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Research Article

A Comparative Study of Ozone CT Discography and Dallas-CT Discography

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Abstract

Purpose: To conduct a comparative study between ozone CT Discography (CT/Discography-CTD) and Dallas-CTD grading and to grade intervertebral disc rupture according to CTD in order to determine the method of chemo nucleolysis.

Methods: (1) 320 patients diagnosed with lumbar intervertebral disc herniation were randomly divided into two groups: one group contained 118 cases of classic CTD (control group), and the other group contained 202 cases of ozone CTD group (experimental group). According to the Dallas-CTD classification, annulus fibrosus rupture was classified into 4 grades: (1) grade 0, no rupture; (2), grade 1, rupture of inner fibrous layer; (3) grade 2, rupture of outer fibrous layer; (4) grade 3, rupture extends beyond outer fibrous layer. The method of nucleolysis was selected according to the Dallas-CTD fibrous rupture classification. (1) Grade 1: ozone nucleolysis monotherapy; (2) Grade 2: application of ozone nucleolysis therapy combined with extradiscal collagenase injection; (3) Grade 3: nucleolysis by combined intradiscal and extradiscal collagenase injection. The McNab criteria were used for evaluation at follow-up after 3 years.

Results: The success rate of puncture under CT monitoring was 100%. (1) The four grades of the control group were: (1) 0% (0 cases) at grade 0; (2) 36.44% (43 cases) at grade 1; (3) 34.75% (41 cases) at grade 2; (4) 28.81% (34 cases) at grade 3. (2) The four grades of the experimental group were (divided into 4 grades according to the classic Dallas-CTD annulus fibrosus rupture patterns): (1) 0% (0 cases) at grade 0; (2) 35.64% (72 cases) at grade 1 (internal rupture type); (3) 33.66% (68 cases) at grade 2 (protrusion type); (4) 30.70% (62 cases) at grade 3 (tear type). There was no statistical difference between the grades of the two groups (using the chi-square test).

Conclusions: (1) Ozone CTD grading and classical Dallas-CTD fibrous rupture grading reflect similar morphological changes in the annulus fibrosus, which is beneficial for clinical determination of the classification of intervertebral disc herniation. (2) Using this classification to select the method of chemo nucleolysis for lumbar intervertebral disc herniation yielded satisfactory results in long-term clinical follow-up and avoided the pain response after intradiscal collagenase injection in the internal rupture and protrusion types of lumbar intervertebral disc herniation. Promoting and applying this technique in the clinic is of great significance.

Keywords: Chemo nucleolysis; Comparative study; Dallas-CTD grading; Ozone CTD grading

Introduction

In 1987, Sachs, et al. [1] first published the Dallas Discogram Description (DDD), which classified different degrees of intervertebral disc degeneration and annulus fibrosus rupture. At the same time, CT Discography (CTD) can clearly distinguish the imaging morphology of intervertebral disc degeneration and annulus fibrosus rupture, and is beneficial for showing the pathological morphology of the intervertebral disc rupture (protrusion or tear) [2,3]. CTD is an effective measure for selection of surgical treatment options and clinical identification and diagnosis. The aim of this study was to investigate the classification of DDD, compare the application of ozone CTD and

classic CTD, and compare these two CTD methods for observing the correlation between the morphological and pathological types of intervertebral disc rupture, and compare the results of pain-induced response with these two CTD methods.

In addition, investigating whether the classification of intervertebral disc rupture with ozone CTD can help guide the selection of interventional therapy is beneficial in intervertebral disc chemo nucleolysis intervention for lumbar intervertebral disc herniation and replacing classical CTD in interventional therapy, thereby advancing the search for simple, safe, and effective methods for discography in clinical intervention for lumbar intervertebral disc herniation.

Data and methods

Data and groups. 320 patients were clinically diagnosed with lumbar intervertebral disc herniation and were randomly divided into 2 groups by the random number table method. Group 1 was the classic CTD group (control group): 118 cases, of which 56 patients were male and 62 patients were female, and the average age was 48.66 years. Group 2 was the ozone CTD group (experimental group): 202 cases, of which 83 patients were male and 119 patients were female, and the average age was 52.26 years. There was no significant difference in age between the two groups.

Methods

Currently, the criteria for clinical diagnosis of lumbar intervertebral disc herniation are generally considered to meet the following conditions: (1) recurrent episodes of low back pain with duration > 6 months with or without history of trauma; (2) intermittent pain at the waist, often radiating to the lower limbs, numbness of the lower extremities in severe cases; (3) physical examination often reveals typical nerve root signs; (4) MRI shows typical intervertebral disc herniation. The 320 patients were selected based on these criteria and were hospitalized for CTD examination and intervertebral disc nucleolysis. The following conditions were classified as contraindications: (1) non-discogenic sciatica; (2) severe degenerative intervertebral disc disease with spinal stenosis or lateral recess stenosis; (3) intervertebral disc herniation accompanied by severe calcification; (4) large protrusions, dural sac compression of more than 50%; (5) sequestered disc herniation; (6) concomitant vertebral spondylolisthesis of 2 degrees or more; (7) severe neurological deficits; (8) concomitant serious organ disease or surgical risk.

CTD Procedure

The 320 patients were given local anesthesia and a posterior lateral approach was taken for intervertebral disc puncture. CT tomography showed that the needle tip was located at the center of the intervertebral disc or 1/3 of the middle-posterior junction. Operation procedure on the 2 CTD groups: control group, a low-pressure injection of 1-2 mL Omnipaque contrast agent was injected into the intervertebral disc suspected of having the lesion and the adjacent intervertebral disc, and then CT tomography was performed. When the contrast agent was injected, the resistance was very large when the volume was < 1 mL, no pain reaction was induced. If no sign of intervertebral disc tear was observed on CT, it was regarded as a non-responsible intervertebral disc. When the contrast agent was injected, the resistance was small when the volume was > 2 mL, and the pain response was induced. CT showed signs of inner layer tear of the annulus fibrosus of the intervertebral disc, rupture of the outer layer of the annulus fibrosus, and complete rupture of the annulus fibrosus, which was regarded as the responsible (lesioned) intervertebral disc. In the experimental group, after injecting 2-3 mL of ozone gas into the suspected intervertebral disc, CT scan was performed, and the pain response was observed during the injection. The pain response was induced, and CT showed signs of inner layer tear of the annulus fibrosus of the intervertebral disc, rupture of the outer layer of the annulus fibrosus, and complete rupture of the annulus fibrosus, which was regarded as the responsible (lesioned) intervertebral disc. Ozone injection was performed similarly in adjacent intervertebral discs, and the pain response was negative. These were control intervertebral discs and were regarded as non-responsible intervertebral discs.

Dallas-CTD grading of annulus fibrosus rupture: preoperative classic CTD and intraoperative ozone CTD annulus fibrosus rupture morphology was classified into 4 grades: (1) grade 0, no rupture; (2), grade 1, rupture of inner fibrous layer; (3) grade 2, rupture of outer fibrous layer; (4) grade 3, rupture extends beyond outer fibrous layer. Intraoperative ozone CTD annulus fibrosus rupture morphology was classified into 4 grades based on the Dallas-CTD annulus fibrosus rupture grade: (1) normal, no rupture of annulus fibrosus; (2) grade 1 (internal rupture type): rupture of inner layer of the annulus fibrosus, ozone did not escape the intervertebral disc Figure 1a; (3) grade 2 (protrusion type): rupture of the outer layer of the annulus fibrosus, ozone escaped to the posterior longitudinal ligament and intervertebral foramen Figure 1b; (4) grade 3 (tear type): the annulus fibrosus ruptures beyond the outer layer, the longitudinal ligament is completely torn, and ozone escaped into the epidural space (Figure 1c).

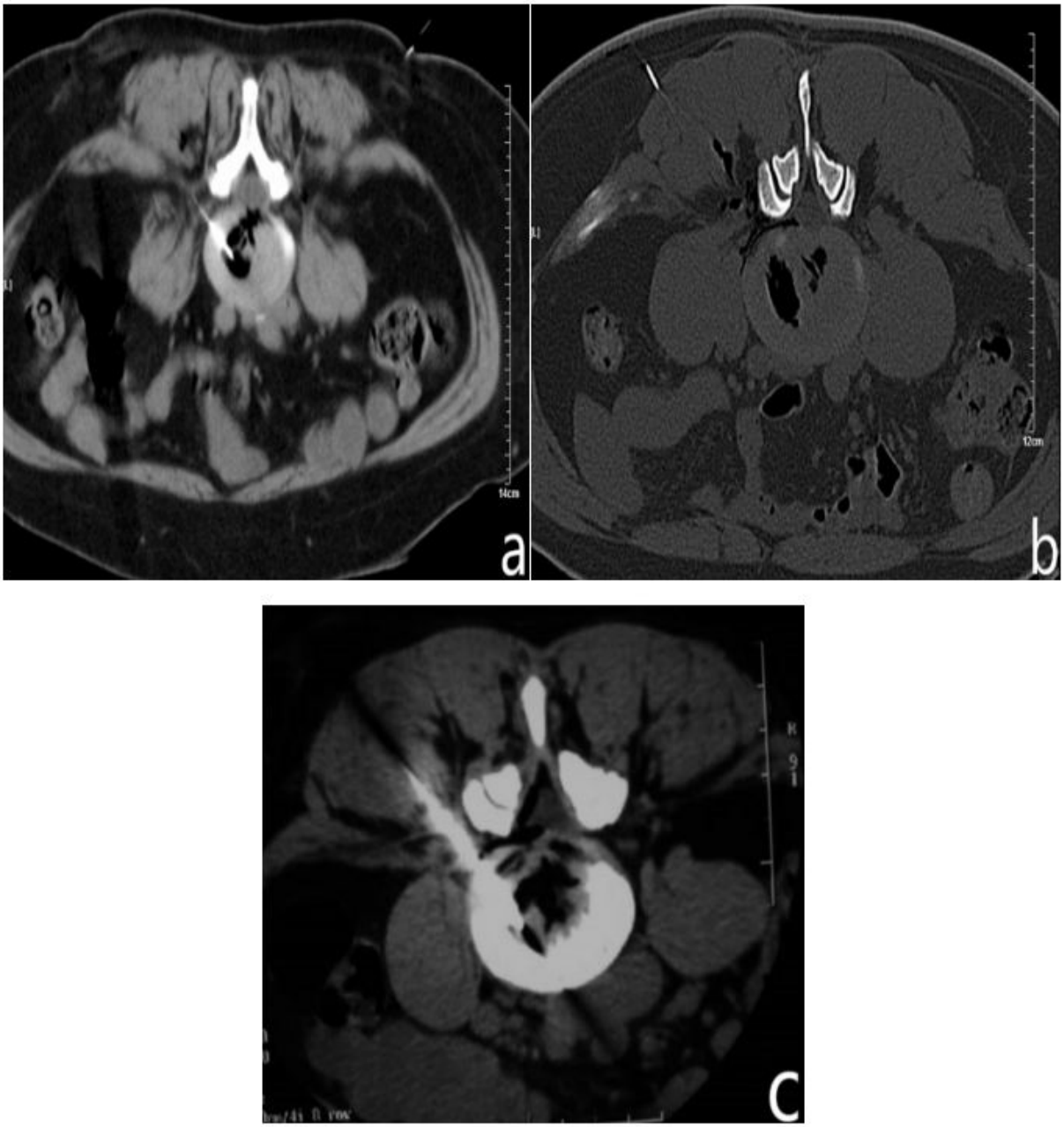

Figure 1: (a): grade 1 (internal rupture type). The needle tip was located at the center of the intervertebral disc or 1/3 of the middle-posterior junction. 2-3 mL of ozone gas was injected into the suspected intervertebral disc and CT showed signs of inner layer tear of the annulus fibrosus of the intervertebral disc. **(b):** (protrusion type). 2-3 mL of ozone gas was injected into the suspected intervertebral disc and CT showed that ozone escaped to the posterior longitudinal ligament and intervertebral foramen. **(c):** grade 3 (tear type). 2-3 mL of ozone gas was injected into the suspected intervertebral disc and CT showed that ozone escaped into the epidural space.

According to Dallas-CTD fibrous rupture classification, intraoperative ozone CTD fibrosis rupture classification was used to select the method of intervertebral disc chemo nucleolysis. (1) grade 1 was treated with ozone nucleolysis monotherapy Figure 1a; (2) grade 2 was treated with ozone nucleolysis therapy combined with extradiscal collagenase injection Figure 1b; (3) grade 3 was treated with nucleolysis by combined intradiscal and extradiscal collagenase injection. The McNab criteria were used for evaluation at follow-up after 3 years (Figure 1c).

Intervertebral disc nucleolysis operation methods: (1) internal rupture type: simple ozone chemo nucleolysis therapy, intradiscal injection of a total of 15-25 mL of 50 μg/ml ozone, then injection of 10 mL of 30 μg/mL ozone and 1 mL of betamethasone HCL; (2) protrusion type: application of ozone combined with collagenase chemo nucleolysis therapy, intradiscal injection of 15-25 mL of 50 μg/ml ozone and injection of 600 U/1 mL collagenase and 1 mL betamethasone HCL into the intervertebral foramen; (3) tear type: extradiscal and intradiscal injection of 300 U/0.5 mL collagenase in the intervertebral disc and 1 mL betamethasone HCL into the intervertebral foramen.

Postoperative follow-up and evaluation of efficacy: After 3 years of follow-up observation, the McNab criteria were used to evaluate efficacy.

Results

Comparing the two CTD groups showed a 100% success rate of puncture under CT monitoring

- The four grades of the control group were: (1) 0% (0 cases) at grade 0; (2) 36.44% (43 cases) at grade 1; (3) 34.75% (41 cases) at grade 2; (4) 28.81% (34 cases) at grade 3.
- The four grades of the experimental group were (divided into 4 grades according to the classic Dallas-CTD annulus fibrosus rupture patterns): (1) 0% (0 cases) at grade 0; (2) 35.64% (72 cases) at grade 1 (internal rupture type); (3) 33.66% (68 cases) at grade 2 (protrusion type); (4) 30.70% (62 cases) at grade 3 (tear type).

There was no statistical difference between the grades of the two groups (using the chi-square test) (Figure 1a).

Relationship between ozone CTD pain-induced response and Dallas CTD classification

In this group of patients, a total of 360 intervertebral discs were determined to have annulus fibrosus rupture by preoperative CTD morphology. 240 discs were confirmed by positive pain-induced reaction by ozone CTD. Of these:

- There were 87 intervertebral discs with inconsistent or partially consistent induced pain, 18 intervertebral discs of grade 1 (internal rupture type) accounting for 20.69%; 25 intervertebral discs of grade 2 (protrusion type) accounting for 28.74%; 44 intervertebral discs of grade 3 (tear type) accounting for 50.57%. The proportion of grades 2 and 3 was 79.31%.
- There was a total of 153 intervertebral discs with replicable pain consistency, 21 intervertebral discs of grade 1 (internal rupture type) accounting for 13.73%; 70 intervertebral discs of grade 2 (protrusion type) accounting for 45.75%; 62 intervertebral discs of grade 3 (tear type) accounting for 40.52%. The proportion of grades 2 and 3 was 86.27%. The intraoperative ozone CTD of adjacent intervertebral discs showed that the Dallas-CTD annulus fibrosus rupture grade was 0 and the pain-induced response was negative. Adjacent intervertebral discs were only used as diagnostic controls and were considered non-responsible discs, and were not treated with chemo nucleolysis.
- The 320 patients in this group were followed up for three years after chemo nucleolysis. The patients with different Dallas-CTD classification were 115 with grade 1, 109 with grade 2, and 96 with grade 3. The overall efficacy rate after treatment in each grade group was 107 for grade 1 (internal rupture type) (93.04%), 95 for grade 2 (protrusion type) (87.16%), and 76 for grade 3 (tear type) (79.17%). 4. Within 3 months after treatment, there were 3 cases of pain reaction in the internal rupture type, 3 cases in the protrusion type, and 2 cases in the tear type. There were no other adverse reactions.

Discussion

Intervertebral discography, also known as nucleography, is an imaging method in which contrast media is injected into the intervertebral disc in order to observe the morphology of the nucleus pulposus and any pathological characteristics of the intervertebral disc. Currently, CTD has been widely used to assess low back pain [3-6]. In standard intervertebral discography, a suspected disc and an adjacent disc must be injected in order for there to be an internal control for the intervertebral disc of the patient. Intervertebral discography can reflect the morphology of the intervertebral disc and can also reveal any pathological characteristics.

In recent years, Kim, et al. [7] reported that Dallas-CTD annulus fibrosus rupture is classified into four levels. Classification of annulus fibrosus rupture by CTD can reflect annulus fibrosus inner layer rupture, outer layer rupture, and rupture that extends beyond the outer layer, complete rupture of the posterior longitudinal ligament, and other various morphological changes. In addition to the significance of morphological [8] changes in the intervertebral disc, the most important aspect of discography is to observe the pain-induced response of the patient during injection, especially the positive pain-induced response that occurs during low-pressure injection, which is of great diagnostic value. Studies have shown that high-grade annulus fibrosus rupture is associated with positive discography. In this group of CTD patients with positive pain-induced response, the incidence of positive pain-induced response was 79.31% and 86.27% for Dallas-CTD grades of 2 and 3, respectively, regardless of inconsistent or partially consistent pain induction or replicability of pain consistency in the intervertebral disc; this is consistent with previous research results.

Peng, et al. [9] reported that the use of CT discography (CTD) can increase the diagnostic ability for annulus fibrosus rupture. Determining whether the annulus fibrosus is ruptured and the degree of rupture is of great significance for the treatment of lumbar intervertebral disc herniation. In this paper, the use of ozone CTD and classic CTD were compared. Both were very similar in morphology and correct determination of annulus fibrosus grading, and there was no statistically significant difference. Moreover, intraoperative application of ozone CTD does not require routine classical CTD to also be conducted, which reduces the inconvenience of intraoperative discography and possible allergic reactions against the contrast agent. Intraoperative ozone imaging and treatment are performed simultaneously based on the intraoperative ozone CTD annulus fibrosus rupture grade, which is greatly helpful for determining which chemo nucleolysis method should be used, and clinical efficacy is significantly improved compared with the traditional method.

Current methods of lumbar chemo nucleolysis in China primarily include two methods: collagenase and chemo nucleolysis. There is still no clear explanation or research on the indications for correct selection between the two methods. In this paper, Dallas-CTD annulus fibrosus rupture grading was used to classify the lesioned intervertebral disc into three types using the CTD classification (grades 1, 2, and 3): internal rupture, protrusion, and tear, and the method of lumbar chemo nucleolysis was determined through this classification. In addition, satisfactory results on long-term follow-up were achieved in all three groups. This preliminary investigation laid the foundation for further studies on the indications for correct selection between the two methods of chemo nucleolysis. Animal studies have shown that injection of collagenase into normal intervertebral discs can seriously damage the endplate, which may be the main cause of low back pain complications caused by intradiscal collagenase injection. Wang et al. showed good efficacy and few low back pain complications with intradiscal collagenase injection in patients with leakage of contrast agent beyond the posterior margin of the intervertebral disc as shown by discography. This is consistent with good efficacy in the patients in this group with the tear type who underwent intradiscal collagenase injection and no obvious pain response after surgery. Therefore, in this group of patients, only patients with tear type lumbar intervertebral disc herniation confirmed by ozone CTD underwent intradiscal collagenase injection, whereas the internal rupture and protrusion groups were treated with ozone injection only. The results showed that the incidence of postoperative low back pain was very low in the three groups, especially in the internal rupture type patients who were treated with ozone chemo nucleolysis and obtained satisfactory results. This result suggests that internal rupture and protrusion type lumbar intervertebral disc herniation should be treated with intradiscal injection in order to avoid the pain response following intradiscal collagenase injection. Shang et al. showed that for tear type lumbar intervertebral disc herniation, collagenase solution can flow toward the nucleus pulposus after intradiscal injection to outside the intervertebral disc, even though the site of annulus fibrosus rupture of the annulus to the intervertebral disc, thereby producing a dissolving effect on the nucleus pulposus tissue at the site of protrusion, reducing nerve root compression, and minimizing damage to the cartilaginous endplate [8]. This result was also confirmed by our observations.

In summary, discography is an important imaging and pain assessment tool for the determination of chronic low back pain secondary to intervertebral disc disease in patients. Ozone CTD can show pathological changes such as annulus fibrosus rupture and has important reference value for determining the pathological classification of intervertebral disc herniation. Through this type of classification, the correct method of chemo nucleolysis can be selected. The long-term clinical follow-up has satisfactory therapeutic effect, and the postoperative pain response is reduced. The clinical application is of great significance. Long-term clinical follow-up outcomes were satisfactory and postoperative pain response was reduced. Promoting and applying this technique in the clinic is of great significance.

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