

Rational approach, technique and selection criteria treating lumbar disk herniations by oxygen–ozone therapy

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Received 2016 May 21; Accepted 2016 Jun 22.

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Abstract

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Radicular lumbar back pain is an important public health problem not yet benefiting from a unequivocal treatment approach. Medical and physical therapies represent the first solution; however, when these fail, the second therapeutic step is still controversial and mini-invasive treatments may play an important role. In these cases oxygen–ozone therapy has been proved to be a very safe and effective option that is widely used with different modalities. This paper, by reviewing oxygen–ozone therapy literature data, aims to describe the rationale of oxygen–ozone therapy for the treatment of lumbar disk herniations, propose an effective procedural technique and clarify patient selection criteria; furthermore, complications and follow-up management are also considered.

Keywords: Lumbar pain, herniated disk, oxygen–ozone therapy, fluoro- and CT-guidance, selection criteria

Introduction

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Low back pain (LBP) is one of the most common and important clinical, social, economic, and public health problems affecting the human population worldwide.¹ In 1.6–43% of the cases there are associated sciatic symptoms,^{1,2} which, 90% of the time, are generated by disk herniation.³

The mechanism of radicular pain in the lumbar region is multifactorial but is likely due to mechanical and/or inflammatory factors. There is a component related to disc herniation that causes a direct compression of the nerve root or dorsal root ganglion, and an indirect compression on perineural vessels. Once the disk gets injured, facet capsule, epidural tissue surrounding the nerve root and the nerve root itself get inflamed with production of a cascade of inflammatory mediators, all of which activate afferents, sensitize nociceptors and make the nerve exquisitely sensitive to pressure, generating pain with either gentle manipulation or pressure.^{3–6} Because of this, the inflammatory component of radicular pain allows that a bulging or protruding disk generates pain without a necessary root compression.

The natural history of disc herniation tends to be favourable. Spontaneous regression of disc herniation is seen in two-thirds of cases⁷ and a spontaneous resolution of pain within the acute phase (from six to 12

weeks after pain onset) in 60–80% of patients.² Nevertheless, the one-year recurrence rate is significant and approximately 37–54% of patients retain the pain after long periods of time (at least 12 months).¹

The first therapeutic approach to lumbar disc herniation must be conservative, with pharmacological, physical and cognitive-behavioural therapy.⁸ In the case of failure after at least three months, the choice and indication for the appropriate therapy remain unclear. Indeed, before resorting to surgical treatment many interventional techniques should be considered.

Percutaneous techniques minimize the invasive nature of surgery, rendering administration more straightforward and faster while sparing healthy tissues and minimizing surgical complications.¹ Many common minimally invasive treatments⁶ rely on the removal of disc material or on the fibrosis of the disc to reduce pressure on the ganglion nerve root. The size of the needles used in these procedures ranges from 8 to 17 gauges (G) and, sometimes, it is difficult to reach safely into the disc. Oxygen–ozone nucleolysis instead is performed through a 20–22 G needle and is often combined with peri-radicular administration of steroids and local anaesthesia.^{6,9}

Ozone (O₃) is a strongly oxidant gas with antiseptic, immunomodulating, analgesic and anti-inflammatory properties.¹⁰ Oxygen–ozone gas mixture (O₂O₃) is commonly used in clinical practice, mostly in Europe and Asia, in the treatment of nociceptive-neuropathic pain, in inflammatory and degenerative processes of the muscle-skeletal system and especially in degenerative disc disease and disc herniation.⁸ O₃ is administered in the form of O₂O₃ at non-toxic concentrations ranging from 1 µg to 40 µg of O₃ per ml of oxygen, using various percutaneous methods.¹

The biological action of medical ozone is not fully understood but some mechanisms of action have been proposed to explain its efficacy in disc herniation treatment:

1. *Reduction of the inflammatory components.* O₃ interrupts the self sustained cycle of the inflammatory cascade by altering the breakdown of arachidonic acid to inflammatory prostaglandins.
2. *Hyper-oxygenation of the area of interest.* Disc herniation impinges on the venous and arterial flow, causing phlebotasis and arteriostenosis, which lead to hypoxemia of the tissues; by applying O₂O₃ to the herniated site, oxygen concentration increases.
3. *Diminishing the size of the herniation.* O₃ breaks down the glycosaminoglycans chains in the nucleus pulposus and reduces their ability to hold water, thereby shrinking the nucleus and subsequently reducing intradiscal and peri-radicular pressure.
4. *Stimulation of the repair process.* O₃ promotes the fibroblastic activity, inducing collagen deposition.¹¹

Procedural technique

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A standard technical protocol has not yet been provided and every operator develops his own technique on the basis of experience and resources availability. In our department, patients do not routinely receive any pre- or post-operation medications; we do not perform local anaesthesia. Working in sterile conditions is essential. Fluoro- or computed tomography (CT)-guidance are both feasible depending on the operator choice. The patient lies in a prone position, a pillow can be placed under the abdomen to increase the lumbo-sacral angle. The approach with the patient lying laterally on the healthy site has been also described.^{12,13}

Disc access is gained with a postero-lateral extra-pedicular approach on the symptomatic side at the level of the disc herniation, even if the puncture site is 6–10 cm away from the vertebral midline, using a 15 cm needle 19–22 G, depending on the patient build, with an angle of about 40°–45°. When the needle enters the disc, a soft resistance is felt. The needle position in the centre of the disc must be confirmed by

fluoroscopy or CT imaging; the ideal needle position is considered to be at the junction between the posterior and the middle third of the disc ([Figures 1](#) and [2](#)). Gas mixture (1–3 ml: 2% O₃ (30–40 µg/ml) in 98% O₂) is injected into the disc. Then the needle tip is withdrawn into the intervertebral foramen (where the operator feels minor resistance) where another 10 ml of O₂O₃ and 2 ml of corticosteroid/local anaesthetic (1/1) are injected; indeed the rationale to puncture the symptomatic and not the healthy side when adopting this technique is based on the concept that the effects of the O₂O₃ and corticosteroid/local anaesthetic mixture are not limited to the disc but affect the intraforaminal nerve root tract as well.

Under CT-guidance the distribution of the O₂O₃ in the disc, foramen and epidural spaces can be observed ([Figure 3](#)). Finally the needle is removed and the patient is required to lie in the bed (in a supine position) for 1 h before being dismissed to home. Heavy activity must be avoided for the following two weeks.

If the postero-lateral approach at L5-S1 level is unfeasible due to the high position of the iliac crests, a curved steerable needle can be adopted: these devices are able to deflect from a straight rigid direction and the tip can be bent in order to bypass a bone structure. If these devices are not available, a translaminar approach can be considered. In this case, CT-guidance is advised because it allows the visualization of the dural sac. The puncture site is 2 cm away from the diseased spinal process in the intervertebral space, the needle is advanced stepwise into the hernia through the space between the medial border of the articular process and the lateral border of the dural sac; the ideal position of the needle tip is inside the herniated portion of the disc. Before injecting slowly O₂O₃ (5–6 ml), an aspiration test is mandatory to make sure that the needle tip is not located in a blood vessel or in the subarachnoid space, containing cerebrospinal fluid.

Indications: clinical and radiological

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LBP syndrome represents a complex nosological entity and it is not a simple task to differentiate the source of the pain. So clinical evaluation and patient selection for O₂O₃ therapy can be extremely challenging. The main objective in patient evaluation is to identify the source of the pain by acquiring a complete history and performing a physical examination, supplemented with appropriate imaging studies. It must be ensured that a conservative approach has already been tried with pharmacological and physical therapy for at least 4–6 weeks.¹⁴ The best clinical indications for O₂O₃ are radicular pain rather than low back pain; the patient must refer pain in a well-discriminated and constant cutaneous dermatome with positive Lasègue test; the pain should score 5 or more on the visual analogue scale (VAS).

If a facet syndrome is supposed, a facet infiltration with steroid and local anaesthetic is suggested as diagnostic test before O₂O₃ treatment.

The clinical evaluation must be in accordance with imaging studies, which must demonstrate lumbar herniation/protrusion congruent with the clinical symptoms; significant structural deformity of spine, severe vertebral osteoarthritis, fractures or calcified hernia should not be present.^{1,14} Recently, some studies referred poor improvement of clinical symptoms if magnetic resonance (MR) diffusion weighted imaging (DWI) prior to the treatment shows a decreased Apparent Diffusion Coefficient index (ADC) of the disc;⁹ this index is related to the content of water of the tissues.

It is important to acknowledge that imaging by itself is not a sufficient indication to treatment, taking into account that disc bulging is present in 52% of the population and disc herniation is present in around 20–28% of asymptomatic subjects.

There should not be a neurological motor deficit, or cauda equina syndrome.² Suspected infectious/inflammatory or neoplastic bone lesions must be excluded.^{3,5,13} In these cases O₂O₃ is completely ineffective.

Absolute contra-indication to the procedure is referred allergy to proposed drugs.¹⁴ Relative contra-indications to the procedure are: bleeding disorder, pregnancy, G6PD deficiency, hyperthyroidism, severe anaemia, severe myasthenia, recent myocardial infarction and history of mental disease.

Although the treatment with O₂O₃ has many advantages, the patient's selection criteria are the key points to a successful clinical result.

Complications

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Ozone therapy for lumbar disc herniation is a procedure with very low or no adverse effects with concentrations of 10–40 µg/ml. Most of the studies report no complications, the overall complications rate being estimated at under 0.1%.^{1,12}

In the literature there have been reported: bilateral vitreo-retinal haemorrhages; thunderclap headache after O₂O₃ therapy related to pneumocephalus as a consequence of inadvertent intrathecal puncture; paraesthesias on the anterolateral portion of the left leg and foot, suggesting nerve injury; a few temporary episodes of impaired sensitivity; one case of vertebrobasilar stroke and a subcutaneous haematoma at the puncture site.¹

Regarding infections, a case of L5-S1 discitis⁸ and a case of fatal septicaemia have been described. As O₃ has disinfecting proprieties, it is not likely for the gas mixture to be infected;¹⁴ probably these complications were due to inadequate asepsis and iatrogenic inoculation of the bacteria during the injection.¹

Follow-up and results in the literature

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One month clinical follow-up should be made in the most objective and quantitative way, using tools to access patient pain and function before and after treatment (Roland–Morris Disability Questionnaire, VAS, Oswestry Disability Index (ODI) or the Modified MacNab criteria).

In the appropriate clinical/imaging context, intradiscal injection of O₂O₃ has a reported success rate that reaches 90% at short-term follow-up (six months)¹² and a 75–82% success rate at long-term follow-up (12 months) with no major or minor side effects.¹ Around 73% of the patients who went through O₂O₃ therapy are still better at five and 10 years.⁴ An average reduction in pain intensity in VAS from 7.58 before treatment to 2.64 two years after treatment has been reported, with similar results in ODI classification.¹

At six months MR follow-up, approximately 75–96% of patients had a significant herniation volume reduction, with the higher reduction observed in larger disks.^{9,10,15} It has been recently reported that the T2 shine-through effect increases already two months after O₂O₃ nucleolysis, which, in the future, may be used to predict shrinkage of lumbar disc herniation.^{15,16} Furthermore, the high negative predictive value of DWI-ADC analysis could be useful to select those patients who will require further treatment with ozone.⁷

Finally, starting a physical rehabilitation programme is strongly recommended.^{3,5,12,17}

Conclusions

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O₂O₃ therapy is a safe and cost-effective approach for patients with sciatica refractive to conservative therapy, having demonstrated good short- and long-term results, significantly shorter recovery time compared with the alternative treatments,¹⁰ and reduction of the need for surgery. Moreover, it must be considered also that patients without a good response to O₂O₃ therapy may still undergo surgical discectomy.^{4,12}

Declaration of conflicting interests

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The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

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The authors received no financial support for the research, authorship, and/or publication of this article.

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Figures and Tables

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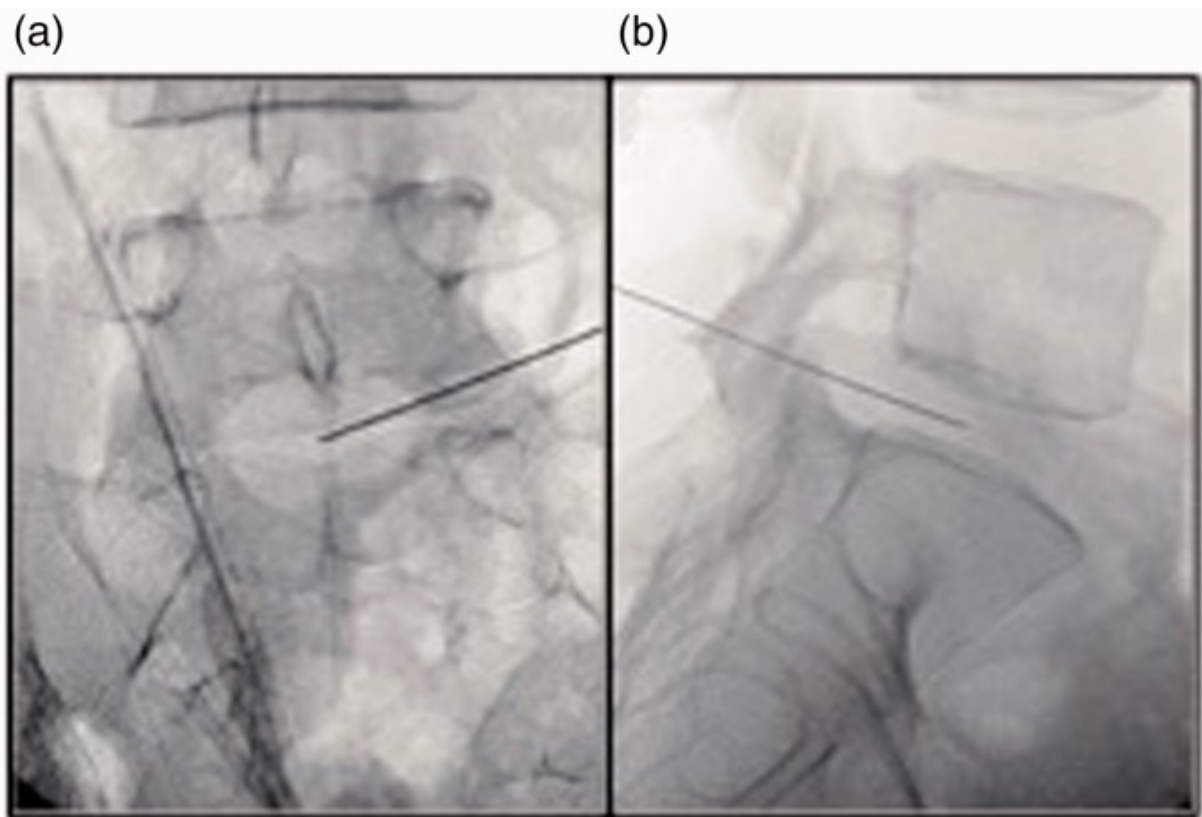
Figure 1.



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Computed tomography-guided positioning of a spinal needle into the nucleus pulposus (arrow).

Figure 2.



Anteroposterior (a) and lateral (b) views of lumbar intersomatic disc puncture under fluoroscopy guidance.

Figure 3.



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Ozone–oxygen mixture diffusion into the disc and the spinal canal.