PAIN MEDICINE CASE REPORTS

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Subchondral Vertebral Body Bone Marrow-Derived Mesenchymal Stem Cells Injections Combined With Lumbar Disc Arthroplasty for Vertebrogenic and Discogenic Pain: A Novel Case Report

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Background: Chronic axial low back pain is often multifactorial, involving overlapping facetogenic, discogenic and vertebrogenic pain generators. Although several treatment modalities exist for clear-cut cases in which the primary pain generator is well defined, optimal management for patients with mixed pathology remains unclear.

Case Report: In this case, a 27-year-old man presented with refractory axial low back pain and severely limited range of motion associated with Modic type 1 endplate changes and discogenic pain at L3–4 and L5–S1 confirmed by provocative discography. After transient benefit from basivertebral nerve ablation and minimal response to medial branch blocks, the patient underwent a multimodal treatment intervention, consisting of subchondral vertebral endplate bone marrow aspirate concentrate (BMAC) injections at L3–4, intradiscal BMAC injection at L5–S1, and lumbar disc arthroplasty at L3–4. Pain improved from 6/10 in severity pre-intervention to 1–2/10 in severity, with a 75% increase in lumbar range of motion at 4 months post-intervention.

Conclusions: This case presents an innovative, motion-preserving restorative treatment approach for multifactorial axial low back pain, combining targeted BMAC injections to the subchondral vertebral endplates and intervertebral disc with disc arthroplasty.

Key words: Subchondral BMAC injections, discogenic pain, disc arthroplasty, Modic changes, case report

BACKGROUND

Chronic low back pain is a leading cause of disability worldwide (1) and oftentimes arises from degenerative spinal pathology involving the intervertebral discs or vertebrae.

Discogenic pain, often exacerbated with lumbar flexion, sitting, and axial loading, can result from degenerative annular fissures, disc desiccation, inflammatory mediator release, and nociceptor sensitization, ultimately disrupting spinal biomechanics (2,3). Vertebrogenic pain, on the other hand, has emerged as a distinct pain generator originating from the basivertebral nerve-innervated vertebral endplates and adjacent subchondral bone marrow (4). In both cases, clinical examination findings and magnetic resonance imaging (MRI) of the spine are used to support a diagnosis. Modic vertebral end plate changes are indicative of vertebrogenic pain, with Type 1 showing inflammatory

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degeneration and Type 2 reflecting chronic, fatty degeneration of the vertebral endplates (5). In select cases with multiple pain generators, provocative discogram can be used to confirm discogenic pain.

Biologic regenerative medicine, using compounds like bone marrow aspirate concentrate (BMAC) and bone marrow-derived mesenchymal stem cells (BM-MSCs), has come to the forefront of pain medicine given the limitations of conservative treatments and the risks associated with more invasive surgical interventions. BMAC is obtained by extracting autologous bone marrow and centrifuging the contents into a "buffy coat fraction" rich in mesenchymal progenitor cells, growth factors, and cytokines. In contrast, BM-MSCs are obtained through ex-vivo expansion of the BMAC to harness the anti-inflammatory and paracrine regenerative properties of multipotent cells. Intradiscal injections of BMAC or BM-MSCs have shown potential in improving pain and function in patients with discogenic low back pain. However, existing evidence remains heterogeneous, largely limited to small clinical studies and systematic reviews (6).

Currently, most regenerative spine research focuses on the intradiscal delivery of biologics. In contrast, subchondral BMAC injections targeting vertebral endplates represent a novel and relatively unexplored approach aimed at addressing vertebrogenic pain. To date, there are no published reports describing the combined use of subchondral vertebral endplate BMAC injections with concurrent lumbar disc arthroplasty. This case highlights a unique multimodal strategy integrating regenerative subchondral and intradiscal therapies alongside surgical disc replacement therapy to address coexisting discogenic and vertebrogenic pain generators.

CASE PRESENTATION

A 27-year-old man presented with chronic axial low back pain that began 6 years prior (2019) following an acute deadlifting injury, characterized by immediate onset of lumbar paresthesias and sharp, pinching pain that led to a fall. His pain was initially localized to tenderness at the L3–L5 spinous processes without radiation and worsened with lumbar flexion and extension. Transient functional immobility followed for approximately 2 weeks, and over time his pain progressed to chronic numbness, tingling and achiness. Months later, he experienced recurrent symptom exacerbations while white water rafting and again in 2021 in the absence of clear trauma.

Lumbar MRI obtained in mid-2021 (Fig. 1) demonstrated a disc bulge at L3–L4 narrowing the neural foramina, moderate to severe disc space narrowing and a Schmorl's node with disc desiccation. A disc bulge at L5-S1 with mild narrowing of neural foramina and disc desiccation was also noted. He subsequently underwent prolonged, intermittent conservative management, including nonsteroidal anti-inflammatory drugs, acetaminophen, dry needling and structured physical therapy, from 2021–2024, with minimal clinical improvement.

Repeat lumbar MRI in mid-2024 (Fig. 2) showed edema surrounding the Schmorl's node involving the anterior superior endplate of L4, which reflected new degenerative endplate Modic type 1 changes. New mild edema was also seen along the inferior endplate of L3.

Given the new MRI findings, the patient underwent basivertebral nerve ablation (BVNA) at L3 and L4, resulting in 50% immediate reduction in pain and improvement in lumbar range of motion. Within 6 months, symptom relief plateaued and he eventually clinically deteriorated, complaining of increased pain severity, development of gluteal radiation, and a transition to more diffuse axial low back pain. Follow-up MRI and computed tomography scan in 2025 demonstrated no significant interval structural change (Figs. 3 and 4).

He underwent subsequent diagnostic bilateral medial branch blocks at L3–L4 and L5–S1, which produced only mild, transient analgesia. Given symptom progression, surgical intervention was discussed, including lumbar fusion. Alternative biologic and surgical options were considered, including intradiscal therapies and lumbar disc arthroplasty.

To assist in identifying the specific pain generator, the patient was referred to the pain management clinic in July 2025. At that time, he complained of low back and buttock pain that he described as chronic, sharp, constant and on average 6 out of 10 in severity. The patient reported difficulty sitting or standing still for more than 30 minutes. On exam, his gait was moderately antalgic. Limited spine range of motion with pain was noted in all directions. Lumbar facet loading test was positive bilaterally. In light of both clinical and imaging findings, it was determined to pursue a medically indicated provocative and analgesic discogram at L3-L4 and L5-S1 disc levels.

RESULTS

During the discogram, the patient experienced concordant pain on provocation at both levels relieved with intradiscal lidocaine, and there was a minimal posterior

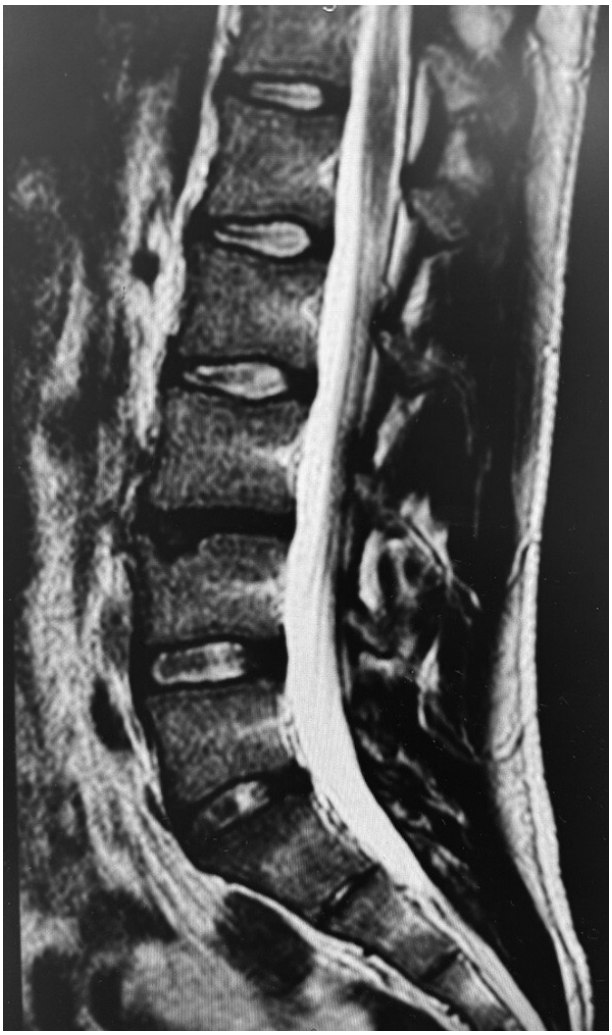

Fig. 1. MRI lumbar spine image from 7/2021.

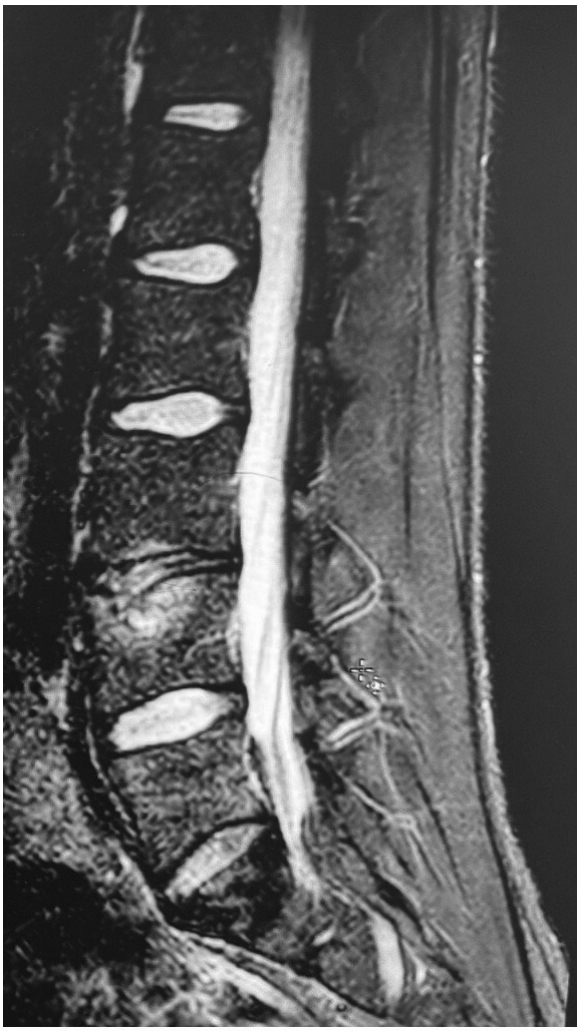

Fig. 2. MRI lumbar spine image from 8/2024.

leak of contrast in the epidural space at L5-S1. Low pressure and low volumes were also noted (Table 1). Given these findings, both discs were determined to be the likely sources of the patient's intractable low back pain.

The patient refused spinal fusion surgery which was recommended by his initial orthopedic surgeon. Through interdisciplinary discussions with the patient, a decision was made to pursue both subchondral bone marrow aspirate concentrate (BMAC) injections at L3-4 levels and intradiscal BM-MSC injections at L5-S1 levels with corresponding facet injections, along with disc replacement surgery at the L3-4 level (Fig. 5).

Harvesting Technique

BMAC were harvested from the right posterior iliac spine using a multiport Jamshidi trocar under fluoroscopic guidance. Six 10 mL syringes were used for the bone marrow aspiration. The cannula was rotated and advanced a few millimeters after each subsequent aspiration. The aspirate underwent dual centrifugation at 3200 rpm for 15 minutes, yielding 7 mL of BMAC, that was mixed with 7 mL of plasma.

Injection Technique

Vertebral body subchondral injections at L3-4 were carried out. The superolateral aspect of the right L3 pedicle was identified and the right pedicle periosteum was anesthetized with 1% Lidocaine. An incision was made and 5" Jamshidi trocar with stylet was introduced until bony contact was made. Using a mallet, the trocar

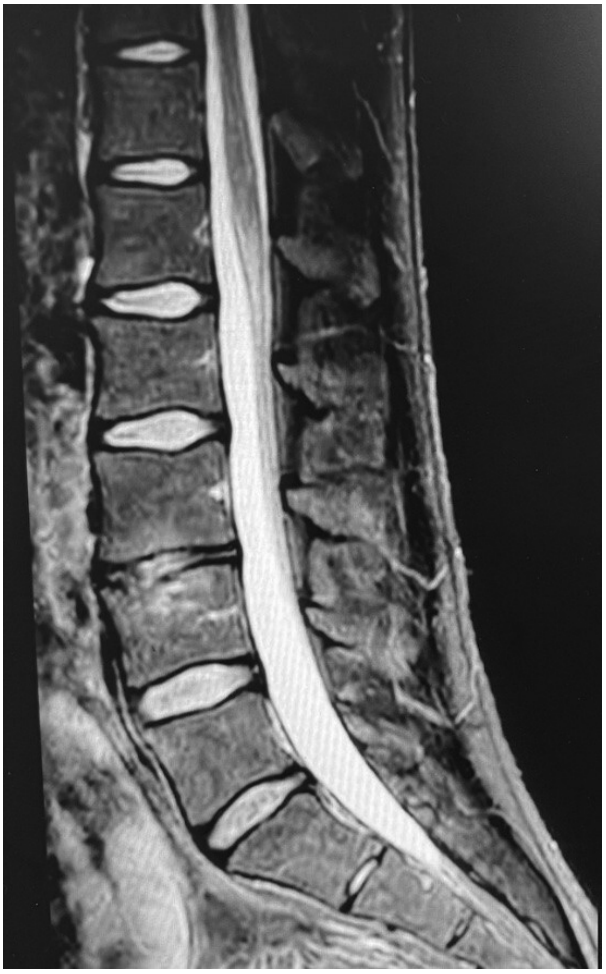

Fig. 3. MRI Lumbar Spine Image from 5/2025.

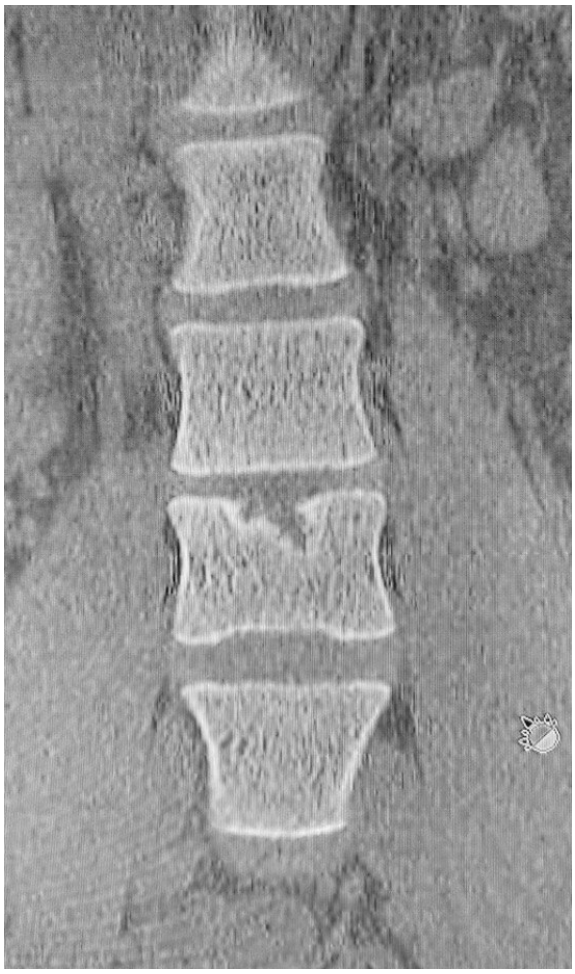

Fig. 4. CT lumbar spine image from 6/19/25.

Table 1. Discogram results.

Parameter	L3-L4	L5-S1
Opening Pressure (PSI)	10	15
Maximum Pressure (PSI)	20	23
Injected Volume (mL)	2.0	2.0
Pain on Provocation	Yes	Yes
Epidural Contrast Leak	None	Minimal Posterior Leak

was advanced through the pedicle to the lower endplate of the L3 vertebral body. The stylet was then removed and a spinal needle was introduced. 2.5 mL of BMAC were injected. The same procedure was repeated at the superior and inferior endplates of L4.

Intradiscal BMAC injections were performed at the L5-S1 disc space: 2.0 mL was placed into the disc and 1.0 mL was injected peridiscally. The bilateral facet joints of L3-4, L4-L5, and L5-S1 were also injected with 0.5 mL of BMAC intraarticularly and periarticularly.

Progression of Symptoms

Postoperatively, the patient reported a progressive reduction in pain following the subchondral injections and disc replacement (Table 2). His low back pain scores were initially rated at 4-5 out of 10 within the first week post-injections. His low back pain increased to 5-6 out of 10 immediately following disc arthroplasty, then gradually improved to 4-5 out of 10 within the first few weeks, 3-4 out of 10 by one month, 2-3 out of 10 by two months, and 1-2 out of 10 by four months postoperatively. Functional outcomes improved in conjunction with his pain, with approximately a 20% increase in lumbar range of motion at 1 week, 35% at 1 month, 50% at 2 months and 75% at four months

(Table 2). Preoperatively, forward flexion was limited to reaching the knees, whereas postoperatively the patient was able to reach the superior aspect of the calves by 1 week, middle of the calves by 1 month, ankles by 2 months and has continued to improve at 4 months. His rotational range of motion also continued to improve, with less guarding and exacerbation of pain.

DISCUSSION

This case describes a novel multimodal approach integrating subchondral BMAC injections, intradiscal biologic therapy, and lumbar disc arthroplasty to treat multifactorial chronic axial low back pain. To our knowledge, this is the first reported case combining biologic augmentation of vertebral endplates with concurrent lumbar disc replacement, addressing several pain generators.

Chronic axial low back pain often arises from multiple overlapping sources within a spinal segment. Discogenic and vertebrogenic nociceptive innervation of the lumbar spine originates via sinuvertebral and basivertebral nerve pathways (7). Another common source of axial back pain is facet joint mediated pain, stemming from the medial branches of the dorsal rami (8). Disc degeneration can result in discogenic pain, while inflammatory and structural endplate changes—frequently seen as Modic changes on MRI—have been implicated in vertebrogenic pain (9). In this patient, provocative discography confirmed discogenic pain at L3–4 and L5–S1, Modic type 1 changes supported a concurrent vertebrogenic pain component, and mild transient relief from bilateral medial branch blocks pointed toward possible facet mediated pain components. As chronic low back pain is increasingly recognized as a multifactorial condition involving overlapping pain generators, imaging findings alone often correlate poorly with symptom severity. A structured diagnostic approach that integrates clinical history, physical examination findings, and targeted diagnostic injections is critical for identifying the predominant source of pain and guiding tailored interventions (10).

Of interest is the unique approach used to specifically target the vertebrogenic pain component of this patient. Currently, BVNA is the mainstay treatment for vertebrogenic pain. In the INTRACEPT randomized controlled trial, BVNA resulted in clinically meaningful improvement at 12 months, with Visual Analog Scale (VAS) pain reduction from 6.7 to 2.9 and an Oswestry Disability Index (ODI) responder rate of 68.9% (4). Long-term follow-up from the SMART trial demonstrated durable benefit, with Fischgrund et al (11) reporting mean ODI improvement of 25.9 points and mean VAS reduction of 4.4 at 5 years, with 66% of patients achieving ≥50% pain relief and 34% reporting complete pain resolution.

However, in this patient, pain relief following BVNA plateaued at approximately six months, after which symptoms progressively worsened, evolving into severe buttock and axial low back pain. This clinical course highlights a potential limitation of BVNA — it does not address the underlying inflammatory or structural pathology of the endplates or subchondral bone marrow. In this case, the subsequent 50% increase in lumbar range of motion and marked reduction in axial low back pain observed two months after subchondral BM-MSC injections suggest that interruption of nociceptive sig-

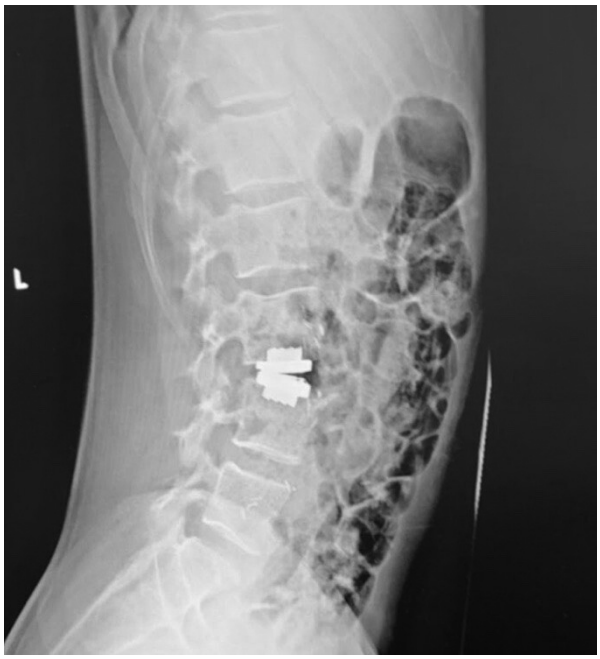

Fig. 5. MRI lumbar spine image after disc replacement surgery at L3-L4.

Table 2. Post-procedure pain and functional improvements.

Outcome	1 Week	1 Month	2 Months	4 Months
Pain Score (0-10 NRS)	4-5	3-4	2-3	1-2
Lumbar Range of Motion Improvement (%)	~20%	~35%	~50%	~75%

Abbreviations: NRS = Numeric Rating Scale

naling alone may be insufficient in the setting of persistent endplate degeneration. Collectively, these findings emphasize the importance of ongoing investigation into treatment strategies that extend beyond isolated neural targets, to more fully address the contributors to chronic low back pain.

Subchondral BM-MSC injections represent a biologically restorative strategy aimed at targeting the inflammatory microenvironment within the vertebral body. Modic changes are characterized by bone marrow inflammation, cytokine signaling, and fibrovascular replacement of normal marrow, suggesting that the subchondral space is a biologically relevant therapeutic target (9). Mesenchymal stromal cells exert well-described anti-inflammatory and immunomodulatory effects through paracrine signaling, including suppression of pro-inflammatory cytokines such as tumor necrosis factor-α, interleukin-1β, and interleukin-6, and upregulation of anti-inflammatory mediators including interleukin-10 and transforming growth factor-β—cytokines that have been implicated in the inflammatory and fibrovascular bone marrow changes characteristic of Modic type 1 endplate degeneration (9,12).

Despite this rationale, subchondral biologic therapies remain largely unexplored, particularly compared to intradiscal biologic interventions. In a prospective study by Pettine et al (13), intradiscal injection of autologous bone marrow aspirate concentrate resulted in a mean reduction in pain scores of approximately 3 points on the visual analog scale and a mean improvement in ODI of 25 points at 12 months, with sustained clinical benefit and no major adverse events reported. Further support comes from a recent meta-analysis by Zhang et al (14), which demonstrated mean reductions in pain scores of approximately 2–3 points on the VAS and mean improvements in ODI of approximately 20–25 points from baseline. In this case, intradiscal BM-MSC injection at L5–S1 was combined with subchondral BM-MSC injections at L3–4 to target both pain generators. Lumbar disc arthroplasty was selected at L3–4 to correct the moderate to severe disc space narrowing and a Schmorl's node with disc desiccation. This was chosen over a spinal fusion surgery with the intention of preserving motion, an important consideration in younger patients (15). However, disc replacement alone does not address vertebral endplate inflammation, highlighting the rationale for adjunctive subchondral biologic therapy.

At present, published clinical literature describing subchondral vertebral body injections directed at degenerative endplate pathology is very limited. Kirchner et al (16) described intraosseous, transpedicular delivery of plasma rich in growth factors to degenerative vertebral endplates, demonstrating technical feasibility and early clinical improvement. Although a different biologic was used, this work provides important proof of concept that the vertebral endplate and subchondral bone marrow are accessible and potentially modifiable therapeutic targets in degenerative spinal pain. The lack of existing literature highlights both the novelty of the treatment approach described in this case, and the imminent need for further investigation.

By 16 weeks post-treatment, the patient still had minimal low back pain and mild range of motion impairments which could point towards ongoing neuromuscular adaptation, facet-mediated pain, or incomplete resolution of endplate inflammation. Existing studies of intradiscal BM-MSC and BMAC therapies have demonstrated sustained clinical improvement through 12 to 36 months, suggesting that longer-term follow-up may be necessary to fully assess the durability and trajectory of this patient's response (13,17).

The limitations of this report include its single-patient design, limited follow-up, and inability to isolate the individual contributions of each intervention. Nevertheless, the favorable early outcome supports the need for prospective studies evaluating the safety, efficacy, and durability of combining subchondral biologic augmentation with lumbar disc arthroplasty. Future investigations should focus on patient selection, optimal biologic delivery techniques, imaging correlates of endplate healing, and long-term clinical outcomes.

CONCLUSION

This case underscores several important concepts. First, chronic low back pain is frequently multifactorial, and durable symptom relief may require simultaneous treatment of multiple pain generators rather than isolated interventions (7,9). Second, subchondral biologic therapies targeting vertebral endplates represent a promising but under-investigated therapeutic frontier, particularly when integrated with motion-preserving surgical techniques. Finally, this approach suggests a shift from purely ablative or mechanical strategies toward combined restorative interventions aimed at modifying both pain signaling pathways and underlying degenerative pathology.

Author Contributions

Sudhir Diwan: Conceptualization, methodology, investigation, review and editing, supervision
Maanas Chiplunkar: Investigation, data curation, formal analysis, writing original draft, review and editing, visualization
Shelby Munoz: Investigation, data curation, formal analysis, visualization

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