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GAIT ANALYSIS FOR ASSESSMENT OF CHRONIC LOW BACK PAIN FROM LUMBAR FACET JOINTS

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ABSTRACT
Chronic low back pain is leading cause of disability among manual workers in India and pathological lumbar facet joints identified as important structural pain generator. Management of pain focused on specific pain generator found to be effective treatment recently. There is universal reliance on only self-reported subjective assessment for pain & disability. Efforts taken to quantify functional gait patterns for objective clinical assessment. Kinematic Gait analysis to assess mainly lumbar or pelvic range of motions, have been utilized widely, with modern gait analysis system; without sub grouping the low back pain participants yielded mixed and poor consistency in results.15 male workers (age 30-55years), suffering from chronic low back pain, diagnosed with facet joint arthropathy, evaluated with observational video gait analysis with sagittal gait parameters for changes in the knee joint and hip joint angles both before and one month after management of pain with interventional pain procedures and compared with matched 15 healthy volunteers (Total 30 subjects). Comparison also made with improvement of Numeric Rating Scale score and Roland- Morris Low Back Pain and Disability Score to assess degree of pain and disability before and after the treatment. Improvements in degree of pain and disability due to chronic facet joint pain, after treatment, also matched with the improvement of different temporo- spatial and sagittal kinematic gait parameters like Stride length, cadence, stance- swing ratio, and mean knee and hip joint angles during some phases of stance (pre swing) and swing (initial swing) respectively, which also became significantly similar to normal healthy subjects. Sagittal kinematic gait analysis, sub grouping the chronic low back pain patients can be used asan effective yet low cost tool for objective evaluation of effectiveness of the pain management in addition to the subjective self reported assessment of pain and disability scales.

KEYWORDS: Sagittal Kinematic Gait Analysis, Facet Joint Arthropathy, Pain Management.

INTRODUCTION

Low back pain is pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds, with or without leg pain (sciatica), and is defined as acute when persists less than four weeks and chronic when it persists for 12 weeks or more[1]. Using the statistical analysis method known as "Years Lived with Disability", Low back Pain remains the most common reason of disability of the humankind followed by major depression, iron deficiency anemia, diabetes, chronic lung diseases and other diseases[2]. A study conducted at the ESI Institute of Pain Management, in India, identified a significant 55% prevalence of chronic low back pain in this population of jute mill workers in India, with lifting of load above 20 kg and repetitive movements of limbs being significant associations[3]. According to anatomical pain generators, chronic low back pain groups have been sub grouped or classified primarily to a) Radicular Pain due to PIVD, b) Facet Joint Syndrome or Arthropathy, c) Sacroiliac Joint Arthropathy Pain and also Discogenic pain and Lumbar spinal Stenosis[4]. Clinically the patients are evaluated with careful history of the illness including standard tools of evaluation with questionnaire like printed visual analogue scale / numeric rating scale, the Rolland-Morris low back pain and disability questionnaire for pain and disability in general; they are also evaluated with special clinical examination by the specialists. For laboratory investigations, apart from routine blood tests, X- Ray and CT Scan are done to rule out abnormality in bones, neuro-physiological diagnostic tests like NCV and EMG are done to rule out nerve or muscle dysfunctions[4]. American Pain Society (APS) has reviewed evidence for different methods of management including surgery over conservative methods for chronic low back pain and hardly found any method with better effectiveness over another[5]. Since last part of the twentieth century, those who are diagnosed with having specific pain generators due to compressions or inflammations with scarring over specific nerve root/s due to prolapsed intervertebral disc, inflammation or arthritis of the lumbar facet joints, sacroiliac arthralgia, and not improved with oral analgesics and physical methods, are being treated with per-cutaneous fluoroscopic guided minimally invasive interventions like epidural injections, radiofrequency ablation of nerves carrying pain from the facet joints, sacroiliac joint steroid injections before referral to other specialists.

Till now there is universal reliance on only subjective & self-reported subjective qualitative assessment for pain with Visual Analogue Scale or 10 or 100 points Numeric Rating Scale and Roland- Morris Low Back Pain and Disability Score or WOMAC (Western Ontario and

McMaster Universities) Index Score respectively to assess disability before and after the treatment[6-8]. Efforts taken to quantify functional gait patterns for objective clinical assessment. Kinematic Gait analysis to assess mainly lumbar or pelvic range of motions, have been utilized widely, with modern gait analysis system usually using both kinematic (motion analysis of axial spine and extremities) and kinetic (estimation of force) during locomotion in the discipline of sports medicine (sportsperson's performance analysis), neurology (Assessment of parkinsonism, cerebellar lesions), Physical medicine (assessment of disability from stroke, paralysis), orthopedics (evaluation of osteoarthritis knee, total knee replacement etc.) since last few decades. Stance and swing phases when the legs are on or off the ground respectively, sagittal kinematic analysis with Temporo spatial parameters like stride length, cadence during locomotion have been seen to be improved after treatment when compared to normal healthy subjects. Similarly analyzing the sub phases of stance during gradual loading and unloading of the body weight to and from the affected side, and also for the swing phase during forward propagation with the lower limbs, have also been seen to be different from normal healthy subjects by the researchers. Quantitative parameters using time-distance and joint angles for the hip, knee and ankle with observational sagittal plane recording and plotting stick diagrams were done to understand the gait patterns found to be low cost and effective by some[9-13]. In order to find the lower spine and lower extremity kinetics, markers were placed over the greater trochanter of femur, lateral condyle of femur, and lateral malleolus as the points to evaluate hip, knee and ankle joints respectively during sagittal observational gait analysis[10]. Kinematic Quantitative Gait analysis is used to get temporal and spatial variables of gait, these data obtained are quantifiable and can be used to plan treatment options like other diagnostic tools or also to assess the outcome of treatment or intervention provided[14]. Some authors showed correlation between decrease in pain with numeric rating scale along with improvement in lumbo-pelvic motion, postural sway during treatment with physical interventions (manipulations, mobilization or trigger point release[15-18] for management of low back pain. Kinetic analysis for the ground reaction force generated during locomotion has been estimated by very few scientists but no conclusive statements could be drawn regarding assessment of the functional ability with persons suffering from low back pain[19]. Till the time of taking this initiative to study the usefulness of gait before and after interventional pain management procedures, for assessment during management of Facet Joint Arthropathy, one of the major sub types of chronic low back pain conditions, no similar study elsewhere, found by the authors.

MATERIALS AND METHODS

All the patients were evaluated by the physicians of the Institute in the outpatient or inpatient department with standard methods of clinical history documentation including the validated instruments for measurement of magnitude or intensity of pain and disability like "Numeric Rating Scale', "Roland Morris Low Back Pain and Disability Questionnaire; Clinical examinations to find the specific type or degree of movements of the lower back and leg region of the patient associated with patients symptoms of pain and disability obtained during documenting the history of illness. Apart from the clinical tests, routine blood tests and radiological investigations like x ray, CT scan or MRI, or electro diagnostic tests like NCV were advised by the treating physicians validating the diagnosis. After approval from the Institutional Ethics Committee of the ESI Institute of Pain Management, 15 patients were selected for the study, who were suffering from chronic low back pain, already diagnosed with facet joint arthralgia, having symptoms even after treated conservatively with physical rest, medicines (analgesics, co analgesics, muscle relaxants), physical methods by the treating physicians based on standard clinical, radiological, electro diagnostic or other investigations were selected for minimally invasive pain management procedures in the operation theatre and recruited for gait analysis. To overcome the environmental and seasonal factors data were collected in day time and during same seasonal condition. The subjects suffering from serious types of low back pain due to malignancy, infection, trauma, metabolic diseases, having past history of back surgery, peripheral vascular disorders, spondylolisthesis greater than 5cm on X Rays, ankylosing spondylosis and other rheumatological disorders, pathological conditions of the nerves due to diabetes or other neurological ailments, extremes of the age *i.e*., below 30 years or above 55 years, disease with difficulty in balance or vertigo pain and disability due to multiple reasons or ailments and unwilling to take participate in the evaluation were excluded from the study. After following all these exclusion criteria only those patients were included in this study as 'pain group' who complained Numeric Rating Scale Score at least 6 out of 10 on a self-reported 10 cm numeric rating scale. 15 male patients suffering from Low Back Pain due to Facet Joint Arthralgia along with 15 age and height normal healthy volunteers were recruited for the study fulfilling the criterion as discussed. A kinematic Gait analysis lab with a wooden walkway, screen walls on the background and digital video camera placed on the stand adjusting the height of the patient at the height of the waists of the patients each time, for the observational gait analysis. On the day of the first visit the subject wore black colored tight dress, designed for the observational gait analysis and coloured adhesive markers were placed on the selected points of the body: on tragus, tip of acromion, greater trochanter, lateral condyle of femur and lateral malleolus of the fibula as per protocols done by others already[8,9,11].Those points which showed maximum angle variations related with low back pain being further analysed- in case of "Knee Angle": greater trochanter, lateral condyle of femur and lateral malleolus of the fibula and for "Hip Angle": This angle is formed by the lines connecting the markers at the tip of acromion, greater trochanter, lateral condyle of femur (Hip angle, termed here, actually reflected the ability of the person for forward flexion or backward extension of the spine or lumbar lordosisangle; for convenience of taking the image with the marker for the lumbosacral joint being viewed from laterally the marker in between the anterior and the posterior superior iliac spine is practically in same vertical line with the marker placed over the greater trochanter of femur and with very close proximity viewed from the video camera at a distance of 3 meters. Other was skipped during analysis due to less related with low back pain. A digital video camera was placed on a stand at the height of 27.5 inches (70 cm) from the floor, laterally 118 inches (3 meters) away from the midpoint of the gait walkway or platform to cover the patient between the head and foot and also to include the walkway into the frame; the length, breadth and height of the walkway being 236 inches (6 meters), 39 inches (1meter) and 3inches (7.5cm) respectively. The patients were requested to stand on the platform and asked to walk to and fro on this comfortably. After some time when the patient started walking freely of his own, the movie button was switched on and recorded for few cycles. The video clip was transferred from the digital camera to the computer, and the mid portion of the recorded gait with comfortable regular pattern of locomotion, to avoid the initial part of the hesitations before adjustment with the new environment, kept for further analysis. After one month of treatment with the fluoroscopy guided radiofrequency treatment for the patients suffering from facet joint arthropathy, the degree of Pain as well as the disability with Numeric Rating Scale and Roland- Morris Low Back Pain and Disability Score was assessed.The Temporo Spatial and sagittal kinematic gait parameters like Stride length, Cadence, Stance- Swing ratio, and mean knee and hip joint angles during the phases of stance (Initial Contact, Loading Response, Mid Stance, Terminal Stance, Pre Swing) and swing (Initial swing, Mid Swing, Terminal Swing) respectively, were plotted both before and one month after the treatment and compared with the mean parameters of the healthy subjects. The data obtained from gait analysis from the subjects before and after the intervention analyzed with SPSS statistical software, version 22.0 available with the Institute.

RESULTS & DISCUSSION

It was found that the improvement in degree of pain and disability due to chronic low back pain with Facet Joint Arthralgia, which was found one month after treatment with subjective and qualitative tools like Numeric Rating Scale and Roland- Morris Low Back Pain and Disability Score, also found to be effectively assessed quantitatively with the improvement of different variables of observational gait analysis like Stride length (Fig. 1, Table 1), cadence (Fig. 2, Table 1), Stance- Swing ratio (Fig. 3), range of knee joint angles (Table 2, 3) and range of Hip joint angles (Table 4) as following:

TABLE 1: Notable Temporo Spatial Parameters of the Facet Joint Arthropathy (FJA) Group before and one month after treatment analyzed with the IBM SPSS V 22.0 Software:

Groups	FJA (N=15)	Control(N=15)	P value (<0.01)	Comments
Mean Stride before treatment	64.18 ± 18 cm	137±15.60 cm	p<0.001 (Significant)	Significantly less than control before treatment
Mean Stride after treatment	87.2± 19.5 cm	137±15.60 cm	p<0.001(Significant)	Some improvement after treatment but notably less than control
Mean Cadence (Steps per minute) before treatment	78.87±8.9 /min	93.5±8.8/min	p<0.001(Significant)	Significantly less than control before treatment
Mean Cadence after the treatment	84.20±9.4/mi	93.5±8.8/min	p<0.01(Significant)	Some improvement after treatment but notably less than control

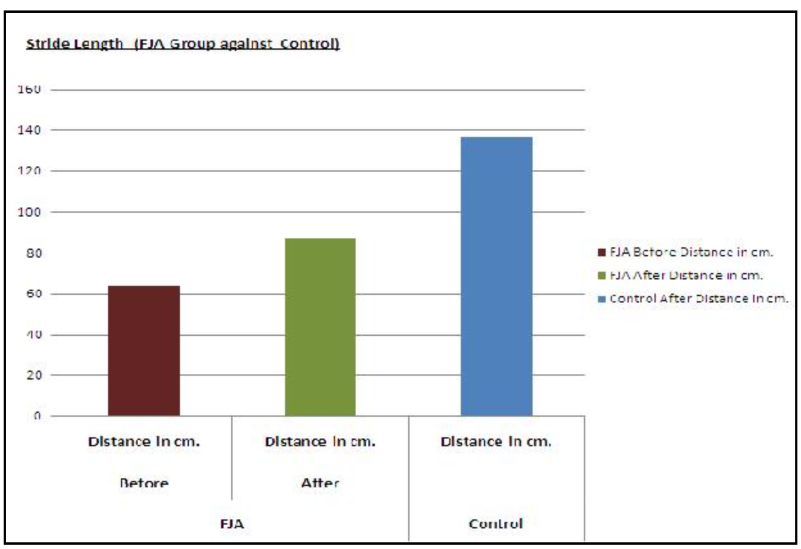

FIGURE 1: Length of stride for the FJA group before and after treatment against the normal healthy control group

Degree of Pain
The patients with chronic low back pain suffering from Facet Joint Pain had significant relief from pain (75%) one month after treatment with interventional pain management procedures.

Disability
The patients from pain due to Facet Joint Arthralgia had significant reduction of disability (80%) measured with the Roland Morris Low Back Pain Disability Questionnaire one month after treatment.

Stride Length
Patients with chronic low back pain due to Facet Joint Arthralgia had significantly less length of stride length, before treatment with interventional pain management compared to controls.

Patients with chronic low back pain due to Facet Joint Arthralgia showed some increased length of stride one month after treatment (Fig. 1, Table 1), though it was not found to be significant.

Cadence
Significantly less cadence in patients with chronic low back pain due to Facet Joint Arthralgia than control group before treatment. Patients with chronic low back pain due to Facet Joint Arthralgia – though some improvement seen after treatment but not found to be significant (Fig. 2, Table 1).

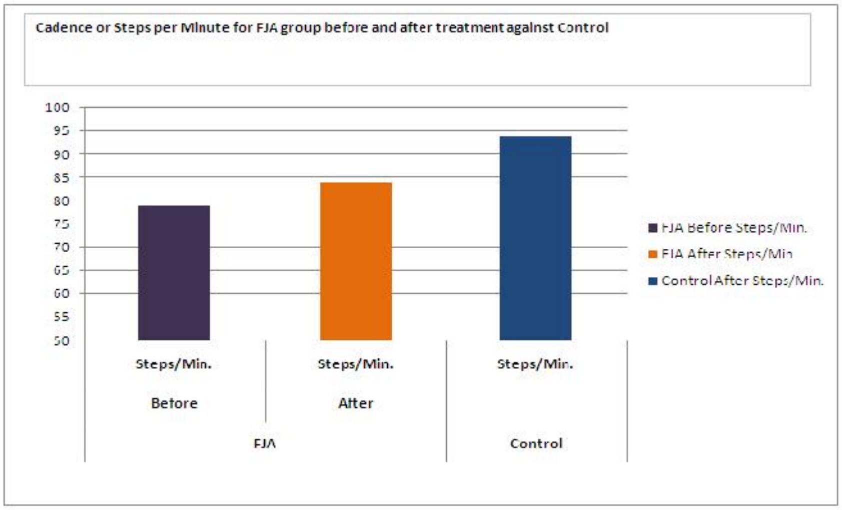

FIGURE 2: Cadence after treatment for the FJA Group

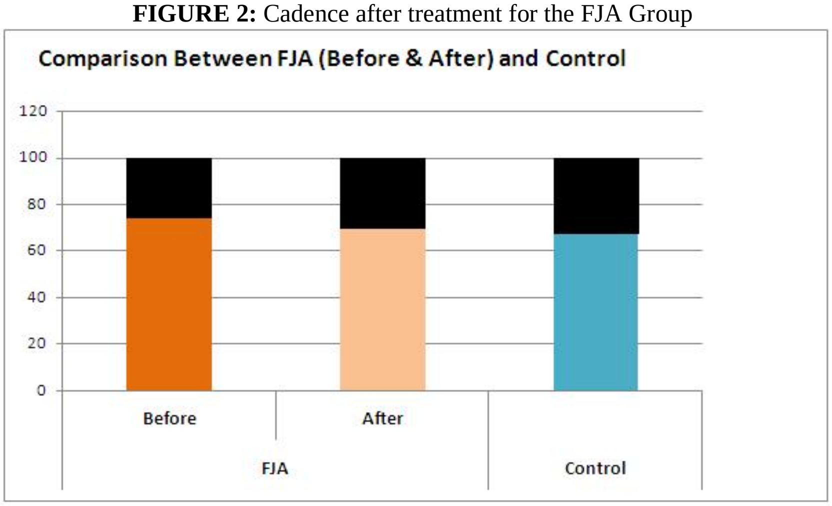

FIGURE 3: Duration of stance and the duration of swing for the FJA group before (Frames- 38.4, Ratio- 2.64, Frames- 36.0, Ratio- 2.21) and after treatment compared with control)

Stance - Swing Ratio:
There was notable increase in the swing time one month after treatment for patients with chronic low back pain due to Facet Joint Arthralgia, improving the Stance-Swing ratio as compared to the healthy control group (Fig. 3)

Sagittal Joint angles

For knee angles before treatment:
At the "Loading Response" of the "Stance" phase:- during low back pain due to FJA before treatment– the angles were significantly more against control. (Table 2, Table 3)

(Probably during this phase of stance, the steady and gradual transfer of body weight to the affected side with controlled concentric flexion of knee with the hamstring muscles aided with the eccentric contraction of the extensor quadriceps muscles, require normal and stable unaffected hip and lumbosacral joints, and less fear for pain - which are affected with FJA of the lumbo-sacral area)

At the "Pre Swing" of the "Stance" phase: during the low back pain due to FJA only the knee angles were significantly more than control. (Table 2).

(Probably for preparing the affected leg for ground clearance, there is more resistance and increased tone of the muscles of legs, due to stiff and painful lumbosacral facet joint, as well as fear of pain, before treatment, and additional load exerted there, before lifting the leg).

During the "Initial Swing" and also the "Mid Swing"- at the "Swing" Phase: during the low back pain - the angles were significantly more than control. (Table 3) (Indicating less flexion or folding at knee joint, resulting in inability to progress forward with comfortable ground clearance, at the affected side, due to stiff and painful lumbosacral facet joint, as well as fear of pain before treatment).

TABLE 2: Notable mean Joint angles for Knee during Stance Phase for the Facet Joint Arthropathy (FJA) Group before and one month after treatment analyzed with the IBM SPSS V 22.0 Software

Groups	FJA (N=15) Degree	Control(N=15) Degree	P value (<0.01)	Comments
Mean knee joint angle before treatment: during Loading Response	174.8 ±4.42	167.9 ±6.7	p<0.01(Significant)	Notably more than control
Mean knee joint angle after treatment: during Loading Response	172.8 ±5.7	167.9 ±6.7	p<0.05 (Significant)	Notably more than control
Mean Joint Angle Before: Pre Swing	143.9 ±7.13	138.6 ±6.4	p<0.05 (Significant)	Notably more than control
Mean Joint Angle After: Pre Swing	136.2 ±7.6	138.6 ±6.4	p=0.358 (Not Significant	Near Normal (Control) / Improved after treatment

TABLE 3: Notable mean Joint angles for Knee during Swing Phase for the Facet Joint Arthropathy (FJA) Group before and one month after treatment analyzed with the IBM SPSS V 22.0 Software

Groups	FJA (N=15) Degree	Control(N=15) Degree	P value (<0.01)	Comments
Mean knee joint angle before treatment: during initial swing	140.4±6.0	127.8±5.5	p<0.001(Significant)	Notably more than control
Mean knee joint angle after treatment: during initial swing	130.1±6.4	127.8±5.5	p=0.305 (Not Significant)	Near Normal (Control) / Improved after treatment
Mean knee joint angle before treatment: during mid-swing phase	146.7±7.2	129.6±6.7	p<0.001(Significant)	Notably more than control
Mean knee joint angle after treatment: during mid-swing	140.4±7.2	129.6±6.7	p<0.001(Significant)	Remained notably more than control/ No improvement

TABLE 4: Notable mean hip Joint angles for the Facet Joint Arthropathy (FJA) Group before and one month after treatment analyzed with the IBM SPSS V 22.0 Software

Groups	FJA (N=15) Degree	Control(N=15) Degree	P value (<0.01)	Comments
Mean Hip Joint Angle before treatment : Initial Contact	167.46±6.9	162±5.3	p<0.05 (Significant)	Notably more than control
Mean Hip Joint Angle after treatment : Initial Contact	165.3±5.6	162±5.3	p=0.125 (Not Significant	Near Normal (Control) / Improved after treatment
Mean Hip Joint Angle before treatment : Initial Swing	168.9±9.5	175±4	p<0.05 (Significant)	Notably less than control
Mean Hip Joint Angle after treatment : Initial Swing	173.2±5	175±4	p=0.285 (Not Significant	Near Normal (Control) / Improved after treatment
Mean Hip Joint Angle before treatment : Terminal Swing	169±7	163±5.7	p<0.05 (Significant)	Notably more than control

For knee angles one month after treatment:

At the "Pre Swing" of the "Stance" Phase: after treatment, there was improvement in knee flexion at the affected side, with Facet Joint Arthropathy, as the mean value came closer to healthy control (Table 2). (Probably after pain relief, the stiffness of the lumbosacral facet joints reduced, and also the fear of pain further reduced; the tone and stiffness of the lower extremity muscles were able to bend the knee to initiate ground clearance for forward progression)

For the "Initial Swing"- at the "Swing" Phase: after treatment, for Facet Joint Arthropathy- the angles improved significantly coming down near the healthy control subjects (Table 3).

(Probably after pain relief, the stiffness of the lumbosacral facet joints reduced, and also the fear of pain further reduced; the tone and stiffness of the lower extremity muscles were able to bend the knee to progress forward comfortably).

For Hip joint angles before treatment

At the “Initial Contact” of the “Stance” Phase: before treatment, due to low back pain for Facet Joint Arthropathy sub group, the hip joint angle was found significantly more than control (Table 4).

(Probably due to pain and stiffness of the facet joint at the affected side, the stride length was less with less distance covered by the advancing knee with lesser flexion at lumbosacral/ hip joint before treatment)

At the “Initial Swing” of the swing phase: in the Facet Joint Arthropathy group, the mean hip joint angle was significantly less than control group (Table 4).

(Probably there was more flexion at the painful lumbosacral spine, to reduce the load at the facet joint, during advancement of leg).

For Hip joint angles one month after treatment

At the “Initial Contact” of the “Stance” Phase: after treatment, due to low back pain for Facet Joint Arthropathy sub group, the hip joint angles came down nearer to healthy control subjects (Table 4).

(Probably due to reduced pain and stiffness of the facet joint at the affected side, the stride length increased with more distance covered by the advancing knee with increased flexion, nearing control, at lumbosacral/hip joint after treatment).

During “Initial Swing” of the “Swing” phase after treatment, due to low back pain for Facet Joint Arthropathy sub group, the flexion at hip joint angles became similar to healthy controls (Table 4).

(Probably there was less flexion at the lumbosacral facet joint, after reduction of pain and disability/stiffness at the affected side, which was able to accept more load than before, during advancement of leg).

CONCLUSION

The use of observational gait analysis found to be an effective tool for objective assessment of outcome of pain management one month after treatment among workers suffering from chronic low back pain due to lumbar facet joint arthropathy asan effective yet low cost tool for objective and quantitative evaluation of effectiveness of the pain management in addition to the subjective assessment of pain and disability scales. However further studies with more number of sufferers from both genders with different social, cultural, psychological and economic background may be considered to establish its universal usefulness.

RECOMMENDATION

Low cost observational video gait analysis using sagittal human motion may be used as an effective quantitative and objective assessment of chronic low back pain due to its common sub groups similar to facet joint arthropathy, both for diagnosis as well as evaluation of effectiveness of interventional pain management methods.

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