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When is the Optimal Time Point for Predicting the 1-Year Follow-up Outcome of Selective Nerve Root Block for Cervical Radiculopathy?

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Study Design: Retrospective study.
Objectives: In the current study, we aimed to (1) evaluate the early and late therapeutic effects of selective nerve root block (SNRB) for cervical radiculopathy, and (2) to determine the optimal time point for predicting the long-term effectiveness of cervical SNRB.
Summary of Literature Review: Although SNRB is an important option for cervical radiculopathy, various studies of cervical SNRB have failed to specify its efficacy, especially long-term effectiveness.
Materials and Methods: We retrospectively enrolled 35 patients with cervical radiculopathy who were regularly followed-up for at least 1 year after SNRB. Clinical outcomes were evaluated using a visual analogue scale (VAS) for pain intensity and the modified Kim's method for patient satisfaction at regular follow-up intervals. In the correlation analysis, stepwise multiple linear regression was used to identify selected and unselected factors.
Results: The average VAS score decreased over time ($p<0.05$); the values just before the injection and at 1 week, 3 weeks, and 1 year of follow-up were 6.11, 3.29, 2.89, and 1.37, respectively. In the stepwise multiple regression analysis, the 1-week VAS score was related to the initial VAS score, the 3-week VAS score was related to the 1-week VAS score, and the last VAS score was related to the 3-week VAS score and symptom duration before the injection. The degree of satisfaction at the 1-year follow-up point was significantly associated with the 3-week VAS score ($p=0.011$).
Conclusions: The current study showed that pain intensity at the 3-week time point after cervical SNRB might be the optimal time point for predicting long-term effectiveness.

Key Words: Cervical spine, Radiculopathy, Selective nerve root block, Long-term effectiveness, Predictor

Introduction

Cervical radiculopathy is a common disease that causes severe pain and limits function in everyday life. It is found in about 0.83 out of 1,000 persons and has an annual occurrence of about two in 1,000 middle-aged persons.[1-3] Selective nerve root block (SNRB), which involves the injection of local anesthetics and steroids, is frequently used to relieve pain when non-steroidal anti-inflammatory drugs and physical therapy are ineffective.

Transforaminal epidural injection with steroids can reduce inflammation and edema in damaged nerve roots, decrease sensitization of the posterior horn neurons, and inhibit the conduction of water-soluble C-fibers.[4] Injecting local anesthetics can also produce therapeutic effects by improving blood flow in compressed nerve roots and reducing epidural inflammation.[5] Although SNRB fails to treat the underlying pathological factors such as herniated discs or stenosis, it is expected to be effective at temporarily or persistently relieving

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pain during the course of natural healing.[6,7] However, many different views exist on the efficacy and role of SNRB, in many systematic reviews and randomized study.[8-12] Previous studies failed to make a definite conclusion about some points of issues regarding SNRB for cervical radiculopathy, including its effectiveness in treating radiating pain.[10-13] Recent studies also demonstrated that SNRB was successful only in minor patients of less than half, and otherwise had critical limitations, risks, and complications.[13-16] Despite these reports, there is still a dearth of data on the effects of SNRB in the cervical spine.[15-17]

Considering these points of view, varying perspectives on cervical SNRB are still presented and have failed to specify detailed information, especially regarding prognosticator for long-term effectiveness. Among the problems of cervical SNRB, the authors focused on the optimal time point for post-injection period to represent long-term outcomes (especially, one-year follow-up outcome) after SNRB for cervical radiculopathy. In the current study we aimed to (1) evaluate the early and late therapeutic effects of SNRB in cervical radiculopathy, and (2) determine the most valuable time point to predict the long-term effectiveness of cervical SNRB.

Methods

1. Study population

This study was approved by Institutional Review Board of our hospital (IRB File No. 2016-09-008). Study participants were selected from the 57 patients who had undergone SNRB to treat upper extremity radiating pain between October 2010 and April 2014. Among them, 35 patients who met the study criteria were included in the study and analyzed (Fig. 1). The average duration of current pain symptoms was 7.1 weeks (range, 1-28 weeks), and the average duration of remote symptoms was 10.8 months (range, 1-60 months). None has myelopathy symptoms, whereas four showed a positive Hoffman sign. The mean age of the patients was 54.5±11.6 years (range, 29-75 years). Twenty patients were men, and 15 were women. Follow-up was performed for an average duration of 31.3±10.2 months (minimum duration, 15 months; maximum duration, 48 months). The fifth cervical nerve root was selected for three patients, the sixth cervical nerve root for 18, the seventh cervical nerve root for 13, and the eighth cervical nerve root for one patient. If the first procedure failed to produce favorable effects, a second procedure was performed 1 week later. No additional procedures were performed, but surgical treatment was planned. The second procedure was performed in 21 of the 35 patients, and the results of the second procedure were analyzed.

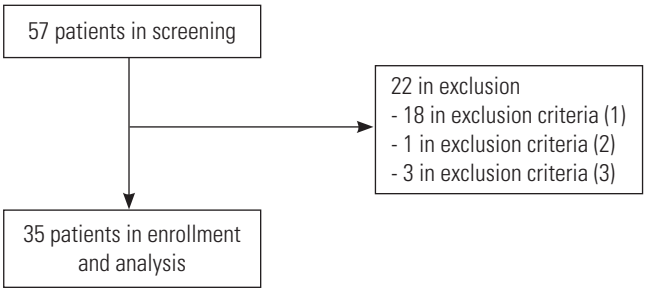

Fig. 1. Flow diagram of patient enrollment.

2. Inclusion and exclusion criteria

All the participants met the following inclusion criteria: (1) unresponsiveness to other conservative treatments (e.g. medication or physical therapy) for ≥ three months; (2) follow-up (≥ one year) after cervical SNRB; and (3) obvious finding of cervical disc herniation confirmed by simple radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) of the cervical spine that definitely corresponded to the clinical manifestations. The exclusion criteria were as follows: (1) responsiveness to other conservative treatment methods, prior to SNRB; (2) inability to accurately record the outcome measures and responses to the questionnaires (e.g. due to stroke or other medical illnesses) at any of the follow-up time points; and (3) fracture, infection, or tumor detected on cervical spine radiography and MRI.

3. Selective nerve root block (SNRB) technique

In patients complaining of radiating pain caused by cervical radiculopathy, we selected a nerve root suspected to cause the condition based on symptoms, diagnostic findings, and imaging-based assessment. A fluoroscope-guided procedure was performed. We used an anterolateral approach to insert a 22-gauge needle into a verified location, confirmed the absence of vascular filling, and injected 0.5 cm^3 of contrast medium to perform a provocation test before the procedure (Fig. 2). A 1:1 mixture of local anesthesia (1% Lidocaine) and steroid (Dexamethasone) was injected into the selected nerve

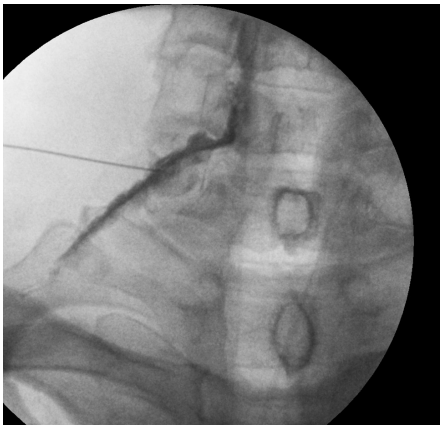

Fig. 2. Provocation test using contrast.

Table 1. Modified Kim's questionnaire

No	Questionnaire	Answer
I	From the SNRB, did you have duration of relief?	0 (No relief)
		1 (Relief <2 months)
		2 (Relief <2 months)
II	How would you rate the overall pain relief that you have had from the SNRB?	Early
		0 (None)
		1 (Partial)
		2 (Full)
		Current
		0 (None)
		1 (Partial)
		2 (Full)
III	Do you think the SNRB have improved your ability to perform your daily activities?	0 (None)
		1 (Partially)
		2 (Yes)
IV	What was your overall satisfaction with the SNRB?	0 (Unsatisfied)
		1 (Satisfied)
		2 (Very satisfied)
V	Would you repeat the SNRB, if necessary?	0 (No)
		1 (Yes)

SNRB: selective nerve root block.

root. The scores in the visual analog scale (VAS) were used to measure the degree of radiating pain, including axial cervical pain, before the procedure, one week and three weeks after the procedure, and at each follow-up. An ascending ordinal scale, which is an adaptation of the questionnaire developed by Kim et al.,[18] was used to conduct a survey to assess the patients' satisfaction by phone (Table 1).

4. Study endpoints

The primary study endpoint was pain intensity at the radiating pain on the upper extremity, based on the visual analogue scale (VAS). Patients were instructed to make a mark on horizontally oriented, 10-point VAS sheet, which labeled "no pain; zero point" at the far left and "greatest pain; ten point" at the far right. The VAS scores were obtained before injection, every week within one month, every three months, and one year after injection. Patients were blinded to their previous pain scores.

Secondary endpoints were included patient satisfaction, as assessed with modified Kim's method, and complications such as neuritis during or after injection. The patient satisfaction was obtained at the last follow-up time point of one year after surgery. The questionnaires and clinical records were collected and analyzed by one orthopedic surgeon who was not involved in this study.

5. Statistical analysis

Statistical analyses were performed using an SPSS program version 21.0 (SPSS, Chicago, IL, USA), and two-tailed p-values <0.05 were considered statistically significant. Chi-square test, paired t-test, and repeated measurement of one-way analysis of variance (ANOVA) were performed to determine inter-group differences. For correlation analysis, the stepwise multiple linear regression test was used to identify associated (selected and unselected) factors. For the selected factors, a standardized coefficient (ß) was used to determine the level of correlation. The selected factors were level of pain caused by the procedure, the degree of pain relief immediately post-procedure, the VAS scores in each phase, and Hoffman sign status. Additionally, general factors such as patient age, gender, and recent and remote symptom durations were included as well.

Table 2. Cross tabulation of the provocative test and relief test

		Relief test			
		1 (equivocal relief)	2 (relief)	3 (dramatic relief)	Total
Provocative test	2 (dissimilar pain)	1	10	0	11
	3 (concordant pain)	0	5	19	24
	Total	1	15	19	35

*Fisher's exact test; p=0.000.

Results

In the provocative test, 24 out of 35 patients reported concordant pain, and 11 reported similar pain. Nineteen out of 24 patients who reported concordant pain experienced dramatic relief immediately after the procedure, and five had relief. Ten out of 11 patients who reported similar pain also experienced dramatic relief, whereas the remaining patient reported equivocal relief. Chi-square test for the degree of pain relief right after the procedure found that the more similar pain in the provocative test, the greater the degree of relief (p=0.000) (Table 2).

The mean VAS scores pre-procedure, one week and three weeks post-procedure, and at the final follow-up were 6.11 ±1.3, 3.29±1.6, 2.89±1.8, and 1.37±1.6, respectively. Thus, pain decreased in a statistically significant manner after the procedure and continued to decrease with time ($p<0.05$).

26 out of 35 patients (74.3%) complained of pain more than VAS ≥ 6 before the procedure. In 1 week after procedure, only three patients scored ≥7 score in VAS, and all remaining 32 patients (91.4%) experienced pain relief of more than two grades (Table 3). When the stepwise multiple regression analysis was performed to identify factors affecting the VAS score one week after the procedure, a higher one-week VAS score was associated with a higher initial VAS score and positive Hoffman sign (R=0.590, R-square=0.349, b: initial VAS=0.418, Hoffman sign=0.352, p=0.002) (Table 4). The one-week VAS had no correlation with any other factor, such as status of pain caused by the provocative test or the level of recovery immediately post-procedure.

Even after three weeks, three patients who had complained of severe pain (VAS ≥6) at one week failed to have favorable effects, and the remaining patients exhibited a similar VAS score distribution to that of the first week (p=0.001) (Table 5). Multiple regression analysis revealed that the VAS scores at three weeks were strongly correlated with those at one week, but they had no correlation with any other factor, such as provocation or the degree of pain relief immediately post-procedure (R=0.881, R-square=0.775, b: VAS 1-week=

Table 3. Cross tabulation of initial VAS and 1-week VAS

		1 week VAS								
		1	2	3	4	5	6	7	8	Total
Initial VAS	3	1	0	0	0	0	0	0	0	1
	4	0	1	2	0	0	0	0	0	3
	5	0	2	0	3	0	0	0	0	5
	6	1	3	7	2	0	0	0	0	13
	7	1	2	1	2	1	0	1	0	8
	8	0	1	0	1	1	0	1	1	5
	Total	3	9	10	8	2	0	2	1	35

*Fisher's exact test; p=0.146.
VAS: visual analog scale.

Table 4. Selected variables according to the result of stepwise method of multiple regression

Selected variable Model II*	Coefficient			
	Unstand B	SE	Beta	p
(Constant)	-0.278	1.245		0.825
Initial VAS	0.548	0.200	0.418	0.010
Hoffman sign	2.440	1.054	0.352	0.028
R=0.590, R-square=0.349, p=0.002				

*Dependent variable: 1 week VAS
VAS: visual analog scale, SE: standard error.

Table 5. Cross tabulation of 1-week VAS and 3-week VAS

		3-week VAS									
		0	1	2	3	4	5	6	7	8	Total
1-week VAS	3	1	0	0	0	0	0	0	0	0	1
	4	0	1	0	2	0	0	0	0	0	3
	5	0	0	2	2	0	1	0	0	0	5
	6	0	2	5	1	5	0	0	0	0	13
	7	0	3	1	1	2	0	0	1	0	8
	8	1	0	1	0	0	1	1	0	1	5
	Total	2	6	9	6	7	2	1	1	1	35

*Fisher's exact test; p=0.001.
VAS: Visual analog scale.

Table 6. Selected variables according to the result of stepwise method of multiple regression

Selected variable Model I*	Coefficient			
	Unstand B	SE	Beta	p
(Constant)	-0.339	0.355	-	0.348
1-week VAS	0.989	0.097	0.881	0.000
R=0.881, R-square=0.775, p=0.000				

*Dependent variable = 3-week VAS.
VAS: visual analog scale, SE: standard error.

Table 7. Cross tabulation of 3-week VAS and final VAS

		Final VAS						
		0	1	2	3	4	5	Total
3-week VAS	0	2	0	0	0	0	0	2
	1	4	2	0	0	0	0	6
	2	2	6	1	0	0	0	9
	3	3	0	3	0	0	0	6
	4	1	1	0	3	0	2	7
	5	0	0	0	1	1	0	2
	6	1	0	0	0	0	0	1
	7	0	0	0	0	0	1	1
	8	1	0	0	0	0	0	1
	Total	14	9	4	4	1	3	35

*Fisher's exact test; p=0.002.
VAS: Visual analog scale.

0.881, p=0.000) (Table 6).

At the final follow-up, only three patients complained of moderate pain (VAS=5), and the remaining 32 patients (91.4%) recovered (VAS ≤4) (p=0.002) (Table 7). Three weeks after the procedure, two out of three patients who had complained of severe pain reported complete elimination of the pain, and one was on medication due to a VAS of 5. The remaining two patients with VAS of 5 in the final follow-up were among the seven patients with VAS of 4 score three weeks post-procedure. Multiple regression analysis revealed that a higher three-week VAS score and longer recent and remote symptom duration were associated with a higher VAS score at the final follow-up (R=0.662, R-square=0.438, b: VAS 3-week=0.424, recent duration=0.372, remote duration=0.324, p=0.01) (Table 8). This result implies that the failure to relieve pain immediately after the procedure and the long remote symptom duration can lead to poor procedure outcomes.

In the final follow-up, two patients failed to get pain relief

Table 8. Selected variables according to the result of stepwise method of multiple regression

Selected variable Model III*	Coefficient			
	Unstand B	SE	Beta	p
(Constant)	-0.539	0.486	-	0.277
3-week VAS	0.362	0.125	0.424	0.007
Recent duration	0.104	0.040	0.372	0.014
Remote duration	0.021	0.010	0.324	0.035
R=0.662, R-square=0.438, p=0.001				

*Dependent variable: final VAS.
VAS: visual analog scale, SE: standard error.

Table 9. Selected variables according to the result of stepwise method of multiple regression

Selected variable Model II*	Coefficient			
	Unstand B	SE	Beta	p
(Constant)	2.770	0.392	-	0.000
Remote duration	-0.14	0.003	-0.559	0.000
Age	-0.21	0.007	-0.407	0.005
R=0.700, R-square=0.490, p=0.000				

*Dependent variable: duration of relief.
SE: standard error.

Table 10. Selected variables according to the result of stepwise method of multiple regression

Selected variable Model I*	Coefficient			
	Unstand B	SE	Beta	p
(Constant)	2.513	0.323	-	0.000
3-week VAS	-0.254	0.094	-0.443	0.011
R=0.443, R-square=0.196, p=0.011				

*Dependent variable: degree of satisfaction.
VAS: Visual analog scale, SE: Standard error.

from the procedure, 15 had pain relief for less than two months, and 18 had pain relief for more than two months. Multiple regression analysis revealed that a long remote symptom duration and older patient age were associated with the shorter duration of pain relief (R=0.700, R-square=0.490, b: remote duration=-0.559, age=-0.407, p=0.000) (Table 9). Thirteen out of 35 patients were highly satisfied with the procedure, two were moderately satisfied, 17 were slightly satisfied, and three were dissatisfied and underwent anterior cervical discectomy and interbody fusion. Multiple regression analysis showed that the lower three-week VAS score was an only associated factor of the patient's satisfaction degree at the last follow-up time point (R=0.443, R-square=0.196, b: VAS 3-week=-0.443, p=0.011) (Table 10).

Discussion

SNRB is an effective method for managing cervical radiculopathy, but it is also a very useful diagnostic technique for identifying the nerve root causing the condition. More specifically, it can identify problematic nerve roots in patients with multiple degenerative spondylosis lesions, and it can identify nerve roots in those with inconclusive imaging, such as patients with pacemakers, and those with nonspecific limb pain.[19-21] We have also used SNRB to identify the nerve root causing symptoms, performed SNRB as one of the final preoperative treatment methods when surgery was considered due to failed conservative treatment for cervical radiating pain, and frequently used SNRB as a diagnostic technique when we had doubts about which nerve root was causing pain symptoms.

While most researchers agree that SNRB is therapeutically an effective option in controlling pain for a short period of time, its long-term effects are still controversial, and it is not well known what factors allow for successful early pain control. Mallinson et al.[22] performed SNRB in 301 cases of lumbar and cervical radiculopathy and reported that 69.1% of patients had favorable effects lasting for at least one week, regardless of the location (cervical or lumbar) or pain status. Engel et al.[23] performed a literature review of 16 cases of fluoroscope guided SNRB and concluded that about 50% of patients had a 50% reduction in radiating pain lasting at least four weeks. According to the GRADE (Grades of Recommendation, Assessment, Development, and Evaluation) assessment system, fluoroscope-guided cervical SNRB is less effective and is less likely to prevent the need for surgical treatment. Chung et al.[2] reported that radiating pain was reduced by nearly 50% 12 months after the procedure in 28 cervical radiculopathy patients and that the level of satisfaction decreased gradually with time (71% in three months, 64% in six months, and 50% in 12 months). Furthermore, he showed that the VAS scores were significant higher at 12 months than at six months. Thus, they indicated limited long-term effects of the procedure and recommended surgical treatment if it had no effect by six months. Vallee et al.[24] conducted prospective research on fluoroscope-guided cervical SNRB to treat cervical radiating pain in 34 patients and found that 50% of the patients saw relief lasting up to six months, 56% were satisfied enough to resume their daily routines six months post-procedure, and that those with no radiating pain relief at two weeks continued to have no pain relief. Takeuchi et al.[25] conducted retrospective research in 39 patients undergoing ultrasound-guided cervical SNRB and found that 24 patients (62%) saw pain relief lasting more than 17 months and that 15 (38%) received surgical treatment due to pain recurrence within three months after the procedure. In our study, a higher three-week VAS score was significantly correlated with a higher VAS score at the final follow-up. In other words, while favorable long-term effects can be expected from patients for whom the procedure is effective in relieving pain in three weeks, it is more reasonable to give surgical treatment to those who experience no favorable effect during this period due to unsatisfactory long-term pain relief. This result agrees with the general principle that it is necessary to consider surgical treatment in any case where severe pain lasts three to six weeks after conservative

treatment.[26] Meanwhile, we also conducted a survey on patient satisfaction, which was expected to play a crucial role in determining the usefulness of SNRB. Throughout step-wise regression analysis, we also found that patients with more favorable three-week pain scores were significantly more satisfied at one-year follow-up time, as of the result of pain intensity. Based on those outcomes of the current study, we suggest that three-week pain intensity after cervical SNRB may be a critical factor to predict long-term effectiveness of SNRB

SNRB is still controversial in many ways. Most of all, the effectiveness and usefulness of the pre-procedural provocative test has been debated. Mallinson et al.[22] reported no statistical correlation between the score for pain relief seven days post-procedure and the mean score for pain relief in the last three days of follow-up. In our study, levels of provoked pain had no correlation with satisfaction or with VAS scores at each follow-up. Taking these results into account, the level of symptom occurrence in the provocative test is probably related with epineural penetration status. While local anesthetics are effective in relieving pain immediately after the procedure, they are expected to be more effective when injected epineurally. The effects of steroids on pain and satisfaction at one week and three weeks post-procedure are probably attributed to the wide-ranging effects based on the spread, even without epineural penetration. Pfirrmann et al.[28] showed that the provocative test was not necessary for a therapeutic purpose, and Mallinson et al.[22] recommended against using epineural injections, citing likely nerve injury and the patient's discomfort caused by severe pain. However, we still believe that the provocative test is more accurate method for identifying the nerve root causing the symptoms than other imaging modalities, when there are multiple nerve root lesions causing the symptoms.[29]

Although several studies have reported the effectiveness of cervical SNRB, no study regarding proposing critical time point to predict long-term outcome of SNRB have reported. Based on the results from the current study, we revealed the correlation between three-week pain intensity after SNRB and one-year pain intensity and patient satisfaction. Cervical SNRB significantly relieved pain up to three weeks after the procedure, and is expected to give a high level of satisfaction as well as favorable long-term effects. However, patients without favorable effects for three weeks after procedure may require surgical treatment because they are expected to experience unsatisfactory long-term improvement. That is an important point for physicians and patients, since pain intensity at three-week time point after SNRB can predict the one-year state in pain intensity and functional status.

As with any study, there are a number of limitations with ours. This was a retrospective observational study that conducted at single institution and center with a relatively small sample size and short follow-up period. Consequently, further studies with larger sample size and extended follow-up period under prospective design should be necessary to better determine. Next, our study may have a selection and performance bias partly. Our study would not consider the degree of the forminal stenosis on the affected side, and their correlation between symptoms and pathology degree, which might lead to selection bias, somewhat. The recovery rate of the symptoms (radiating pain) may depend on the disc level of the nerve root, and repeated selective nerve root blocks may influence the recovery rate of VAS. Finally, our study may have some study biases such as a sampling bias, as patients refusing to answer the survey questions were excluded, and memory biases that could have affected the responses to the patient satisfaction survey.

Conclusion

Cervical SNRB can play a useful role in making patients more satisfied by the early relief of their pain. The current study showed a possibility of the correlation between three-week pain intensity after SNRB and one-year pain intensity and patient satisfaction. In other words, cervical SNRB significantly relieved pain up to three weeks after the procedure, and is expected to give a high level of satisfaction as well as favorable long-term effects. Due to several limitation of the current study, the outcomes from the current study could not be generalized, thus further studies should be necessary with larger sample sizes, extended follow-up, and high-quality study design.

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경추 방사통을 위한 선택적 신경근 차단술의 1년 후 결과를 예측하는데에, 어느 시점이 가장 이상적인가?

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연구 계획: 후향적 연구
목적: 경부 방사통을 위한 신경근 차단술 후 1년간 결과를 평가하고, 1년 후 결과를 예측하는데에 차단술 후 어느 시점이 가장 이상적인지 알아보고자 한다.
선행 연구문헌의 요약: 경부 방사통을 위한 신경근 차단술이 효과적인 치료방법으로 알려져있으나, 아직 차단술의 유효성, 장기 결과 평가 및 관련 인자에 대해서는 연구가 부족하다.
대상 및 방법: 경추 방사통으로 선택적 신경근 차단술 후 1년 이상 추시가 된 35명의 환자를 대상으로 연구를 진행하였다. 통증 정도(VAS), 환자 만족도를 평가하였으며, 평가를 위하여 단계적 다중회귀분석 방법을 이용하여 1년 후 결과와 가장 높은 상관성을 보이는 시기를 확인하였다.
결과: 통증 점수는 차단술 후 점차 완화되었고($p<0.05$), 평균 점수는 시술 전 6.11, 시술 후 1주째 3.29, 3주째 2.89, 그리고 1년 후 1.37 이었다. 단계적 다중회귀분석 통계 처리 후, 1주째 통증 점수는 차단술 전 통증 점수와 연관성을 보였고, 3주째 통증 점수는 1주째 통증 점수와, 1년 후 통증 점수는 3주째 통증 점수와 차단술 전 증상 지속 기간과 의미있는 연관성을 보였다. 차단술 1년 후 환자 만족도는 차단술 후 3주째 결과와 의미있는 연관성을 보였다 ($p=0.011$).
결론: 선택적 신경근 차단술 후 3주째의 임상 결과 (통증 정도)는 차단술 1년 후의 결과와 가장 밀접한 연관성을 보였다.

색인 단어: 경추, 방사통, 선택적 신경근 차단술, 장기 결과, 예측
약칭 제목: 경추의 선택적 신경근 차단술의 예후 평가

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