CERVICAL INTERVERTEBRAL DISC DENERVATION DURING ROTATOR CUFF TENDON PLASTY

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Objective. To analyze the effect of denervation of intervertebral discs in the cervical spine on the results of surgical treatment of patients with injuries to rotator cuff tendons of the shoulder joint.

Material and Methods. Study design: descriptive hypothesis-generating study. The study included patients requiring surgical treatment of rotator cuff tear. Two groups were identified: Group A included 28 patients who underwent plastic repair of rotator cuff tear with additional denervation of intervertebral discs, and Group B — 30 patients who underwent only plastic surgery for rotator cuff tear. The intensity of pain according to the VAS, functional activity due to neck pain (NDI), functionality of the shoulder joint (UCLA), and the degree of intervertebral disc degeneration according to MRI were assessed, and the effectiveness of treatment was determined. Statistical calculations were performed using the RStudio program.

Results. In the group of patients with denervation of intervertebral discs, a more pronounced decrease in the intensity of pain syndrome at 3, 6, and 12 months ($p < 0.001$; $p < 0.001$; and $p = 0.002$), a more proportion of effectively treated patients at 3 months ($p = 0.003$), and significant increase in functional activity according to NDI at 3, 6 and 12 months of follow-up period ($p < 0.001$; $p = 0.010$; and $p = 0.045$) were observed.

Conclusions. There is an underestimation of the role of degenerative cervical spine pathology in the occurrence of shoulder joint pain. In the case of rotation cuff plasty the additional denervation reduces the intensity of pain syndrome in the shoulder joint in the postoperative period.

Key Words: denervation of intervertebral discs in the cervical spine, rotator cuff tear, intensity of pain syndrome, degeneration of the intervertebral disc.

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The main complaints of patients with injuries to rotator cuff are restricted motion and pain. Up to 67 % of patients note shoulder joint pain [1]. Shoulder joint function is restored by surgery, which is supposed to reduce pain. However, pain often remains after surgery [2]. About 45 % of adult patients experience severe pain in the postoperative period [3, 4].

The exact cause of shoulder pain often remains undetermined, which is partially due to a vast number of potentially involved structures [5]. Shoulder joint pain is caused by cervical spine pathology in 24 % of patients [6]. Shoulder joint pain can be of a referred nature, as evidenced by selective pain-provoking denervation of the cervical facet joints [7] and intervertebral discs [8]. Referred pain resulting from degenerative damage to the intervertebral disc is located in the tissues sharing autonomic innervation and being within the same sclerotome as the affected disc [8, 9]. The area of perceived pain reflects not the structure that serves as the pain source but the neurological segments innervating the source [10]. Referred pain clinically manifests itself as upper limb pain often experienced in the neck; it may be accompanied by motor, sensory, or reflex deficits and is most common in people over 50 years of age [11]. Referred pain is confirmed by provocative tests; however, there is still a high risk of a false positive result, which reaches up to 27–63 % [12].

Degenerative diseases of the cervical spine are often asymptomatic; however, they are associated with discogenic pain syndrome in 10–15 % of adult population [13, 14]. There is also a risk of comorbidity: one of ten patients with degenerative cervical spine disease has a comorbid pathology of the shoulder joint [15]. According to MRI data, asymptomatic partial- and full-thickness rotator cuff tears are found in 4 % of patients under 40 years of age and in more than 50 % of individuals over 60 years of age [16].

The combination of clinical symptoms (pain and restricted neck and shoulder joint movements), as well as the presence of a pathology in the cervical spine and shoulder joint evidenced by MRI, are often a difficult diagnostic task. Pain is a determining factor for the patient's discharge from the hospital and the start of rehabilitation treatment. It has a number of harmful effects that affect the patient's physical and emotional status as well as his satisfaction with the treatment [17]. We hypothesized that, in addition to a structural damage to the shoulder joint, degenerative changes in the cervical spine may provoke and maintain joint pain. This aspect prevents verification of a clinical diagnosis and limits the possibility of assessing surgery effectiveness, while the severity of shoulder joint pain in the postoperative period does not allow early rehabilitation.

The study was conducted according to the requirements of the Declaration of Helsinki (2008 version), with permission of the local ethics committee of Novosibirsk Research Institute of Traumatology and Orthopedics n.a. Ya.L. Tsivyan, and in accordance with the requirements of the Russian Federal Standard (Good Clinical Practice, 2005).

The aim of the study is to analyze the effect of denervation of cervical intervertebral discs on the results of surgical treatment of patients with injuries to rotator cuff tendons.

Material and Methods

The study is a descriptive prospective study of the results of surgical treatment of patients with rotator cuff injury.

The study included patients treated at the Department of Traumatology and Orthopedic No. 4 and Neurosurgery Department No. 2 of Novosibirsk Research Institute of Traumatology and Orthopedics n.a. Ya.L. Tsivyan in 2016–2017.

The inclusion criteria were the following:

– age is within the range of 18–65 years;

– full-thickness damage to the rotator cuff tendons (MRI-confirmed supraspinatus, infraspinatus, and subscapularis tendon tears);

– UCLA score is ⩽ 27 points;

– degenerative changes in the cervical spine (MRI-confirmed Pfirrmann grade ⩾II disc degeneration without signs of compression of intraspinal neurovascular structures).

Patients with the following criteria were excluded from the study: shoulder joint pathology (irreparable rotator cuff tears and more than 50 % fatty degeneration according to MRI), grade 3–4 degenerative diseases of the shoulder joint, a history of operations on the same shoulder joint and cervical spine, segmental instability in the cervical spine, idiopathic osteofibrous dysplasia in the cervical spine, a history of cervical spine surgeries, as well as other diseases contributing to degenerative changes in the cervical spine (injuries, tumors, inflammatory diseases of the cervical spine, etc.)

Patients with nervous system diseases and other pathologies that make it impossible to objectify the diagnosis of shoulder joint pathology and individuals with a severe concomitant somatic pathology were also excluded.

The parameters were assessed before surgery, two days, as well as three, six, and 12 months after surgery.

Effectiveness assessment. The subjective patient state and clinical effectiveness of the performed treatment were assessed using the following scales: pain intensity was evaluated using the VAS, shoulder joint state was determined using the integrative University of California Los Angeles (UCLA) scale, and deterioration of the quality of life due to cervical spine pain was estimated using the Neck Disability Index (NDI). The main study parameter was treatment effectiveness. This parameter corresponded to the change in the VAS score value: a decrease in the value by 2.6 points compared to the preoperative one was considered a good clinical result [18].

The parameters possibly contributing to the clinical outcome of surgical treatment, demographic data, and cervical spine MRI data (disc degeneration grade according to Pfirrmann scale [19]) were also assessed.

Radiological examination. All patients underwent MRI of the shoulder joint at the preoperative stage (the degree of damage to rotator cuff tendons, shoulder retraction, and the degree of degenerative-dystrophic changes in the ligamentous apparatus were assessed, the absence of damage to the articular lip was confirmed; the study was repeated six months after surgery to confirm the repaired tendon structure), MRI of the cervical spine (degenerative changes in the cervical spine, as well as the presence of protrusions, hernias, and stenosis, were assessed; non-degenerative diseases of the spine, which are a contraindication to manipulations including disc punctures, were excluded; disc degeneration grade according to the Pfirrmann scale was assessed), and radiological examination of the cervical spine (segmental instability in the cervical spine, traumatic and congenital deformities, as well as anomalies were excluded).

Surgical treatment. All patients were divided into two groups. Group A included patients who underwent reconstructive plasty of the rotator cuff and chemical denervation of C4–C5 and C5–C6 intervertebral discs on the next day to avoid cross-innervation.

Group B consisted of patients who underwent rotator cuff plasty without any additional surgical procedures.

Reconstructive plasty of the rotator cuff was performed arthroscopically; it included suturing of the damaged tendon and anchor fixation.

In the postoperative period, patients underwent shoulder joint immobilization using the abduction splint for four weeks and a restorative treatment course.

Group A patients additionally underwent denervation of C4–C5 and C5–C6 discs under local anesthesia on the next day after rotator cuff reconstruction [8, 21] (Fig. 1, 2).

In order to achieve persistent, reliable, and non-reversible denervation of irritated receptors, 96 % sterile ethanol supplemented with 2 % novocaine at a 1 : 1 ratio was used. Each disc was slowly soaked in alcohol–novocaine solution (three to four times on average) until the injection was completely painless. The needles were removed, and a sterile bandage was applied. No external immobilization was required.

Clinical effectiveness was assessed using UCLA, VAS, and NDI scales in the postoperative period (two days, three, six, and 12 months after surgery).

Statistical analysis. Continuous data are presented as median [interquartile range], binary data are shown as quantity and percent [95 % confidence interval (CI) according to Wilson's method], and categorical data are expressed in count per category (%).

Continuous data were not assessed for normality of distribution due to the small group size, while the groups were compared using the nonparametric Mann–Whitney U test with calculation of the value and 95 % CI for pseudo-median of pairwise differences as the estimate of the mean difference. Binary data between the groups were compared using the two-tailed Fisher's exact test with estimating the odds ratio (OR) and 95 % CI for OR. General group comparison and comparison of individual categories for categorical data were performed using the two-tailed Fisher's exact test;

Benjamini – Hochberg correction was used to eliminate multiple comparison errors for individual categories [22].

All calculations were performed using the free RStudio software version (v. 1.1.463) in R language (v. 3.5.1) [23].

Results

Population analysis. A total of 58 patients were included in the study based on the eligibility criteria. There were 28 individuals in Group A (tendon plasty followed by intervertebral disc denervation) and 30 patients in Group B (tendon plasty only). A total of one, three, and 10 patients were lost after three, six, and 12 months in the postoperative period, respectively.

All patients were of working age: mean age was 47 [37.25; 53.25] years in Group A and 53 [38.00; 56.75] years in Group B.

According to the cervical spine MRI data, Pfirrmann grade II disc degeneration prevailed among the patients.

According to the NDI data, neck pain-related function was moderately reduced in all patients: 34 [30.0; 38.0] in Group A and 34 [30.5; 36.0] in Group B.

According to the UCLA scale, all patients noted unsatisfactory shoulder function: 20 [18.00; 21.50] in Group A and 20 [18.00; 22.75] in Group B.

Based on the study results, a decrease in pain intensity according to the VAS is observed in patients of the both groups at all follow-up periods. An intergroup comparison revealed a pronounced tendency towards the difference between the groups ($p = 0.059$) two days after surgery, as well as three, six, and 12 months after surgery. This difference was considered statistically significant ($p < 0.001$, $p < 0.001$, and $p = 0.002$, respectively). Group A patients reported less pain compared to Group B patients (Table 1).

A significant reduction in pain in Group A patients after intervertebral disc denervation allowed early rehabilitation (10–14 days after surgery) and shoulder joint recovery through passive movements. In Group B, these measures were started only on day 20–24 after pain relief.

The proportion of effectively treated patients in each group increased until month six and then remained at the same level (Table 2). The proportion of effectively treated patients in Group A was significantly higher at month three after surgery ($p = 0.003$); this pattern between the groups persists at month six of the follow-up ($p = 0.055$).

All patients had an improvement in shoulder joint function and state according to the integrative UCLA scale; no significant differences were noted between the groups by month three after surgery ($p = 0.574$).

The NDI value, which determines a patient's functional disability, decreased during all postoperative follow-up periods (Table 3). A significant difference between the groups occurred by month three ($p < 0.001$) and persisted until the end of the follow-up period: patients in group A noted a greater functional activity.

A regression analysis was conducted to determine the relationship between treatment effectiveness and initial patient characteristics (age, Pfirrmann disc degeneration grade, and pain intensity according to VAS). A significant correlation was established between treatment effectiveness and initial pain intensity according to the VAS in Group B patients by months three and six after surgery ($p = 0.008$ and $p = 0.010$, respectively).

Treatment failure analysis. Despite the observed pain regression in the general cohort, two patients in Group A and two patients in Group B complained of persistent shoulder pain after surgery. It should be noted that these patients were of the older age group (56 years old) and had degenerative changes in the shoulder joint (stage 2–3 arthritis). Despite the restored joint anatomy, the progression of degenerative changes indicates pain persistence.

Three patients noted recurrence of shoulder pain with intact shoulder joint anatomy (according to MRI data) at follow-up month six. Further examination confirmed pseudoradicular pain in the cervical spine in these patients.

By follow-up month 12, two individuals with Pfirrmann grade IV discs noted progression of degenerative changes in the cervical spine that required surgery.

No complications were noted during the follow-up period.

Discussion

The diagnosis in patients with a complicated medical history or a mixed pattern of neck and shoulder pain is clinically challenging. First of all, the physician should rely on a complete medical

Fig. 1
EOC control of C5–C6 disc puncture

Fig. 2
Intraoperative photographs of a patient during denervation of C4–C5 and C5–C6 discs

history and imaging results. However, a high risk of overdiagnosis and detection of false positive results is known during radiological examination of the cervical spine and shoulder joint at the first visit to the doctor [5].

Hawkins et al. [24] presented the data that, of eight patients with a combined pathology of the cervical spine and shoulder joint who underwent surgical treatment for shoulder joint pathology, six patients noted complete pain regression, while two patients required cervical spine decompression as the second stage of surgery. Manifold and McCann [25] reported that elimination of a shoulder pathology also decreased neck pain in 20 out of 23 patients. Subacromial decompression in patients aged 42–65 years was shown to have no advantages over placebo in reducing shoulder pain, improving function and the quality of life [26]. Therefore, the authors concluded that, in the absence of progressive neurological deficits, thorough conservative treatment of the shoulder joint may be reasonable, especially in patients with a comorbidity.

We chose a rather narrow sample of patients because approximately 45 % of adult patients report severe postoperative pain after rotator cuff repair. This was the key aspect in choosing the inclusion and exclusion criteria and made it possible to obtain absolutely homogeneous groups of patients (while excluding gross pathologies of the shoulder joint and cervical spine) that still required surgical treatment of the rotator cuff.

In our study, most of the patients noted decreased pain in the shoulder joint and functional improvement according to the NDI in the postoperative period. Decreased neck pain-related disability is more typical of Group A patients; however, this pattern is also observed in Group B. Reduced intensity of shoulder joint pain improves the quality of life and general functional activity, as evidenced by the NDI data.

We defined treatment effectiveness as regression of the VAS value by more than 2.6 points compared to the preoperative one [18]. A larger proportion of patients with effective treatment outcome was found in Group A (74 % versus 33 % by follow-up month three; 89 % versus 64 % by follow-up month six; 88 % versus 74 % by follow-up month 12), which suggests the effect of the performed denervation on pain severity. Chemical denervation of cervical discs is an effective measure to treat discogenic pain [9, 27, 28] that reduces both referred and myofascial pain [9].

A significant correlation between treatment effectiveness and initial pain intensity according to the VAS in Group B at follow-up months three and six ($p = 0.008$ and $p = 0.010$, respectively) shows that the higher the preoperative pain intensity is, the greater pain regression is achieved in the postoperative period. The absence of this pattern in Group A patients, who underwent intervertebral disc denervation, requires further investigation.

Despite the lack of a definite answer regarding etiology of intervertebral disc degeneration, the main pathogenetic mechanism underlying it is considered aging, since it is a multifactorial process. The most common Pfirrmann disc degeneration grades were grade II and IV for the second to the fifth decade of life and for the sixth decade and older, respectively [29]. These findings are sup-

Table 1
Intergroup comparison of pain intensity using the VAS

Follow-up period	Group A (n = 28), score – n (%)	Group B (n = 30), score – n (%)	Two-tailed Fisher's exact test p level category: p; p correction
Upon admission			General comparison: 0.933
	2 – 1 (3.6)	2 – 1 (3.3)	2: >0.999; >0.999
	3 – 5 (17.9)	3 – 7 (23.3)	3: 0.749; >0.999
	4 – 10 (35.7)	4 – 11 (36.7)	4: >0.999; >0.999
	5 – 7 (25.0)	5 – 8 (26.7)	5: >0.999; >0.999
	6 – 5 (17.9)	6 – 3 (10.0)	6: 0.464; >0.999
After 2 days			General comparison: 0.059
	1 – 5 (17.9)	1 – 1 (3.3)	1: 0.097; 0.282
	2 – 9 (32.1)	2 – 7 (23.3)	2: 0.561; 0.701
	3 – 11 (39.3)	3 – 10 (33.3)	3: 0.786; 0.786
	4 – 3 (10.7)	4 – 8 (26.7)	4: 0.182; 0.304
	5 – 0 (0.0)	5 – 4 (13.3)	5: 0.113; 0.282
After 3 months			General comparison: <0.001
	0 – 8 (29.6)	0 – 0 (0.0)	0: 0.001; 0.007
	1 – 10 (37.0)	1 – 6 (20.0)	1: 0.238; 0.297
	2 – 8 (29.6)	2 – 11 (36.7)	2: 0.779; 0.779
	3 – 1 (3.7)	3 – 9 (30.0)	3: 0.013; 0.033
	4 – 0 (0.0)	4 – 4 (13.3)	4: 0.114; 0.190
After 6 months			General comparison: <0.001
	0 – 17 (63.0)	0 – 5 (17.9)	0: <0.001; 0.004
	1 – 9 (33.3)	1 – 10 (35.7)	1: >0.999; >0.999
	2 – 1 (3.7)	2 – 9 (32.1)	2: 0.012; 0.023
	3 – 0 (0.0)	3 – 4 (14.3)	3: 0.111; 0.149
After 12 months			General comparison: 0.002
	0 – 17 (68.0)	0 – 5 (21.7)	0: 0.002; 0.007
	1 – 7 (28.0)	1 – 8 (34.8)	1: 0.757; 0.757
	2 – 1 (4.0)	2 – 7 (30.4)	2: 0.020; 0.041
	3 – 0 (0.0)	3 – 3 (13.0)	3: 0.102; 0.137

Table 2
Intergroup comparison of treatment effectiveness

Follow-up period	Group A (n = 28) n; % [95 % CI]	Group A (n = 28) n; % [95 % CI]	Odds ratio [95 % CI]	Two-tailed Fisher's exact test, p level
After 2 days	10; 36 [21; 54]	4; 13 [5; 30]	0.3 [0.1; 1.2]	0.067
After 3 months	20; 74 [55; 87]	10; 33 [19; 51]	0.2 [0.0; 0.6]	0.003
After 6 months	24; 89 [72; 96]	18; 64 [46; 79]	0.2 [0.0; 1.1]	0.055
After 12 months	22; 88 [70; 96]	17; 74 [54; 87]	0.4 [0.1; 2.2]	0.279

The achieved VAS result is 2.6 points higher than the initial one.

Table 3
Comparison of NDI between the groups

Follow-up period	Group A (n = 28) MED [IQR] MEAN ± SD	Group B (n = 30) MED [IQR] MEAN ± SD	Difference [95 % CI]	Mann – Whitney U test, p level
After 2 days	34 [30; 38] 34.00 ± 4.62	34 [30.5; 36.0] 33.87 ± 4.10	0 [-2; 2]	0.981
After 3 months	26 [24; 26] 25.41 ± 2.27	30 [26.5; 32.0] 29.20 ± 3.13	4 [2; 6]	<0.001
After 6 months	24 [22; 26] 23.48 ± 3.12	26 [24.00; 28.00] 25.79 ± 3.05	2 [0; 4]	0.010
After 12 months	22 [20; 24] 22.56 ± 2.92	24 [22.00; 26.00] 24.35 ± 2.87	2 [0; 4]	0.045

MED – median, IQR – interquartile range, SD – standard deviation.

ported by recent systematic literature reviews [30, 31].

We have not found any data on possible correlation between the effect of chemical denervation of a cervical disc and its degeneration grade, which can serve as the basis for further research. However, there are a lot of data indicating the effectiveness of this procedure in the form of regressed referred, radicular, and myofascial pain [9, 27, 28].

Our pilot study allowed us to determine the following patterns that require further investigation: a more pronounced decrease in pain intensity, a larger proportion of effectively treated patients in the group with intervertebral disc denervation, and a significant improvement in pain-related functional disability.

The study has several limitations, one of which is the small population sample. Some parameters (pain intensity according to the VAS at day two ($p = 0.059$), treatment effectiveness at day two ($p = 0.067$) and month six ($p = 0.055$)) demonstrated only certain tendencies. However, we can assume that significant differences can be confirmed using a proper power of the study. Another limitation was the lack of placebo control, since the effect of psychological factors on pain severity cannot be excluded.

All of the above allows us to hypothesize that denervation of intervertebral discs in shoulder joint pain in the presence of degenerative changes in the cervical spine may statistically significantly increase the effectiveness of surgery for rotator cuff injury at months three and six after surgery, provided that there is a proper statistical validation for calculation of the population sample of patients and integrity of the experiment.

Conclusion

There is an underestimation of the role of degenerative cervical spine pathology in the occurrence of shoulder joint pain. The supplementation of rotator cuff plasty with denervation reduces the intensity of shoulder joint pain in the postoperative period.

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