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ORIGINAL ARTICLE

Comparison of alcohol ablation with repeated thermal radiofrequency ablation in medial branch neurotomy for the treatment of recurrent thoracolumbar facet joint pain

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Abstract
Purpose Chemical denervation is not recommended as part of the routine care of chronic non-cancer pain. Physicians face a dilemma when it comes to repeated interventions in cases of recurrent thoracolumbar facet joint pain after successful thermal radiofrequency ablation (RFA) in medial branch neurotomy. This study was performed to compare the effects of alcohol ablation (AA) with thermal RFA in patients with recurrent thoracolumbar facet joint pain after thermal RFA treatment.
Methods Forty patients with recurrent thoracolumbar facet joint pain after successful thermal RFA defined as a numeric rating scale (NRS) score of $\geq$7 or a revised Oswestry disability index (ODI) of $\geq$22 % were randomly allocated to two groups receiving either the same repeated RFA ($n = 20$) or AA ($n = 20$). The recurrence rate was assessed with NRS and ODI during the next 24 months, and adverse events in each group were recorded.
Results During the 24-month follow-up after RFA and AA, one and 17 patients, respectively, were without recurring thoracolumbar facet joint pain. The median effective periods in the RFA and AA groups were 10.7 (range 5.4–24) and 24 (range 16.8–24) months, respectively ($p < 0.000$). No significant complications were observed with the exception of injection site pain, which occurred in both groups.
Conclusion In our patient cohort, alcohol ablation in medial branch neurotomy provided a longer period of pain relief and better quality of life than repeated radiofrequency medial branch neurotomy in the treatment of recurrent thoracolumbar facet joint pain syndrome after successful thermal RFA without significant complications during the 24-month follow-up.

Keywords Ablation technique · Ethyl alcohol · Facet joint · Radiofrequency catheter ablation · Recurrence

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Introduction

Radiofrequency ablation (RFA) in facet joint pain syndrome is currently preferred over other modalities due to its precision, reproducibility, and effectiveness. This technique also has the advantage that it can stimulate nerves before initiation of the ablation process, thereby avoiding ablation of the wrong nerve elements; this provides a considerable safety margin [1]. However, in one study, repeated RFA (up to sevenfold or more) for the treatment of lumbar facet pain provided pain relief lasting for a mean of 10.5 months [2]. Thus, the dilemma faced by clinicians is how many times and how often should their patients receive repeated interventions during their remaining years of life.

Chemical neurolysis, an alternative treatment for facet joint pain syndrome, is generally accepted only for the relief of terminal cancer patients experiencing chronic intractable pain whose life expectancy is less than 1 year. Potential complications arising from chemical neurolysis of the peripheral nerves include necrosis of the skin and other non-target tissue, neuritis, anesthesia dolorosa, and prolonged motor paralysis [3]. The risks of chemical

neurolysis are considered to outweigh its benefits. Therefore, the American Society of Anesthesiologists' Task Force on Chronic Pain Management and American Society of Regional Anesthesia and Pain Medicine recommended in 2010 that chemical denervation should not be used in the routine care of non-cancer patients with chronic pain [4].

Clinicians constantly seek long-term solutions rather than short-lived interventions for the treatment of patients with recurrent thoracolumbar facet joint pain after thermal RFA of the medial branch of the posterior ramus. The recurrence of the facet joint pain after successful RFA treatment of the medial branch of the posterior ramus generally initiates a search for alternative ablation methods that provide longer lasting pain relief. Chemical ablation using alcohol may be a solution for short-lasting RFA if safety is secured. The aim of our study was to compare the effects of thermal RFA with alcohol ablation (AA) in patients with recurrent thoracolumbar facet joint pain after initial successful thermal RFA of the medial branch of the posterior ramus.

Materials and methods

A prospective, randomized, controlled single center clinical study was performed from January 2006 to December 2007 to compare the effects of AA and repeated thermal RFA in patients with recurrent thoracolumbar facet joint pain after successful thermal RFA of the medial branch of the posterior ramus. The protocol was approved by the Policy of the Ethical Committee at Pusan National University Hospital Institutional Review Board. After being provided sufficient information, all trial participants provided written informed consent documents listing the diagnosis (recurrent facet joint pain), the nature and purpose of a proposed treatment (AA and thermal RFA), alternatives (repeated thermal RFA), the risks and benefits of the alternative treatment (neuritis and prolonged pain relief), and the risks and benefits of not receiving treatment (no intervention).

The first step undertaken in our study was to assess the recurrence of thoracolumbar facet joint pain using the numeric rating scale (NRS) or the revised Oswestry disability index (ODI). Pain intensity was measured using the 11-point NRS, where 0 indicates no pain at all and 10 is the worst pain imaginable. The revised ODI, expressed as the disability percentile with respect to activities of daily living, is standardly used as a disease-specific measure of disability among patients with low back pain [5]. In our study, patients were considered to have recurrent thoracolumbar facet joint pain after successful thermal RFA when the NCR score was $\geq$7 and the revised ODI was $\geq$22 %.

Forty patients with recurrent thoracolumbar facet joint syndrome were diagnosed by controlled comparative local anesthetic blocks using lidocaine and bupivacaine after initial successful RF medial branch neurotomy. Initial successful RFA was defined as (1) $\geq$50 % relief of the targeted pain lasting for more than 6 months after RFA and (2) sufficient patient satisfaction with the result of the prior RFA to have it performed again when the benefits dissipated. The patients were randomly divided into the AA group ($n = 20$) and the repeated thermal RFA group ($n = 20$) (Fig. 1).

In both groups, the medial branch of the posterior ramus was ablated in the same manner. First, the skin at the treatment site was sterilized. Then, to reduce injection pain, 30 mg of ketorolac was injected intravenously before the ablative procedures were performed. At least two medial branches of each joint were ablated. If the T3–T4 facet joint was suspected to be involved, medial branch ablations were carried out at T2 and T3 levels [6]. After skin infiltration with 1 % of lidocaine, a RFDE-10, 22-gauge, 10-cm disposable

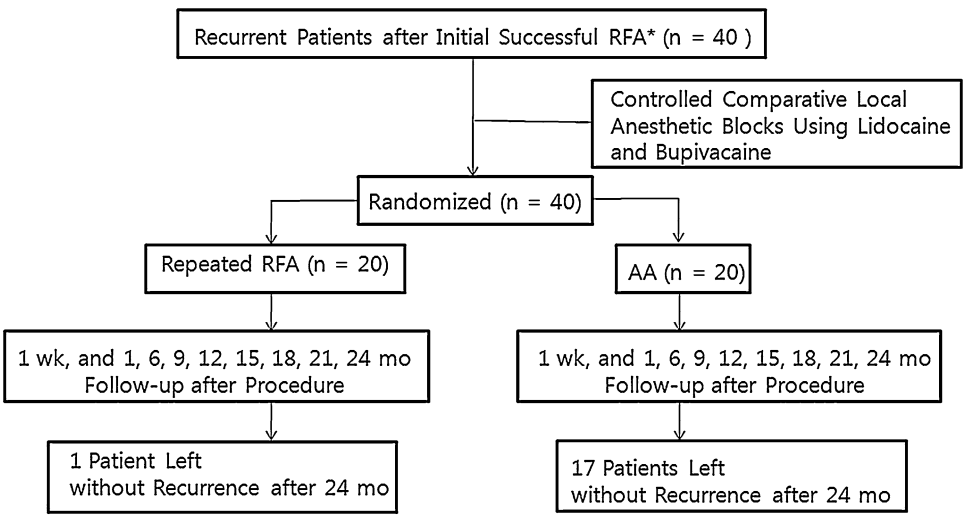

Fig. 1 Patient flow chart. *Asterisk* Initial successful radiofrequency ablation (*RFA*) was defined as (1) $\geq$50 % relief of the targeted pain lasting for more than 6 months after RFA and (2) sufficient patient satisfaction with the result of the prior RFA to have it performed again when the benefits dissipated

electrode with a 10-mm exposed tip (NeuroTherm, Wilmington, MA) was placed parallel to the targeted nerves along the expected course of the nerve at the base of the transverse process. In cases involving the lumbar vertebrae, the electrode was not allowed to contact the base of the superior articular process or the mamillo-accessory ligament. This was ensured by visualization of the bony anatomy using fluoroscopy [7]. A NT1100 or NT500 RF Generator (NeuroTherm) was used for sensory and motor stimulation.

In the RFA group, 0.2 ml of iopamidol (Pamiray® 300; Dongkook Pharm, Seoul, Korea) was injected to verify proper placement of the nonvascular needle tip. Impedance was verified at 300–700 Ω to confirm proper electrode placement and the integrity of the RF system. The RF electrode was positioned such that sensory stimulation (50 Hz) reproduced the patients' pain at less than 0.5 V. Motor stimulation up to 1 V was applied to observe contractions of the leg, which indicate incorrect placement of the electrode at a position deemed to be too close to the ventral ramus. Lesioning was performed at 90 °C for 90 s after the injection of 0.5 ml of 1 % lidocaine to generate a single thermal RFA at each level.

In the AA group, impedance verification and sensory/motor stimulation were performed in the same manner as in the RFA group. Needle placement was ensured from the anteroposterior viewpoint before the injection of contrast medium was monitored from the lateral viewpoint. When the needle was appropriately placed between the posterior epidural surface and facet joint, as seen from the lateral viewpoint, we injected contrast medium with a 1-ml syringe. The injected volume of contrast medium was carefully measured and recorded with the objective of preventing leakage into the posterior epidural surface; the volume of the dehydrated alcohol (Daihan Pharm, Ansan, Korea) injection should be no more than the volume of contrast medium injected. Next, the same volume of 1 % lidocaine was injected as used for the alcohol injection. Finally, after a sufficient analgesic effect was reached with lidocaine, the determined alcohol volume was slowly injected over 15 s to avoid unwanted spread (Fig. 2).

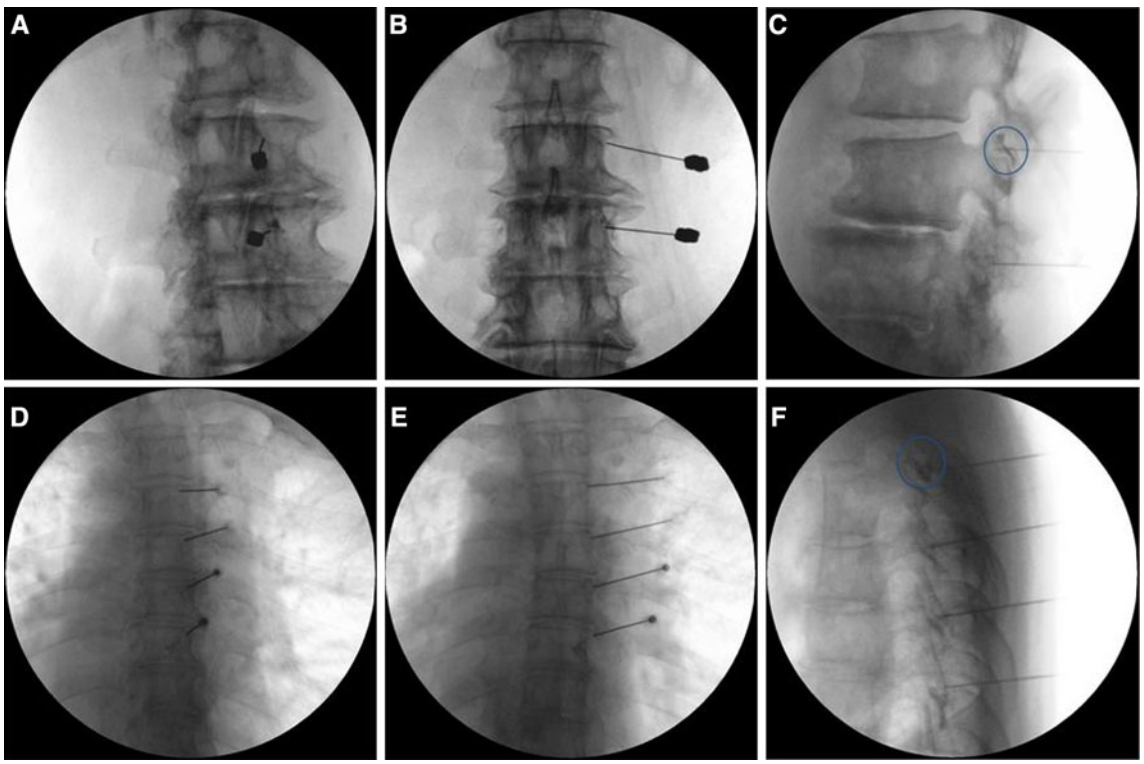

Fig. 2 Alcohol medial branch neurotomy for recurrent lumbar (**a**–**c**) and thoracic (**d**–**f**) facet joint pain. **a** Oblique viewpoint: two needles must be placed at the meeting point (point of intersection) of the right superior articular process and transverse process of the L2 and L3 vertebrae. The contrast medium from the lower needle at L3 has infiltrated the upper outer quadrant of the pedicle. **b** Anteroposterior (AP) viewpoint: needle placement is confirmed in the AP viewpoint before monitoring the injection of contrast medium from the lateral viewpoint. **c** Lateral viewpoint: when the needle is appropriately placed between the posterior epidural surface and the facet joint, contrast medium is injected at the L2 vertebra with a 1-ml syringe (*circle*). The injected volume of contrast medium is carefully measured to avoid leakage into the posterior epidural surface. The next step is to perform sensory and motor stimulation at 50 and 2 Hz, respectively. Finally, after a sufficient analgesic effect is reached with lidocaine, the determined alcohol volume is slowly injected over 15 s to avoid unwanted spread. **d**–**f** The same procedure was performed at the thoracic facet joints

The initial duration of pain relief on the basis of a NRS of <7 and a revised ODI of <22 % was recorded as the interval between the initial RFA procedure and the repeated RFA procedure or AA procedure. Factors that may affect the duration of pain relief and quality of life, such as the location of the first RFA site (unilateral/bilateral), previous level of procedure (thoracic, lumbar, or thoracolumbar), previous fusion surgery, previous vertebroplasty or kyphoplasty due to osteoporotic compression fracture, and severe kyphoscoliosis, were evaluated for both groups. The number of patients without recurring thoracolumbar facet joint pain after RFA or AA was assessed using the NRS and revised ODI before the intervention and at 1 week and 1, 6, 9, 12, 15, 18, 21, and 24 months thereafter. Adverse effects in both groups were assessed.

Statistical analysis was performed using the SPSS ver. 12.0 for Windows software package (SPSS, Chicago, IL). All values were calculated as the mean ± standard deviation (SD), except for NRS and the revised ODI which were expressed as the median and range. Demographic and baseline characteristics, including age and the initial duration of pain relief, were analyzed using the Wilcoxon rank sum test for both groups. The data with respect to the patient's sex, first RFA site, previous level of RFA, previous fusion surgery, previous vertebroplasty or kyphoplasty, and severe kyphoscoliosis were analyzed using the chi-square test for the inter-group comparison. The numbers of patients without recurrence in both groups were compared using the Kaplan–Meier product limit estimates, and the two curves were compared using the log rank test at each follow-up period.

There was no need to compare NRS scores and ODI scores in both groups because the patients without recurrence were defined as those with a NRS score of <7 and an ODI of <22 % in this study.

Results

There were no differences between the baseline characteristics of the two groups in terms of age, sex, and initial duration of pain relief. There was no significant difference between the two groups with respect to factors such as the location of the first RFA site (unilateral/bilateral), previous level of procedure (thoracic, lumbar, or thoracolumbar), previous fusion surgery, previous vertebroplasty or kyphoplasty due to osteoporotic compression fracture, and severe kyphoscoliosis (Table 1).

There was a significant difference in the recurrence ratios between the groups during the 24 months following the procedures (19 in the repeated thermal RFA and 3 in the AA group), and the median effective period in the AA group was significantly longer than that in the repeated thermal RFA group [24 (range 16.8–24) vs. 10.7 (range 5.4–24) months, respectively] based on the Kaplan–Meier product limit estimates ($p < 0.001$). The treatment method, AA compared to RFA, provided longer pain relief using the log rank test with 24 months censored ($p < 0.001$) (Fig. 3).

No significant complications were identified except for pain in the deep soft tissue of the injection site in five and seven patients in the repeated RFA and AA groups. The deep pain from RFA was expressed as an aching and shooting pain for up to 6 h; however, the deep pain from AA was described as a burning pain and dysesthesia for up to 12 h. However, the pain subsided within 24 h in both groups.

Table 1 Demographic and baseline characteristics of the study population

Groups	Repeated radiofrequency ablation (n = 20)	Alcohol ablation (n = 20)
Age (years) (mean ± SD)	67.8 ± 18.2	68.7 ± 15.5
Sex (male/female) (n)	9/11	8/12
Initial duration of pain relief (months)	10.4 (range 6.3–13.3)	10.7 (range 6.3–12.7)
First radiofrequency ablation site (unilateral/bilateral) (n)	3/17	4/16
Previous level of radiofrequency ablation (T/L/TL) (n)	3/8/9	3/7/10
Previous fusion surgery (n)	5	6
Previous vertebroplasty or kyphoplasty due to osteoporotic compression fracture (n)	4	4
Severe kyphoscoliosis (n)	2	3

T Thoracic vertebrae, *L* lumbar vertebrae, *TL* thoracolumbar vertebrae, *SD* standard deviation

Discussion

In our patient cohort alcohol ablation provided longer pain relief and a better quality of life than repeated medial branch neurotomy with RFA in recurrent thoracolumbar facet joint pain syndrome after successful thermal RFA without significant complications during the 24-month follow-up study. The median effective periods in the RFA and AA groups were 10.7 (range 5.4–24) and 24 (range 16.8–24) months, respectively.

A number of mechanisms are presumed to account for the longer effects of AA without recurrence and for its higher success rate compared to that of RFA. First, the action of AA on the medial branch of the posterior ramus is thought to be relatively extensive compared to that of RFA. Due to the normal anatomic, degenerative, or postoperative

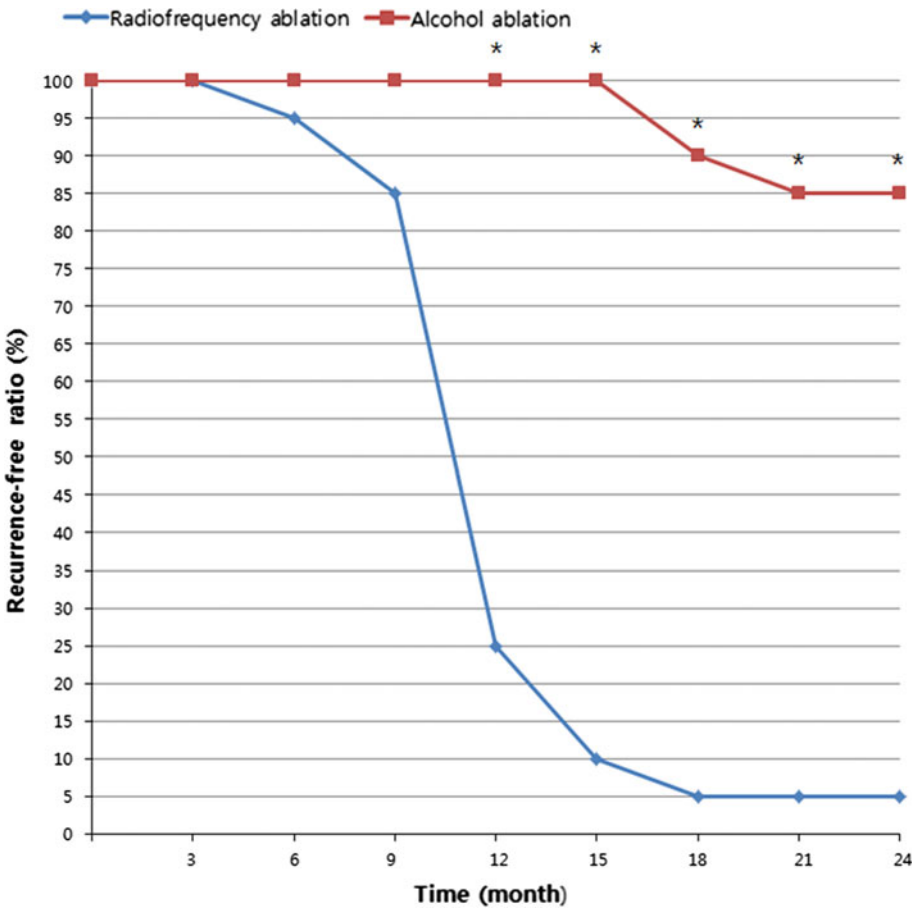

Fig. 3 Kaplan–Meier plot of recurrent-free ratio during a 24-months period by treatment method. The Kaplan–Meier plot, as the product limit estimator, showed that the treatment effect of alcohol ablation (AA) compared to that of the radiofrequency ablation (RFA) censored 24-month data was sustained longer according to the log rank test. The median effective periods in RFA and AA groups were 10.7 (range 5.4–24) and 24 (range 16.8–24) months, respectively ($p < 0.001$). Variations such as the location of the first RFA site (unilateral/bilateral), previous level of procedure (thoracic, lumbar, or thoracolumbar), previous fusion surgery, previous vertebroplasty or kyphoplasty due to osteoporotic compression fracture, and severe kyphoscoliosis did not affect the duration of pain relief using the Cox proportional hazards test. *$p < 0.001$

variations in nerve passages, extensive ablation is required for reliable effects. In addition, electrodes must be placed parallel to the nerve, which requires an insertion in the ventro-cephalad direction at an angle of approximately 45° to the transverse plane of the vertebra that is crossed by the nerve. In addition, electrodes need to be angled at about 15° medially to avoid the mamillo-accessory ligament, especially when this ligament is ossified [3]. Second, alcohol may produce a more potent, nonselective destruction of nervous tissue by inducing denaturation of cell membrane proteins and extracting lipid compounds. This process can cause demyelination and Wallerian degeneration [8]. However, thermal RFA causes only endoneural edema, as indicated by an increase in the interstitial space between nerve fibers [9].

In a trial reported by Silvers [10], chemical ablation for the treatment of lumbar facet joint pain was performed using 0.5 ml of 0.4 % phenol, and 69 % of the patients reported more than 50 % pain relief over a median period of 6.2 years (range 1–10 years). A similar result was obtained during the 2-year follow-up of our study. The differences between the study of Silvers [10] and our study include the use of a different chemical ablation and the inclusion criterion of only patients who already had had RFA treatment. After Shealy [11] introduced the use of radiofrequency for denervation of the lumbar facet joints, fluoroscopic RFA of the medial branch of posterior ramus has been commonly used as an effective treatment for facet joint pain. It offers the advantage of precision, effectiveness, and reproducibility, and it is largely a safe procedure. The ability to stimulate nerves before ablation prevents ablation of the wrong nerve elements [1]. The result of repeated RFA in this study is similar to the results of other studies for lumbar facet joint pain [2, 12]. There is no evidence that the duration of pain relief was prolonged after repeated RFA in these two studies. Schofferman et al. [2] carried out repeated RFA in a number of patients for up to seven times or more. Hence, a dilemma arises with respect to repeated intervention in the case of recurrent thoracolumbar facet joint pain because it is difficult to determine the number of repetitions and the length of time for which the intervention should be continued.

To obtain successful results from RFA or AA on the medial branch of the posterior ramus, controlled comparative local anesthetic blocks using two different anesthetics were given to initially rule out a false-positive diagnosis. To ensure safety and to reduce complications from the AA procedure, we performed the impedance verification and

sensory and motor stimulation in the same manner in both the AA and RFA group. Subsequently, the volume of alcohol injected was determined to be no more than the volume of contrast medium, which is carefully measured and injected to prevent leakage into the posterior epidural surface or posterior non-targeted tissues, as observed by fluoroscopy from the lateral viewpoint. Local anesthetic was injected prior to alcohol injection to minimize the irritant effect of the alcohol. In comparison, in the RFA procedure, a proper electrode with an active tip must be prepared for a sufficient lesion size, and it must be placed parallel to the targeted nerves at the base of the transverse process, always avoiding contact with the base of the superior articular process and the mamillo-accessory ligament [6].

The recurrence of facet joint pain after nerve ablation depends on peripheral nerve regeneration, which is related to the extent of the injury. The regeneration of a peripheral nerve injury depends on the extent of tissue damage, including damage to the myelin, axon, endoneurium, perineurium, and epineurium, in that order. When axonal continuity with the surrounding myelin is lost, the endoneurium is still preserved or partially injured; consequently, complete recovery is possible due to the presence of the remaining uninjured mesenchymal latticework that provides a path for the subsequent sprouting of axons to reinnervate their target organ [12]. AA may provide less recurrence of facet joint pain than RFA not only due to myelin and axon damage but also due to irreversible endoneurial or perineurial damage.

The complications associated with nerve ablation are largely related to neural plasticity. Functional deficits caused by nerve injuries can be compensated for by reinnervation of denervated targets through the regeneration of injured axons or by the collateral branching of undamaged axons, and subsequent remodeling of nervous system circuitry related to the lost functions [13].

There are a number of limitations to this study. First, The follow-up period was only 2 years. Future studies should be conducted over a longer period of time. A comparative chemical neurolysis study using alcohol and phenol is also needed. Second, factors such as advanced age, previous fusion surgery, vertebroplasty or kyphoplasty due to comorbid osteoporosis, and severe kyphoscoliosis may affect the success rate of ablation. Fortunately, these factors were evenly distributed in both groups in our study and presumably had little effect on this result. However, patients with these factors should be isolated and studied in more detail in larger groups to investigate the contribution of destroyed or deformed anatomy in the treatment of facet joint pain. A third limitation is that the age range was highly variable, and no specific age group was selected.

In conclusion, in our study cohort, alcohol medial branch neurotomy provided a longer relief of recurrent thoracolumbar facet joint pain and a better quality of life compared with repeated radiofrequency medial branch neurotomy, without significant complications during the 24-month follow-up. In the case of recurrence after RFA of the medial branch of posterior ramus, a careful injection of alcohol at a volume that is less than that of the injected contrast medium may be an alternative treatment to repeated RFA.

Conflict of interest None.

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