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Percutaneous nucleoplasty for discoradicular conflict

A. Alexandre, L. Corò, A. Azuelos, and **M. Pellone**

EU.N.I. European Neurosurgical Institute, Treviso, Italy

Summary

Minimally invasive techniques for the treatment of degenerative pathology of the spine have come to be preferred by surgeons since the destructive effect on bony structures is eliminated and scar formation is dramatically reduced. A critical review of the pathogenetic mechanisms for low back pain and sciatalgia has recently yielded that mechanical compression is one but non essential component of the matter. The importance of chemical irritative processes is stressed. Coblation nucleoplasty is one of these minimally invasive techniques. It provokes ablation of the nucleus of the disk by a controlled thermal effect produced by radiofrequency. By this procedure one to two ml of tissue are colliquated in a few minutes. From February 2001 to May 2003 we treated 1390 patients for of lumbosciatalgic pain caused by disc pathology. The alteration consisted of disc bulging or contained disc herniation. Exclusion criteria as provided by the protocol of the multicentric study conceived by Conor O'Neill have been respected. This technique has been conceived in order to obtain progressive results in cases of contained disc herniation which has scanty natural tendency to shrinkage, as demonstrated by several studies on the natural history of evolution of this pathology. Contained disc herniation is a pathology most difficult to manage by conservative procedures, physiotherapy and drugs, but we all agree that open surgery should be avoided. By this minimally invasive procedure the patient will not be compelled to abandon physiotherapy and his normal daily activities for more than a few days.

Keywords: Percutaneous nucleoplasty; disc pathology; sciatic pain.

Introduction

Lumbar and sciatic pain concern 35% of the European people, and these problems are often due to degenerative intervertebral disc pathology.

For 50 years neurosurgeons have searched for a method to allow shrinkage of herniated or protruded discs, in order to resolve the problem of severe pain and dysfunction in an enormous amount of patients. Recently, in consideration of the pathogenetical mechanisms of the disease, surgeons have reduced the indication for traditional open surgery and have turned their choice to minimally invasive techniques with the aim of respecting anatomy and of solving the problem without producing epidural scars [1, 11, 13].

The review of the reliable data concerning the clinical and pathomorphological evolution of the problem [2, 15], together with the causative biological mechanisms, has lead to important considerations.

1. The evaluation of relevant surgical casuistic shows that the percentage of success of open surgery for lumbosacral disc herniation is roughly 93–98% upon short term evaluation, but 5 to 7 years later it significantly decreases (75–80%). The so-called failed back surgery syndrome (FBSS) is caused by fibrosis or by recurring hernia [15].
2. Data provided by studies on natural history of lumbar disc herniation and radiculopathy indicate that large and migrated herniations tend to decrease in volume to a greater extent than protrusions or small contained herniations which have less tendency to spontaneous regression [18]. Morphologic changes are usually observable after 6 months and correspond to a favourable clinical outcome but they tend to lag behind improvement of leg pain.
3. Studies on the efficacy of serotonin receptor blocker for symptomatic lumbar disc herniation [5] show that patients with uncontained disc herniation responded more favourably to the 5-HT(2A) blocker treatment than patients with contained disc herniation. A 5-HT(2A) blocker has the potential to block the cascade of acute nerve root inflammation and to alleviate symptoms in lumbar disc herniation [16].
4. Studies on pain originating from this pathology show that it may be the consequence of biochemical mechanisms of acid intoxication of the nerve, which may be somehow independent from the mechanical problem, but may depend either from autoimmune

reaction, producing a chronic inflammatory response which engenders an acid environment, or a situation of ischemia [17, 20]. These problems may be solved by biochemical treatment, reducing the need for surgical aggression [1, 2, 22]. On the other hand the development of an autoimmune response against a ''non-self'' material, leading to a chronic inflammatory reaction, is demonstrated [12].

From these considerations the evolution has derived towards the need for a specific treatment of contained herniations. A number of percutaneous non-invasive techniques have been conceived with the aim to provoke shrinkage of the discal tissue. The common principle of these techniques is that of acting directly on the discal structure, without access to the spinal canal [3, 13]. This drastically reduces epidural formation of scar tissue, which may risk to compress nervous tissues and adhere to the moving bones.

Nucleoplasty by coblation (a system developed by Arthro Care) tackles this problem, allowing removal of discal nucleus by radiofrequency with a controlled thermal effect [1, 2, 4, 19, 21, 23].

The process takes place at temperatures ranging from 40 to 70 degrees due to the effect of a layer of ''ionized plasma'', engendered around the extremity of the Spine Wand. The ''plasma'' has sufficient energy to break molecular bridges thereby disrupting molecules. Degradation products will spontaneously come out from the operative canal.

This radiofrequency ablation, which utilizes low temperatures over a short time (2 to 3 minutes) without damaging surrounding tissues allows reduction of the discal volume by about 10 to 20%.

Patients and methods

Patients

We have followed the Protocol for Nucleoplasty in lumbar pathology as proposed by Conor O'Neill [1, 19]. Inclusion criteria for patients were:

1. Age between 18 and 65, for patients convinced to search for a solution of the problem by this technique, and to work with physiotherapy and gymnastic.
2. Chronic lumbar pain with or without radicular pain, lasting more than three months and with failure of medical and physical conservative treatments
3. absence of neurological deficit
4. One level positive provocative discography and negative control level.

Exclusion criteria for this outcome analysis included disc herniation with sequestration, large contained herniation occupying one-third or more of the spinal canal, severe spinal stenosis due to extensive osteophytosis, presence of secondary pain issues, psychological disorders, gait disorders depending on different neurological or orthopaedic pathology.

Contraindications to the procedure were evidence of infection, severe coagulopathies or impossibility of interrupting anticoagulation treatment.

From February 2001 to May 2003 we treated 1390 patients, males 43.5% and females 56.5%. They presented with lumbalgia and/or lumbosciatalgia due to disc bulging or partially contained disc herniation (989 cases in L4-L5 and 234 in L3L4, 167 in L5-S1) as shown by TAC and/or NMR investigations.

These patients had been resistant to previous conservative treatments such as drugs, physiotherapy, and TENS.

There was no or only minor neurological deficit in all cases.

Surgery

Mild endovenous anaesthesia is applied to the patient in lateral decubitus. The approach is from postero-lateral as for discography, using a 17 Gauge needle. Under fluoroscopy we identify the involved disc, and the guiding needle is located at the annulus – nucleus junction.

Trough the needle the Spine Wand electrode is introduced, calibrating its length in order to move from one to the opposite margin of the annulus.

After the fluoroscopic control of the correct positioning of the electrode coblation is performed. Advancing the wand in ablation mode a channel is obtained up to the opposite anular margin. Retraction of the wand in coagulation mode will complete the individual channel preparation. Six channels are created thanks to the shape of the wand, turning around the clock positions.

The working protocol pinpoints the possible risks:

1. Damage to the root along with puncture.
2. Conduction of the electric stimulus to nervous structures when the Spine Wand is not perfectly located.

For these two reasons the procedure should be executed under mild sedation, in order to evidentiate the irritation of nerve roots.

3. Perforation of vessels.
4. Infections.

Postoperatively patients were allowed to perform walking and sitting as needed during their daily activities, but were instructed to limit bending, rotating, and lifting more than 5 kg for two weeks. A qualified instructor showed them physical exercises to be started thereafter.

Results

From serial follow-up at 15 days, 1 month, 6 months and 1 year, we have collected the following results:

Results	15 days	1 month	6 months	1 year
Excellent	50.8%	53.3%	51.5%	55.8%
Good	23%	26.6%	31.5%	24.9%
Scanty	13.9%	10%	8.5%	12.4%
None	12.3%	10%	8.5%	6.9%

Excellent Total resolution of the clinical picture, and full re-uptake of daily activities.

Good Fairly total resolution of pain, with rather good quality of life.

Scanty Insignificant pain resolution and inability to take up normal daily activities.

None No results both on pain and clinical field.

Evaluation of the results was based on the JOA Score Scale:

(Hirabayashi Method: (JOA final − JOA preop)/(15 − JOA preop) × 100 = % value of recuperation).

By this method a percentage superior to 70% is considered a very good result, and 50 to 70% a good result.

MRI and/or CT were performed 6 months after the procedure. These investigations have shown that bulging was eliminated in 34%, significantly reduced in 48% and unvaried in 18% of cases.

Comment and conclusions

Safety and efficacy of this technique was carefully analyzed by Chen *et al.* They concluded that a safe volumetric removal of the nucleus is achieved and that no disruption or necrosis of the surrounding vital structures occurs [8] no change in temperature is detected at 5 mm away from the tip of the wand [9], and after 2 channels are created within the disc intradiscal pressure decreases dramatically [10].

Sharp and Isaac [21] reported an overall success rate of 79%, with 67% success in the group of patients who had previous surgery, and 82% success in the group that had no prior surgical intervention at 12 months.

Evaluation of the results as far as the immediate postoperative period is concerned has shown that 5% of patients as long as about ten days complained about lateralized postural lumbar pain and hypertone – contraction of paravertebral muscles, probably due to irritation of the methameric Lushka nerve. We had no kind of complications related to the procedure, and patients never suffered from radiculopathy. This in spite of the fact that during the procedure at the moment of coblation rapid muscular contractions of muscles depending from the involved nerve root have occasionally been observed. This fact never occurred during the coagulation phase. The observed muscular contractions, in our opinion, are related to the diffusion of radiofrequencies along the nerve.

The most recent experimental studies by O'Neil [19] showed that coblation due to the physical and thermal effects on the pathological disc, entails biochemical effects. These findings have been evaluated and demonstrated. They consist, in the first postoperative period, of a decrease of interleukin 1, a substance which is known to have hyperalgesic effects, and in a subsequent (at 12 weeks) augmentation of interleukin 8, which may express the reparatory response of the disc.

These changes are in line with the clinical observation that amelioration will progressively occur, starting from the first weeks. The initial immediate recovery, followed by the rapid decrease in disc volume, is not the entire result.

This technique has good results in cases of contained disc herniations. This kind of herniation has a scanty natural tendency to shrink and loss of compressive effect on the nerve root, as demonstrated by several studies on the natural history of the evolution of disc herniation.

These cases are the most difficult to manage by conservative procedures, physiotherapy and drugs and we all agree that open surgery should be avoided.

It has become imperative to search for therapeutic techniques which are minimally disruptive to the anular structure, in view of the growing knowledge regarding the factors affecting anular healing and disc integrity. Mochida *et al.* [18] during their analysis of disc material removal have concluded that nucleotomy to reduce disc herniation should mimic asymptomatic disc degeneration and should therefore produce a gradual degenerative course, which is not achieved with removal of a large amount of disc material. A two-fold decrease in success rates for discectomies form 71 to 36% was seen in patients with a large amount of disc material removed averaging 3.8 grams including the central area of the nucleus, in contrast to removal of migrated material, averaging 1 g.

Percutaneous disc decompression, irrespective of the technique, is based on the principle that a small volume loss in a closed hydraulic space, like an intact disc, results in a disproportionately large drop of pressure.

Case *et al.* [7] have studied the matter and showed that a large rise in pressure will regularly result from a small increase in volume and vice versa. Chen *et al.* [10] have shown that after 2 coblation channels have been created within the disc, intradiscal pressure decreases dramatically.

Fagan and co-workers have recently described in detail discal innervation. They have identified areas where innervation is most concentrated. These include the perianular connective tissue and the central endplate. As they underline, this does not necessarily imply that these are the most important sources of pain, but some of the nerves identified may function as nociceptors [14]. Thus it is likely that coblation nucleoplasty has an effect on discogenic pain since it denervates in a concentrated manner the central endplate area.

Many of the nerves in the loose perianular connective tissue are ramii communicantes passing over the disc to connect the spinal nerves with the sympathetic chain. They do not directly supply the anulus, but they are potentially affected by mechanical or chemical noxious stimuli associated with disc degeneration, particularly if sensitized by prior release of inflammatory mediators [6, 14, 17]. Nucleoplasty will act on these nerves too, reducing discal pressure.

Although this outcome analysis may receive criticism since it is neither randomized to a placebo-controlled group nor double-blinded, the data is nevertheless compelling. We must remark that several reports indicate that the results of observational studies do not differ significantly from the results of randomized controlled trials [5, 12].

By this minimally invasive procedure the patient is not compelled to do without physiotherapy and abandon his normal daily activities for more than a few days.

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Correspondence: Alberto Alexandre M.D., EU.N.I. European Neurosurgical Institute, Via Ghirada 2, 31100 Treviso, Italy. e-mail: alexandre@eunionline.com