presents characteristic features, a correct diagnosis is easily made. It is often the case that clinical practice does not provide classic textbook examples, and the clinician must be vigilant by performing a careful history, examination, and other indicated procedures to rule out life-threatening conditions. Our patient presented symptoms of mechanical low back pain but was later found to have spinal metastases originating from cell carcinoma of the lung.

The ability to reproduce symptoms with movement or palpation, or even the ability to achieve short-term symptomatic improvement through mechanical interventions, does not rule out the possibility of threatening pain sources. Failure to achieve long-term symptomatic improvements with conservative management can be an indicator of threatening pathology and provides sufficient cause for medical referral. Physiotherapists should use additional caution during differential diagnosis of low back pain, especially when these symptoms are of unknown origin and are in the upper lumbar spine.

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Review

MANAGING PREOPERATIVE USE OF HERBAL MEDICATIONS

P. Daliu

Department of Pharmacy, Faculty of Medical Science of Albanian University, Tirane, Albania

Correspondence to:
Patricia Daliu, PhD
Department of Pharmacy,
Albanian University,
Bulevardi Zogu I,
Tirane, Albania
e-mail: p.daliu@albanianuniversity.edu.al

ABSTRACT

Herbal medicine is an increasingly common form of alternative therapy all over the world. Most herbal products are considered dietary supplements and thus are not regulated as medicines. During the preoperative evaluation, physicians should explicitly elicit and document a history of herbal medication use. Some herbal medications have potentially harmful side effects as well as adverse interactions with conventional drugs, especially before the preoperative conditions. Physicians should be familiar with the potential perioperative effects of the commonly used herbal medications to prevent, recognize, and treat potentially serious problems associated with their use and discontinuation. The purpose of this article was to review the recent literature on the potential risks of commonly used herbal medications: Echinacea, Ephedra, Garlic, Ginkgo Biloba, St. John's Wort, Ginseng, Kava, Valeriana, and bring focus to new molecular pharmacokinetic and pharmacodynamic evidence and mechanisms.

KEYWORDS: *herbal medicine, safety, preoperative assessment, risk interactions, echinacea, ephedra, garlic, ginkgo, ginseng, Kava, St. John's wort, Valerian*

INTRODUCTION

The power and the poisoning of medicinal plants have been known for centuries. Lately, there has been renewed interest in coniine's medical uses, particularly for pain relief without an addictive side effect. However, Socrates' death has almost always been attributed to his drinking an extract of poison hemlock, Conium maculatum (1). The use of complementary medicines is increasingly popular around the globe. Variously referred to as "herbals" or "supplements," numerous factors contribute to their resurgence; the most frequent among them is that because they are "natural," patients often hold the belief that these supplements are safer than prescription medications (2).

Morbidity and mortality associated with these may be more likely in the perioperative period because of the polypharmacy and physiological alterations. Such complications include myocardial infarction, stroke, bleeding, inadequate oral anticoagulation, prolonged or inadequate anesthesia, organ transplant rejection, and interference with medications indispensable for patient care (3).

Of the herbal medications (HMs) clinicians are likely to encounter, this review has identified the eight herbs that potentially pose the greatest impact on the care of patients undergoing surgery and proposed rational strategies for managing the preoperative use of these agents. These account for over 50% of all single herb preparations among the 1500-1800 HMs sold without prescription. Non herbal dietary supplements such as vitamins, minerals, amino acids, and

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hormones are beyond the scope of this review. Some non-herbal dietary supplements that surgical patients are most likely to take, such as glucosamine and chondroitin for osteoarthritis, appear safe (4).

The prevention, recognition, and treatment of complications begin with explicitly eliciting and documenting a history of herbal medicine use. Familiarity with the scientific literature on HMs is necessary because the current regulatory mechanism for commercial herbal preparations sold does not necessarily protect against unpredictable or undesirable effects. The aim of this paper is to provide a framework for physicians practicing in the contemporary environment of widespread herbal medicine use (5). The most extensive surveys on complementary and alternative medicines worldwide revealed that approximately 32% of the population used HMs. Patients undergoing surgery appear to use HMs significantly more frequently than the general population. Over 70% of these patients fail to disclose their herbal medicine use during routine preoperative assessment. Explanations for this phenomenon include patient-held beliefs that physicians are unknowledgeable about HMs or prejudiced against their use (6). Some patients may fear admitting reliance on unconventional therapies to their physicians. Others may neglect to mention HMs when using them for reasons perceived as unrelated to their medical care. Still, others would not consider these substances to be medications and neglect to report them during routine questioning. For these reasons, it is necessary for physicians specifically to seek out a history of herbal medicine use in presurgical patients.

Regulation and safety of herbal medications

HMs were classified as dietary supplements in the Dietary Supplement Health and Education Act (DSHEA) of 1994. This exempts them from the proof of safety and efficacy required of prescription and over-the-counter drugs. The burden is shifted to the Food and Drug Administration (FDA) to prove a product unsafe before it can be removed from the market (7). Manufacturers are not required to conduct preclinical animal studies, premarketing controlled clinical trials, or post-marketing surveillance, and the inability to patent HMs discourages them from performing this costly research. Many studies have been recently addressed to assess their safety, efficacy, and regulation since they are getting growing attention in the market and research to clear the difference between them and other market-available food-derived products that claim beneficial effects on health.

The current regulatory mechanism provides little assurance that commercial preparations have predictable pharmacological effects and that product labels are accurate. The potency of HMs can vary from manufacturer to manufacturer and from lot to lot. Plants may be misidentified or deliberately replaced with cheaper or more readily available alternatives (8). Some herbal manufacturers have tried to standardize products to fixed concentrations of selected chemical constituents (9). However, the benefit of this effort is uncertain because many products achieve their effects through the combined or synergistic actions of different compounds. Even when advertised and labeled as standardized, potency can vary considerably. Because there is no mechanism for post-marketing events, which is unknown, empirical evidence from a long history of use supports the notion that most HMs are safe. Nevertheless, some have been associated with severe harm (10).

Adverse events are underreported, however, because there is no central mechanism for mandatory reporting as there is for conventional medications. Other factors that contribute to underreporting are that physicians do not recognize adverse events, and patients are reluctant to report and seek treatment for adverse reactions associated with HMs (11). This reluctance has been attributed to the belief that physicians cannot be consulted in the use of unconventional therapies and to patients' unwillingness to admit the use of these remedies to physicians. The deficiencies in monitoring adverse events mean that safety profiles are usually limited to animal studies, case reports, or predictions derived from known pharmacology.

Commonly used herbal medications

Despite many uncertainties in commercial preparations, HMs adhere to the principles of modern pharmacology. A single herbal medication may adversely impact the perioperative period through several different mechanisms. These are direct effects (intrinsic pharmacological effects), pharmacodynamic interactions (alteration of the action of conventional drugs at effector sites), and pharmacokinetic interactions (alteration of the absorption, distribution, metabolism, and elimination of conventional drugs).

Echinacea

Three species of echinacea, a member of the daisy family, are used to prevent and treat viral, bacterial, and fungal infections, particularly those of upper respiratory origins. Pharmacological activity cannot be attributed to a single compound, although the lipophilic fraction, which contains the alkylamides, polyacetylenes, and essential oils, appears to be more active than the hydrophilic fraction (12).

Echinacea had a few immunostimulatory effects in preclinical studies. At the same time, no studies specifically address interactions between echinacea and immunosuppressive drugs.

Expert opinion generally warns against the concomitant use of echinacea and these drugs, owing to the probability of diminished effectiveness. Therefore, patients who may require perioperative immunosuppression, such as those awaiting organ transplants, should be counseled to avoid echinacea. In contrast to the immunostimulatory effects with short-term use, long-term use of more than 8 weeks is accompanied by the potential for immunosuppression and a 'theoretically increased risk of certain post-surgical complications such as poor wound healing and opportunistic infections (13)

Echinacea has also been associated with allergic reactions, including one reported case of anaphylaxis. Therefore, echinacea should be used with caution in patients with asthma, atopy, or allergic rhinitis. Concerns of potential hepatoxicity have also been raised, although documented cases are lacking. In the absence of definitive information, patients with pre-existing liver dysfunction should be cautious using echinacea (14). Furthermore, since the pharmacokinetics of echinacea have not been studied, it may be prudent to discontinue this herb before surgery when compromises in hepatic function or blood flow are anticipated. These situations often occur secondary to concomitant administration or as an effect of surgical manipulation.

Ephedra

Ephedra, known as ma Huang in Chinese medicine, is a shrub native to central Asia. It promotes weight loss, increases energy, and treats respiratory conditions such as asthma and bronchitis. Ephedra contains alkaloids, including ephedrine, pseudoephedrine, norephedrine, methyl ephedrine, and pseudoephedrine (15). Ephedrine, the predominant active compound, is a non-catecholamine sympathomimetic that exhibits ßl and ß2 activity by acting directly at adrenergic receptors and indirectly by releasing endogenous norepinephrine (noradrenaline). These sympathomimetic effects have been associated with more than 1070 reported adverse events, including fatal cardiac and central nervous system results in tachyphylaxis from depletion of endogenous catecholamine stores and may contribute to perioperative hemodynamic instability (16). In these situations, direct-acting sympathomimetics may be preferred as first-line therapy for intraoperative hypotension and bradycardia.

Concomitant use of ephedra and monoamine oxidase inhibitors can result in life-threatening hyperpyrexia, hypertension, and coma. Heavy ephedra use has been also documented as a very rare cause of radiolucent kidney stones.

Recently, the pharmacokinetics of ephedrine have been studied in humans. Ephedrine has an elimination half-life of 5.2 h, with 70-80% of the compound excreted unchanged in the urine. Based on the pharmacokinetic data and the known cardiovascular risks of ephedra, including myocardial infarction, stroke, and cardiovascular collapse from catecholamine depletion, this herb should be discontinued for complications (17). Although ephedrine is widely used as first-line therapy for intraoperative hypotension and bradycardia, the unsupervised preoperative use of ephedra raises particular concerns. Vasoconstriction and, in some cases, vasospasm of coronary and cerebral arteries may cause myocardial infarction and thrombotic stroke. Patients who have consumed ephedra and are later anesthetized with halothane may be at risk of developing intraoperative ventricular arrhythmias because halothane sensitizes the myocardium to ventricular arrhythmias caused by exogenous catecholamines (18). Ephedra may also affect cardiovascular function by causing hypersensitivity myocarditis, characterized by cardiomyopathy with myocardial lymphocyte and eosinophil infiltration. Is important to highlight that this herb should be discontinued at least 24 h prior to surgery (19).

Garlic

One of the most widely used medicinal plants in traditional medicine is garlic. Allium sativum L. belongs to the Amaryllidaceae family and has pronounced nutritional and medicinal properties. It has the potential to modify the risk of developing atherosclerosis by reducing blood pressure, thrombus formation, and serum lipid and cholesterol levels. These effects are primarily attributed to the sulfur-containing compounds, particularly allicin and its transformation products. Commercial garlic preparations may be standardized to a fixed alliin and allicin content (20). According to various studies that have proven the drug interaction of this valuable plant with chemical drugs, the simultaneous use of garlic with chemical medications should be used attentively to prevent different side effects (21, 22).

Garlic inhibits platelet aggregation in vivo in a dose-dependent range. The effect of one of its constituents, ajoene, appears to be irreversible and may potentiate the effect of other platelet inhibitors such as prostacyclin, forskolin, indomethacin, and dipyridamole. Although these effects have not been consistently demonstrated in volunteers, there is one case in the literature of an octogenarian who developed a spontaneous epidural hematoma that was attributed to heavy garlic use (23). In addition to bleeding concerns, garlic has the potential to lower blood pressure. Allicin decreased systemic and pulmonary vascular resistance and reduced blood pressure in laboratory animals.

Although there are insufficient pharmacokinetic data on garlic's constituents, the potential for irreversible inhibition of platelet function may warrant the discontinuation of garlic at least 7 days prior to su rgery, especially if postoperative bleeding is a particular concern or other platelet inhibitors are given (24).

Ginkgo

Ginkgo is derived from the leaf of *Ginkgo biloba*. It has been used for cognitive disorders, peripheral vascular disease, age-related macular degeneration, vertigo, tinnitus, erectile dysfunction, and altitude sickness. Studies have suggested that ginkgo may stabilize or improve cognitive performance in patients with Alzheimer's disease and multi-infarct dementia (25). The compounds believed responsible for their pharmacological effects are terpenoids and trials are standardized for ginkgo-flavone glycosides and terpenoids (26).

Ginkgo appears to alter circulation, act as an antioxidant, modulate neurotransmitter and receptor activity, and inhibit platelet-activating factor (PAF). Of these effects, the inhibition of PAF raises the most significant concern for the perioperative period since platelet function may be altered. Clinical trials in a small number of patients have not demonstrated bleeding complications, but recently, four reported cases of spontaneous intracranial bleeding, one case of spontaneous hyphemia, and one case of postoperative bleeding following laparoscopic cholecystectomy have been associated with ginkgo use (26, 27).

The elimination half-lives of the terpenoids after oral administration are between 3 and 10. Based on the pharmacokinetic data and the risk of bleeding, particularly in the surgical population, ginkgo should be discontinued at least 36 h prior to surgery (28).

Ginseng

Panax ginseng is a beneficial herb consumed for a long time by people in East Asian countries. Consumption of ginseng-based products, such as red ginseng (RG), as a health food, has rapidly increased worldwide in recent years. Generally, saponins in ginseng, called ginsenosides, are regarded as the primary active components of ginseng with multiple pharmacological activities. Ginseng has been labeled an 'adaptogen' since it reputedly protects the body against stress and restores homeostasis. Commercially available ginseng preparations may be standardized to ginsenoside content (29).

Ginseng has a broad but incompletely understood pharmacological profile because of the many heterogeneous and sometimes opposing effects of different ginsenosides. The underlying mechanism appears to be like that classically described for steroid hormones. A potential therapeutic use for this herb has to do with its ability to lower postprandial blood glucose in both type 2 diabetics and non-diabetics, but this effect may create unintended hypoglycemia, particularly in patients who have fasted before surgery (30).

There is a concern about ginseng's effect on coagulation pathways. Ginsenosides inhibit platelet aggregation in vitro and prolong both thrombin time and activated partial thromboplastin time in rats. One early study suggested that the antiplatelet activity of panaxynol, a constituent of ginseng, may be irreversible in humans. Although ginseng may inhibit the coagulation cascade, ginseng use was associated with a significant decrease in warfarin anticoagulation in one reported case (31, 32). The pharmacokinetics of ginsenosides Rgl, Re, and Rb2 have been investigated in rabbits, with elimination half-life between 0.8 and 7.4. This data suggests that ginseng should be discontinued at least 24h prior to surgery (33). However, because ginseng platelet inhibition may be irreversible, it is probably prudent to discontinue ginseng use at least 7 days prior to surgery (34).

Kava

Kava is derived from the dried root of the pepper plant *Piper methysticum*. Kava has gained widespread popularity as an anxiolytic and sedative medical plant. The kavalactones appear to be the source of kava's pharmacological activity, and clinical trials suggest therapeutic potential in the symptomatic treatment of anxiety, which is attributed to these phytochemical compounds (35).

Because of its psychomotor effects, kava was one of the first HMs expected to interact with anesthetics (36). The kavalactones have dose-dependent effects on the central nervous system, including antiepileptic, neuroprotective, and local anesthetic properties. Kava may act as a sedative/hypnotic by potentiating inhibitory neurotransmission of y-aminobutyric acid (GABA). The kavalactones increase barbiturate sleep time in laboratory animals. This effect may explain the mechanism underlying the report of a coma attributed to an alprazolam-kava interaction (37). Although kava has abuse potential, whether long-term use can result in addiction, tolerance, and acute withdrawal after abstinence has not been satisfactorily investigated. With heavy use, kava produces 'kava dermopathy', characterized by reversible scaly cutaneous eruptions.

Peak plasma levels occur 1.8 h after an oral dose, and the elimination half-life of kavalactones is 9 h. Unchanged kavalactones and their metabolites undergo renal and fecal elimination (38). The pharmacokinetic data and possibility for the potentiation of the sedative effects of anesthetics suggest that this herbal medication should be discontinued at least 24 h prior to surgery.

St John's wort

St John's wort is the common name for *Hypericum perforatum*. Several clinical trials have reported efficacy in the short-term treatment of mild-to-moderate depression. The compounds believed to be responsible for pharmacological activity are hypericin and hyperforin. Commercial preparations are often standardized to a fixed hypericin content of 0.3% (39).

St John's wort exerts its effects by inhibiting serotonin, norepinephrine, and dopamine reuptake. Concomitant use of this herb with or without serotonin reuptake inhibitors may create a syndrome of central serotonin excess (40).

The use of St John's wort can significantly increase the metabolism of many concomitantly administered drugs, some of which are vital to the perioperative care of specific patients. The long half-life and alterations in the metabolism of many drugs make concomitant use of St John's wort a particular risk in the perioperative setting. The pharmacokinetic data suggest that this herbal medication should be discontinued at least 5 days prior to surgery (41).

The cytochrome P450 3A4 isoform is induced, approximately doubling its metabolic activity. Interactions with substrates of the 3A4 isoform, including indinavir sulfate, ethinylestradiol, and cyclosporin, have been documented. In one series of 45 organ transplant patients, St John's wort was associated with an average decrease of 49% in blood cyclosporin levels. Huppertz et al. reported two cases of acute heart transplant rejection associated with this pharmacokinetic interaction (42). Other P450 3A4 substrates commonly used in the perioperative period include fentanyl, midazolam, lidocaine, calcium channel blockers, and 5-hydroxytryptamine (HT)3 receptor antagonists. St John's wort also affects digoxin pharmacokinetics; in addition to the 3A4 isoform, the cytochrome P450 2C9 isoform may also be induced (43). The anticoagulant effect of warfarin, a substrate of the 2C9 isoform, was reduced in seven reported cases. Other 2C9 substrates include non-steroidal anti-inflammatory drugs. Furthermore, the enzyme induction caused by St John's wort may be more pronounced when other enzyme inducers, including other HMs, are taken concomitantly (44).

Valerian

Valerian is an herb native to the Americas, Europe, and Asia temperate areas. Valerian contains many compounds acting synergistically, but the sesquiterpenes are the primary source of valerian's pharmacological effects (45). It is used as a sedative, particularly in the treatment of insomnia, and virtually all herbal sleep aids contain valerian.

Valerian produces dose-dependent sedation and hypnosis. These effects appear to be mediated through modulation of GABA neurotransmission and receptor function (46). Valerian increases barbiturate sleep time in experimental animals. In one case, valerian withdrawal appeared to mimic an acute benzodiazepine withdrawal syndrome after the patient presented with delirium and cardiac complications following surgery, and his symptoms were attenuated by benzodiazepine administration (47). Based upon these findings, valerian should be expected to potentiate the sedative effects of anesthetics and adjuvants, such as midazolam, that act at the GABA receptor.

The pharmacokinetics of valerian's constituents have not been studied, although their effects are thought to be short-lived. Caution should be used with abrupt discontinuation in patients who may be physically dependent upon valerian, owing to the risk of benzodiazepine-like withdrawal. In these individuals, it may be prudent to taper this herbal medication with close medical supervision over several weeks before surgery (48). If this is not feasible, physicians can advise patients to continue taking valerian until surgery. Based on the mechanism of action and a reported case of efficacy, benzodiazepines can be used to treat withdrawal symptoms should they develop in the postoperative period (38).

DISCUSSION

The task of caring perioperatively for patients who use HMs is an evolving challenge. Because most patients may not volunteer this information in the preoperative evaluation, physicians should specifically elicit and document a history of herbal medication use. Obtaining such a history may be difficult. Written questionnaires for information on herbal medication use have not proved to be beneficial in identifying patients taking these remedies since half of the patients who use alternative therapies fail to report this information unless questioned in person. An oral history, however, can also be inadequate today. Unless this information is directly solicited, patients may not be forthcoming. Even when a positive history of herbal medication use is obtained, one in five patients is unable to correctly identify the preparation they are taking (49). Therefore, patients should be asked to bring their HMs and other dietary supplements during the preoperative evaluation.

Patients who use HMs may be more likely than those who do not avoid conventional diagnosis and therapy. Hence, a history of herbal medicine use should prompt physicians to suspect the presence of undiagnosed disorders causing symptoms that may lead to self-medication. These recommendations also apply to pediatric patients because caretakers may treat children with HMs without medical supervision since one in six parents reported giving dietary supplements to their children.

Although there are no existing official standards or guidelines on the preoperative use of HMs, public and professional education suggests that they be discontinued at least 2-3 weeks before surgery. Our review of the literature favors a more targeted approach. Pharmacokinetic data on selected active constituents indicate that some HMs are eliminated quickly and may be discontinued closer to surgery. Moreover, some patients require non-elective surgery or are non-compliant with instructions to discontinue HMs preoperatively. These factors and the high frequency of herbal medicine use may mean that many patients will take HMs until the time of surgery. Therefore, clinicians should be familiar with commonly used HMs to recognize and treat complications that may arise.

Clinicians should also recognize that presurgical discontinuation of all HMs may not free a patient from risk. Withdrawal of regular medication is associated with increased morbidity and mortality after surgery. In alcoholics, preoperative abstinence may result in poorer postoperative outcomes than continued preoperative drinking (50).

CONCLUSIONS

Because this field is rapidly evolving, sources for reliable and updated information are important in helping physicians stay abreast of new discoveries about the effects of HMs and other dietary supplements. This information is necessary to prevent, recognize, and treat potentially serious problems associated with herbal medicines, whether alone or in conjunction with conventional medications.

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Review

THE IDEAL POSTURE IN DENTISTRY: ERGONOMIC ASSET OR LIABILITY? A MINI-REVIEW

F. Tricca[1], S.R. Tari[1], S. Benedicenti[2], S.A. Gehrke[3] and R. Scarano[1*]

[1]Department of Innovative Technologies in Medicine and Dentistry, University of Chieti-Pescara, Chieti, Italy;
[2]Department of Surgical Sciences and Integrated Diagnostics, University of Genoa, Genoa, Italy;
[3]Department of Research, Bioface/PgO/UCAM, Montevideo, Uruguay, Department of Biotechnology, Universidad Católica de Murcia (UCAM), Murcia, Spain

[*]*Correspondence to*:
Roberta Scarano, PhD
Department of Innovative Technologies in Medicine and Dentistry,
University of Chieti-Pescara,
66100 Chieti, Italy
e-mail: rscarano@unich.it

ABSTRACT

Proper ergonomics can prevent musculoskeletal disorders (MSDs) among dental practitioners. Static and awkward postures contribute significantly to the onset of MSDs, affecting various parts of the body. This review emphasizes the importance of dynamic posture over a static one. Any prolonged contraction of the muscular tissue leads to a restriction of capillaries and a reduced intake of nutrients, lactate accumulation within the tissues with subsequent pain, muscle imbalance, and activation of adaptive systems, which significantly impact the spine, neck, shoulders, and wrist health. A general overview of the main MSDs was also provided along with preventive strategies to increase the awareness on such a topical issue among clinicians.

KEYWORDS: *ergonomics, musculoskeletal disorders, injury, static posture, dynamic posture, wrist pain, back pain, neck pain, shoulder pain, preventive strategies*

INTRODUCTION

Ergonomics is the scientific discipline that examines the interaction between the components of a system and the functions for which they are designed. The aim of this science is to improve the safety and efficiency of individual procedures, transform them into practical routines, and prevent musculoskeletal disorders (MSDs).

Dental practitioners tend to assume a static forced posture to deliver quality dental treatment. Postural changes profoundly impact the musculoskeletal system, with implications for muscles, nerves, ligaments, tendons, joints, and even vertebral disks (1). Since cumulative trauma can bring occupational illness and even long-term disability, maintaining a balanced posture is fundamental during day-to-day clinical practice.

MSDs have a detrimental effect on the quality of life and represent an evergreen challenge in the healthcare system (2, 3). Several studies reported high incidences of musculoskeletal pain/discomfort in the dental population (4, 5), and MSDs were described by Hill et al. as one of the most common reasons for early retirement (6) and lost/reduced wages.

Proper posture provides more concentration, attention, and working energy, reducing pain, stress, and muscular tension and a lower risk for therapeutical errors (7). Even though the equipment has improved considerably, clinicians still work with incorrect postures derived from bad habits (7). A frequent need to bend and twist the neck and upper back

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to better visualize the oral cavity remains, especially if a direct vision is adopted (8). Moreover, the presence of the dental assistant is another fundamental issue that can influence the operator's position.

It is important for the clinician to achieve a vast knowledge of ergonomics and develop a self-perception of the body to change improper, detrimental postures, avoiding the onset of MSDs. This review delves into this issue to describe preventive strategies to avoid some of the most reported MSDs.

MATERIAL AND METHODS

Search strategy

By conducting an electronic search on the MEDLINE bibliographic database (PubMed), 185 articles with a time span from 1982 to 2024 were selected using the following algorithm: "Dentist*" AND ("Musculoskeletal disorder" OR "MSD" OR “MSDs”) AND "Ergonom". Sixteen articles were chosen as the primary sources of data. The references were also scanned to identify other potentially eligible studies.

DISCUSSION

The development of MSDs involves multifactorial risk factors (9), and the dental profession is highly related to an increased prevalence of MSDs (10). Various studies have reported a high incidence of MSDs among dentists, from 46 to 93% (11). Static and awkward postures, improper clinician or patient position, poorly designed instruments, and improper techniques represent many of the most reported risk factors (12).

Investigating the influence of gender, Hosseini et al. (13) and al-Mohrej et al. (14) reported a higher risk for female dentists with significantly higher ORs. However, contradicting results were published by Batham et al. (15). The health status of the clinician was also considered by Pejčić et al. (16); the presence of chronic diseases (e.g., cardiovascular disease and diabetes), allergies, pre-existing MSD, varicose veins, headache, hand weakness, and sleeping disorders were highly correlated to the onset of musculoskeletal pain.

Even if studies showed a direct correlation between older age and MSDs (14-17), some reported a mild trend in dentists with more experience. This outcome can be easily attributed to an increased awareness and the adoption of preventive measures by older, experienced dentists (18). In addition, a high BMI (19) or reduced physical activity (14) were reported as being other critical factors potentially involved in the onset of MSDs.

Wrist pain

Carpal Tunnel Syndrome (CTS) represents the most common entrapment neuropathy, affecting around 3-6% of the adult population (20). It has generally been reported as one of the leading causes of wrist pain. The diagnosis is based on clinical signs and the detection of median nerve dysfunction through nerve conduction studies (21).

Among the dental healthcare personnel, this percentage was reported to be higher; a systematic review conducted by Chenna et al. (22) showed that one out of seven clinicians may be affected by the syndrome.

CTS is derived from an increased pressure on the median nerve by the thickening of irritated tendons. Numbness, pain, and tingling in the distribution of the median nerve (e.g., thumb, index finger, middle finger, and half of the ring finger) (23) are the main symptoms reported (24). Since the discomfort and symptoms gradually subside, they may be ignored initially. Repetitive movements, the generation of high forces, mechanical stresses, and vibrational exposure are thought to be the main risk factors related to the genesis of such a condition (25).

Back pain

Low back pain is reported as being the leading cause of occupational disability in dentistry (26). A poor postural alignment can accelerate the wear of spine-supporting structures (muscles, ligament, disks, and vertebrae), leading to trauma accumulation and muscle imbalance with chronic pain. Maintaining a proper sitting position reduces the static muscle workload necessary to support the foot, knee, hip, and spine joints. In addition, it’s important to highlight that even if a proper sitting posture is maintained, over time, due to fatigue, there is a tendency to assume a slumped posture.

Sitting in a prolonged slumped posture was observed to impair the functionality of transversus abdominis and oblique abdominal muscles, which play a pivotal role in stabilizing the spine and postural control during the seated posture (27). Flexion of the knee to the hip to about 90 degrees is often observed in a conventional sitting position. Over 60 degrees from a hypothetical vertical gravity line, the passive tension of the hamstrings increases. The direct result of such a position is a posterior pelvic tilt (Fig. 1). The pelvis rotates backward, determining a kyphosis of the lumbar spine with increased muscle strain pressure on spine ligaments, muscles, and internal organs.

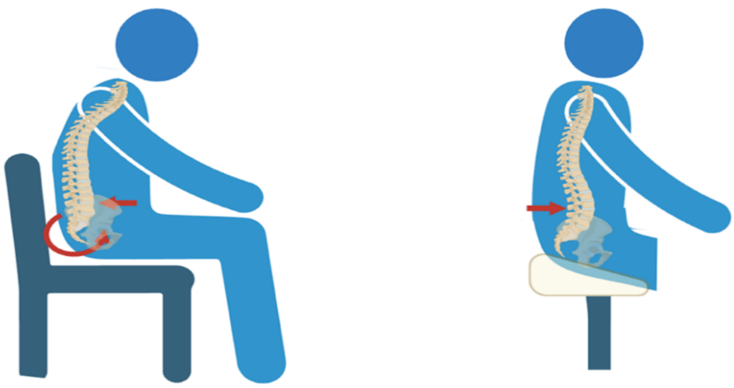

Fig. 1. *Slumped/conventional vs. ergonomic posture. When a person is seated with a forward-sloping seat, the tension in the hamstring muscles is relieved, and the pelvis is pulled forward, maintaining the lordosis of the lumbar spine. In a slumped/ conventional posture, the increased passive tension of the hamstrings pulls the pelvis backward (posterior pelvic tilt), generating a flattening/kyphosis of the lumbar spine.*

Using a forward-sloping seat with hips at 60 degrees from the vertical line, the tension is relieved, and the pelvis is moved afterward (28), preserving the physiological curves of the spine. Furthermore, interesting results were recorded when lumbar support was considered.

Andersson et al. (29), studying the effects of unsupported and supported sitting, reported an optimal reduction in both the myoelectric activity and disk pressure when the back was supported. An unsupported sitting position, accompanied by forward flexion and rotation, is related to increased pressure in the lumbar spinal disks (30). Bulging or herniation is a direct consequence of this scenario, with a serious involvement of the spinal cord or peripheral nerves and subsequent low back, hip, or leg pain (31) (Fig. 2).

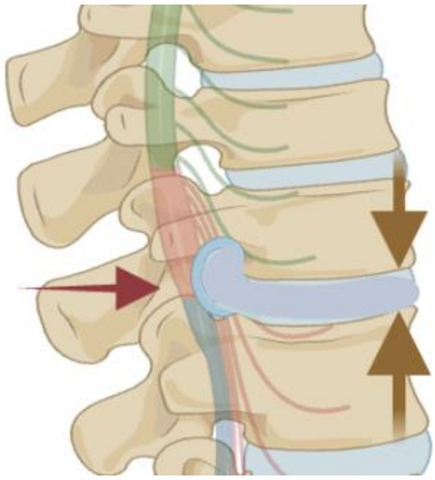

Fig. 2. *Flattening of the spinal lordosis can result in the dislocation of the annulus fibrosus with disk bulge or herniation. As only the outer layer of the annulus fibrosus is innervated, degeneration of almost the totality of the disk is generally encountered when pain is reported.*

Lake (32) showed, in a population of Canadian dentists, how a forward trunk inclination, ranging from 19 to 54 degrees prolonged for 2/3 of each treatment hour, can lead to massive pressure on vertebral disks compared to standing position.

It was observed that clinicians spent from 78 % to 100% in a seated position during dental treatments(33-36). Interestingly, Ratzon et al. (37) reported more severe lower back pain from dentists who work solely in a sitting position. In general, any prolonged static posture has been shown to increase MSDs (38). Static muscle activity involves a prolonged contraction of the muscular tissue, a capillary restriction, a reduced nutrient intake, and lactate accumulation within the tissues. This position can only be maintained for a short time until pain and injury occur.

Neck and shoulder pain

While hand injury arises more frequently from repetitive motions and improper exertion of force, neck and shoulder problems are derived from maintaining a static and awkward posture (39).

A significant part of the shoulder’s functionality depends on the rotator cuff. This structure comprises important muscles (supraspinatus, infraspinatus, teres minor, and subscapularis) and tendons, which stabilize the shoulder, providing a wide range of motions. Pain and loss of active range of motion with overhead activity are among the most reported symptoms(40) when rotator cuff tendinitis or shoulder impingement occurs. An ergonomic study conducted by Rucker et al. reported that 66% of dentists raise the dominant elbow approximately 45 degrees for most of their work (41).

A prolonged arm abduction and forward flexion of more than 30 degrees is thought to be an essential risk factor for the onset of injury to the rotator cuff since they lead to the compression of the supraspinatus tendon under the coracoacromial arch (rotator cuff impingement) (42). In addition, a sustained awkward posture involves a forward bending and rotation of the head, neck, and trunk to one side, generating a shortening and strengthening of muscles involved in the movement. These muscles may become ischemic, developing trigger points, pain, or asymmetrical forces, which can misalign the spinal column. A forward-head-and-rounded-shoulder posture is often the result of such poor ergonomics.

In this scenario, the anterior mover muscles (such as the scalene, sternocleidomastoid, and pectoralis muscles) become short and tight due to the forward head posture. Meanwhile, the stabilizer muscles of the shoulder blades (including the middle and lower trapezius, rhomboid, and serratus anterior muscles) become weak and elongated.

An American observational study highlighted how, most of the time (86%), dental operators usually assume trunk and cervical flexion with angles ranging from 30 to 60 degrees (33). Assuming these positions, the forward movement of the head and the trunk is accompanied by a more significant effort by the neck and lumbar muscles (43, 44), leading to MSDs.

Protective muscle contraction and substitution reinforce the imbalance cycle, generating joint hypomobility, nerve compression, and even spinal disk degeneration/ herniation (31). Pain, stiffness, and muscle spasms in the cervical musculature may follow the condition. Trapezius myalgia, tension neck syndrome (45), or thoracic outlet syndrome (39) are some of the other MSDs related to the prolonged maintenance of such postures.

Preventive strategies

For CTS, keeping a neutral position with the forearms and wrist in a straight line is an effective preventive measure, as well as frequent stretching and breaks.

While seated, the clinician should maintain the lumbar lordosis to prevent low back pain (46-48). A slight anterior tilt of the seated angle, from 5 to 15 degrees, is recommended to reduce the massive passive tension of the hamstrings and the flattening of the lumbar spine. A saddle operator stool can also be a useful tool to maintain the spine's natural position. The lumbar support of the chair should be used as much as possible and should be moved forward until it reaches the lumbar lordosis of the back. In addition, the use of a magnification system is also highly recommended.

A significant decrease in neck flexion is one of the most important advantages of using loops or microscopes (49), as they oblige the operator to maintain an optimal working distance, which allows the proper positioning of elbows and shoulders, avoiding the onset of a forward-head position. It is also important to highlight that the permanence in static postures for a prolonged time during the treatment plays a fundamental role in determining MSDs. Rather than achieving an ideal posture, the literature promotes the concept of dynamic posture. Alternating between standing and sitting may be an effective strategy to prevent injuries (50).

Positioning the patient too high is a common mistake reported by clinicians and forces the operator to a detrimental abduction of the shoulders. The height of the patient should be selected to have a position of forearms parallel to the ground, with the working area at elbow level or slightly higher. Generally, a semi-supine and a supine position should be preferred for mandibular and maxillary procedures, as well as a “chin down” or “chin up” inclination of the patient's head. In addition, clinicians should consider periodic breaks and stretching.

Stretching exercise programs, especially for the side in the reverse direction of awkward prolonged static postures, can prevent muscle imbalances (50) and should be integrated into a daily routine (51).

CONCLUSIONS

Despite the increasing related issues with MSDs and their effects, ergonomics in dentistry remains under-reported. The clinician should be aware of the patient's posture during the treatment, and periodic checks of the patient's spatial position are mandatory to preserve the general well-being of the spine, shoulder, neck, and wrist. As a prolonged static posture can be detrimental to all these structures, dynamic posture with breaks, stretching, and even a change to a standing posture should be considered along with magnification.

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