

Reduction of the Douleur Neuropathique 4 (DN4) Score in the Supraclavicular Nerve Separation and Disability of the Arm Shoulder and Hand (DASH) Score Third Month and Sixth Month Post Open Reduction Internal Fixation of Clavicular Fracture

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ABSTRACT

Introduction: Clavicle fractures are common injuries to the scapular girdle, with fractures in the middle third of the clavicle being the most prevalent. Non-operative treatment is often used but can lead to unsatisfactory outcomes, including pain, malunion, and thoracic outlet syndrome. As a result, operative fixation using Open Reduction and Internal Fixation (ORIF) Plate and Screw (ORIF PS) has gained popularity. Postoperative complications such as numbness around the surgical incision are frequently observed. This study aims to evaluate the differences in functional outcomes in patients with clavicle fractures post ORIF PS using the preserved supraclavicular nerve and non-preserved supraclavicular nerve methods, assessed by the Disability of the Arm Shoulder and Hand (DASH) score and Douleur Neuropathique 4 (DN4) score at 3 and 6 months post-operation.

Methods: This cohort study used medical records data from patients with middle third clavicle fractures at RSUP Prof. Dr. IGNG Ngoerah. Patients were divided into two groups: preserved supraclavicular nerve and

non-preserved supraclavicular nerve. Data were collected at 3 and 6 months post-operation to evaluate DASH and DN4 scores. Statistical analysis was performed using SPSS version 25.0, with the *Kolmogorov-Smirnov* test for normality and appropriate hypothesis tests based on data distribution.

Results: This study involved 51 patients with clavicle fractures undergoing ORIF PS surgery. There were no significant differences in baseline characteristics between the two groups. At three months, the difference in DN4 scores between the preserved and non-preserved groups was not statistically significant ($p=0.347$). However, at six months, the preserved group showed significantly lower DN4 scores ($p=0.012$). The DASH scores at three months showed a significant difference between the two groups ($p<0.001$), with the preserved group showing better scores. At six months, the difference in DASH scores was not significant ($p=0.210$). Longitudinal analysis showed significant reductions in DASH and DN4 scores between three and six months in both groups.

Discussion: This study demonstrates that preserving the supraclavicular nerve during

ORIF clavicle surgery provides significant benefits in reducing neuropathic pain and improving arm function in the long term. These findings support the importance of this approach in clavicle fracture surgeries to reduce complications and enhance functional outcomes.

Conclusion: Preserving the supraclavicular nerve during ORIF clavicle surgery can significantly reduce neuropathic pain and improve arm function in the long term. These findings emphasize the importance of this approach in clinical practice to improve patient outcomes following clavicle fracture surgery.

Keywords: Clavicular fracture, Douleur Neuropathique 4 score, supraclavicular nerve separation, DN4 score, DASH score, ORIF.

INTRODUCTION

A clavicle fracture is the most common injury of the scapular girdle, with 4 out of 5 cases involving the middle part of the clavicle, and accounts for 3% of all fracture incidents (Ropars et al., 2017). Non-displaced clavicle fractures are usually treated non-surgically. However, the results of non-surgical treatment are not always satisfactory, as various complications, such as pain, malunion (abnormal bone alignment), and thoracic outlet syndrome, can occur. Consequently, the use of operative fixation has become more popular due to advancements in surgical fixation techniques and a lower failure rate of healing (Huang et al., 2021).

The use of internal fixation to treat clavicle fractures is increasingly popular, especially in cases of short or significantly displaced fractures. However, one of the frequently observed postoperative complications is numbness around the surgical incision area. The incidence of numbness has been reported to be between 12% and 29%. The study by Huang et al. found that 55% of all patients experienced numbness following clavicle fracture fixation surgery, and 91% of these patients had persistent numbness

after an average of 16 months. Interestingly, in some patients, nerve function seemed to improve regardless of whether the nerves were preserved or sacrificed during surgery. This may be due to collateral reinnervation by axons from other supraclavicular nerves (Huang et al., 2021).

Although this complication initially did not receive serious attention, numbness after clavicle surgery is now considered a potential issue that can cause patient dissatisfaction, which could be prevented with proper precautions. The impact of numbness in the anterior chest area after clavicle surgery may be more significant, particularly in female patients, as this numbness can alter sensations associated with bra straps and may even extend to the breast area (Wang et al., 2010). Nerve injuries may be caused by compression, traction, or laceration, and usually affect the root and trunk of nerves above the clavicle (supraclavicular) or the cords and branches of nerves below the clavicle (infraclavicular). The prognosis for patients depends on the extent of nerve damage. If nerve damage is mild and the nerve remains intact, spontaneous recovery may occur. However, if the nerve is severed, severely damaged, or avulsed from the spinal cord, recovery without surgical intervention is unlikely (Hems, 2015).

The preserved supraclavicular nerve technique aims to preserve the supraclavicular nerve during the surgical procedure to reduce postoperative numbness. (Pierro et al., 2023) The advantage of this method is a potentially lower incidence of numbness and increased patient satisfaction regarding sensation around the incision area. However, disadvantages include a possible increase in surgical time and the risk of other surgical complications related to nerve preservation efforts (Li et al., 2017).

Conversely, the non-preserved supraclavicular nerve technique does not prioritize nerve preservation during surgery, which in the long term can result in issues

such as bothersome postoperative numbness. The advantages of this method are that it is usually quicker and technically simpler, reducing surgical time and potential technical complications. However, patients with non-preserved supraclavicular nerves have a prolonged postoperative numbness rate of up to 86%, which can diminish the patient's quality of life (Huang et al., 2021). Nerve healing is a complex mechanism involving several stages, starting with Wallerian degeneration, in which the distal part of the injured nerve undergoes degeneration to prepare a regenerative environment. Afterward, axon regeneration begins, with nerve fibers growing back from the injury site toward the target tissue, although growth is slow, averaging about 1 mm per day. Reinnervation occurs if the growing axons successfully reach the target tissue, allowing sensory function recovery. However, this recovery is often not completely perfect and may leave residual functional or sensory impairments. Recent studies indicate that factors such as the microenvironment of the nerve, interaction with Schwann cells, and timing of intervention significantly affect the success of nerve regeneration and reinnervation. A deeper understanding of this nerve healing process is essential in formulating postoperative care strategies, particularly in the context of supraclavicular nerve injury, which affects sensory and motor function in the shoulder and arm area (Menorca et al., 2013).

The Douleur Neuropathique 4 Questions (DN4) is a screening tool used to help diagnose neuropathic pain, which is pain caused by injury or dysfunction in the nervous system. DN4 consists of ten questions covering two components: a clinical interview and a physical examination. The first four questions focus on subjective symptoms reported by patients, such as burning sensations, unusual cold sensations, tingling, or electric shocks. The remaining six questions involve a physical examination to assess whether the

patient experiences hyperalgesia (increased sensitivity to pain), allodynia (pain due to normally non-painful stimuli), or decreased sensitivity to touch and needles. This tool is clinically important as it helps differentiate between neuropathic pain and other types of pain, such as nociceptive pain. Thus, DN4 assists clinicians in selecting more appropriate therapy for patients, given that neuropathic pain management often differs from other types of pain (Aho et al., 2020). The importance of understanding functional outcomes and sensory disturbances in clavicle fracture fixation surgery techniques will facilitate the determination of surgical techniques and the execution of clavicle fracture fixation procedures. This study aims to assess the differences in the Disability of the Arm, Shoulder, and Hand (DASH) score and the Douleur Neuropathique 4 (DN4) score in clavicle fracture patients post-ORIF Plate and Screw (ORIF PS) with preserved and non-preserved supraclavicular nerves.

MATERIALS & METHODS

This study is a cohort study conducted following the collection of independent variable data based on medical records. It was conducted after the collection of independent variable data (ORIF PS + preserved nerve and ORIF PS + non-preserved nerve), which was not collected by the researcher but obtained from medical records. A longitudinal review of medical records was conducted, observing outcomes in the form of DASH and DN4 scores at the 3rd and 6th months in a population of patients with closed middle-third clavicle fractures. A longitudinal review of medical records was conducted, observing outcomes in the form of DASH and DN4 scores at the 3rd and 6th months in a population of patients with closed middle-third clavicle fractures. The sample in this study consisted of 36 patients with middle-third clavicle fractures who underwent operative treatment with ORIF PS + preserved supraclavicular nerve and ORIF PS + non-

preserved supraclavicular nerve, meeting inclusion criteria and not meeting exclusion criteria. The inclusion criteria including patients age between 18-65 years; patients with middle-third clavicle fractures; patients with middle-third clavicle fractures who have undergone operative treatment.

Meanwhile, the exclusion criteria including patients who refuse to participate in the study after being given informed consent; patients who cannot be followed up (lost to follow-up); patients with non-displaced middle-third clavicle fractures; patients with motor deficits on the fracture side; patients with mental disorders; patients with injuries on the ipsilateral upper limb or rib injuries causing functional impairment; patients with pathological fractures. Statistical analysis was performed using SPSS software version 25.0.

RESULT

In this study, data were obtained from 51 patients with clavicle fractures who underwent open reduction and internal

fixation with plate and screw using an anterior approach starting in January 2024 at RSUP Prof. Dr. I.G.N.G. Ngoerah, Denpasar, Bali. The study divided these patients into two groups: 24 patients with preserved supraclavicular nerves and 27 patients with non-preserved supraclavicular nerves.

In the group with preserved supraclavicular nerves, 18 patients (75.0%) were male and 6 patients (25.0%) were female, with an average age of 42.13 ± 17.68 years. In the non-preserved supraclavicular nerve group, 18 patients (66.7%) were male and 9 patients (33.3%) were female, with an average age of 39.41 ± 14.23 years.

There were no significant differences in age (years) or gender between the preserved and non-preserved supraclavicular nerve groups ($p > 0.05$). The characteristics of clavicle fracture patients who underwent open reduction and internal fixation with preserved and non-preserved supraclavicular nerves are shown in table 1.

Table 1. Patient Characteristics with Preserved Supraclavicular Nerve and Non-preserved Supraclavicular Nerve

| Characteristic | Total n=51 (%) | Group | P value |
|-----------------------------|-------------------|--|--|
| | | Preserved Supraclavicular Nerve n=24 (%) | Non-preserved Supraclavicular Nerve n=27 (%) |
| Gender | | | |
| Male | 36 (70.6) | 18 (75.0) | 18 (66.7) |
| Female | 15 (29.4) | 6 (25.0) | 9 (33.3) |
| Age (years) (mean \pm SD) | 40.69 \pm 15.84 | 42.13 \pm 17.68 | 39.41 \pm 14.23 |

Note: Chi-square test, Independent t-test

Analysis of DN4 Score Differences in Both Patient Groups in the Third Month

This study compared the DN4 scores between the preserved supraclavicular nerve and non-preserved supraclavicular nerve groups in the third month. The Kolmogorov-Smirnov test for sample normality showed that the DN4 scores were not normally distributed ($p < 0.05$).

Therefore, the non-parametric Mann-Whitney test was used.

The median ranking of the DN4 score in the third month for patients in the preserved supraclavicular nerve group was higher than in the non-preserved group. However, the Mann-Whitney test showed no statistically significant difference in DN4 scores between the preserved and non-preserved groups in the third month ($p=0.347$).

Table 2. Analysis of DN4 Score Differences in Both Patient Groups in the Third Month

| Patient Group | Median (min-max) | P value |
|--|------------------|---------|
| Preserved Supraclavicular Nerve (n=24) | 1.00 (0-3) | 0.347 |
| Non-preserved Supraclavicular Nerve (n=27) | 1.00 (0-3) | |

Mann-Whitney test. Median rank for preserved group: 27.98; non-preserved group: 24.24

Analysis of DN4 Score Differences in Both Patient Groups in the Sixth Month

This study compared DN4 scores in the sixth month between preserved and non-preserved supraclavicular nerve groups. The Kolmogorov-Smirnov test for normality showed non-normal distribution ($p < 0.05$), so the Mann-Whitney test was used.

The median ranking of DN4 scores in the sixth month was lower in the preserved nerve group than in the non-preserved group. The Mann-Whitney test showed a statistically significant difference in DN4 scores between groups in the sixth month ($p=0.012$).

Table 3. Analysis of DN4 Score Differences in the Sixth Month

| Patient Group | Median (min-max) | P value |
|--|------------------|---------|
| Preserved Supraclavicular Nerve (n=24) | 0.00 (0-1) | 0.012 |
| Non-preserved Supraclavicular Nerve (n=27) | 0.00 (0-2) | |

Mann-Whitney test. Median rank for preserved group: 21.63; non-preserved group: 29.89

Analysis of DASH Score Differences in Both Patient Groups in the Third Month

This study compared the DASH scores between the preserved and non-preserved supraclavicular nerve groups in the third month. The Kolmogorov-Smirnov test showed that the DASH scores were normally distributed ($p > 0.05$). A parametric independent t-test was then used.

The average DASH score in the preserved group was lower than in the non-preserved group in the third month. Levene's test for homogeneity indicated homogenous data ($p=0.526$). The independent t-test showed a statistically significant difference in DASH scores between groups in the third month ($p < 0.001$).

Table 4. Analysis of DASH Score Differences in the Third Month

| Patient Group | Mean \pm SD | P value | Mean Difference (95% CI) |
|--|-----------------|---------|--------------------------|
| Preserved Supraclavicular Nerve (n=24) | 5.58 \pm 2.26 | <0.001 | -2.19 (-3.36 to -1.03) |
| Non-preserved Supraclavicular Nerve (n=27) | 7.78 \pm 1.87 | | |

Independent t-test; SD: Standard Deviation

Analysis of DASH Score Differences in Both Patient Groups in the Sixth Month

The study compared DASH scores in the sixth month for preserved and non-preserved groups. Kolmogorov-Smirnov testing indicated non-normal distribution ($p < 0.05$), so the Mann-Whitney test was applied.

The median ranking of DASH scores in the sixth month was lower in the preserved group than in the non-preserved group. However, the Mann-Whitney test showed no statistically significant difference between the groups in the sixth month ($p=0.210$).

Table 5 Analysis of DASH Score Differences in the Sixth Month

| Patient Group | Median (min-max) | P value |
|--|------------------|---------|
| Preserved Supraclavicular Nerve (n=24) | 1.25 (0-4.2) | 0.210 |
| Non-preserved Supraclavicular Nerve (n=27) | 1.70 (0-4.2) | |

Mann-Whitney test. Median rank for preserved group: 23.31; non-preserved group: 28.39

Analysis of DASH Score Differences Between Third and Sixth Months in the Preserved and Non-preserved Groups

This study compared DASH scores between the third and sixth months for both groups. Kolmogorov-Smirnov testing indicated non-normal distribution ($p < 0.05$), so the non-parametric Wilcoxon test was applied.

For the preserved group, the Wilcoxon test showed a statistically significant reduction in DASH scores from the third to sixth month ($p < 0.001$). The non-preserved group also showed a significant reduction in DASH scores between these months ($p < 0.001$).

Table 6. Analysis of DASH Score Differences Between Third and Sixth Months in Preserved and Non-preserved Groups

| Variable | Group | Third Month | Sixth Month | P value |
|------------|----------------------|-----------------|----------------|---------|
| DASH Score | Preserved (n=24) | 5.80 (2.5-10.0) | 1.25 (0.0-4.2) | <0.001 |
| | Non-preserved (n=27) | 7.50 (3.3-10.8) | 1.70 (0.0-4.2) | |

Wilcoxon test. P: Preserved supraclavicular nerve; NP: Non-preserved supraclavicular nerve. Preserved group negative ranks: 23; positive ranks: 0; ties: 1. Non-preserved group negative ranks: 27; positive ranks: 0; ties: 0.

Analysis of DN4 Score Differences Between Third and Sixth Months in the Preserved and Non-preserved Groups

This study compared DN4 scores between the third and sixth months for both groups. The Kolmogorov-Smirnov test indicated non-normal distribution ($p < 0.05$), so the Wilcoxon test was used.

For the preserved group, the Wilcoxon test showed a statistically significant reduction in DN4 scores between the third and sixth months ($p < 0.001$). In the non-preserved group, a significant reduction in DN4 scores was also found between these months ($p = 0.004$).

Table 7. Analysis of DN4 Score Differences Between Third and Sixth Months in Preserved and Non-preserved Groups

| Variable | Group | Third Month | Sixth Month | P value |
|-----------|----------------------|-------------|-------------|---------|
| DN4 Score | Preserved (n=24) | 1.00 (0-3) | 0 (0-1) | <0.001 |
| | Non-preserved (n=27) | 1.00 (0-3) | 0 (0-1) | |

Wilcoxon test. P: Preserved supraclavicular nerve; NP: Non-preserved supraclavicular nerve. Preserved group negative ranks: 23; positive ranks: 0; ties: 1. Non-preserved group negative ranks: 27; positive ranks: 0; ties: 0.

DISCUSSION

This study involved 51 patients with clavicle fractures who underwent open reduction and internal fixation (ORIF) surgery with an anterior approach at RSUP

Prof. Dr. I.G.N.G. Ngoerah, Denpasar, Bali. Patients were divided into two groups: 24 patients in the preserved supraclavicular nerve group and 27 in the non-preserved supraclavicular nerve group. The preserved

group included 18 males (75%) and 6 females (25%), with an average age of 42.13 ± 17.68 years. The non-preserved group included 18 males (66.7%) and 9 females (33.3%), with an average age of 39.41 ± 14.23 years. Statistical analysis showed no significant differences in age and gender characteristics between the two groups ($p > 0.05$). This homogeneity ensures that there are no fundamental group characteristic differences, minimizing potential confounding factors in this study. The risk of bias due to confounding factors is minimal, as it was controlled through inclusion and exclusion criteria.

Analysis of DN4 Score Differences Between the Two Patient Groups in the Third Month

In the third month after surgery, DN4 score analysis showed that the mean ranking in the preserved supraclavicular nerve group was higher than in the non-preserved group. However, this difference was not statistically significant ($p=0.347$), indicating that neuropathic pain was similar between the two groups in the early recovery phase. This may be due to the initial adaptation period during which preserved nerves are still in the healing and regeneration process. Other studies, such as Zhang et al., also noted that the benefits of nerve preservation may take longer to become apparent, as nerve healing affects short-term pain levels (Zhang et al., 2019). Li et al. reported similar findings, showing that it took at least two weeks to observe differences in sensory reduction in the medial and lateral areas (Li et al., 2017). Based on this discussion, where DN4 scores did not differ significantly between groups in the third month, hypothesis 1 is not accepted.

Analysis of DN4 Score Differences Between the Two Patient Groups in the Sixth Month

In the sixth month, the average DN4 score ranking in the preserved supraclavicular nerve group was lower than in the non-

preserved group, with a statistically significant difference ($p=0.012$). This result indicates that nerve preservation provides clearer long-term benefits in reducing neuropathic pain. These findings align with research by Pierro et al., which showed that nerve preservation reduces the incidence of neuropathic pain in post-operative clavicle fracture patients, suggesting that preserved nerves may protect against chronic neuropathic pain (Pierro et al., 2023). Based on this discussion, where DN4 scores differed significantly between groups in the sixth month, hypothesis 1 is accepted.

Analysis of DASH Score Differences Between the Two Patient Groups in the Third Month

In the third month, the average DASH score in the preserved supraclavicular nerve group was lower than in the non-preserved group, with a statistically significant difference ($p<0.001$). This suggests that nerve preservation offers quicker functional benefits, likely due to faster pain reduction and sensory improvement. Faster pain reduction enables patients to be more active in rehabilitation and daily activities, contributing to improved arm function. Other studies also indicate that patients who undergo nerve preservation procedures report lower levels of pain and numbness, as well as better arm function compared to the non-preserved group. Although DASH score differences between the two groups were not significant at a one-year follow-up, better improvement trends were observed in the preserved group (Hu, Su, and Chien, 2023). This finding supports previous studies indicating that supraclavicular nerve preservation reduces the risk of post-operative complications such as chronic pain and numbness (Shukla et al., 2017). Based on this discussion, where DASH scores differed significantly between groups in the third month, hypothesis 1 is accepted.

Analysis of DASH Score Differences Between the Two Patient Groups in the Sixth Month

In the sixth month, the average DASH score ranking in the preserved supraclavicular nerve group was lower than in the non-preserved group, though the difference was not statistically significant ($p=0.210$). This suggests that other factors, such as rehabilitation and muscle recovery, also play essential roles in long-term functional outcomes. Although the early benefits of nerve preservation were more visible, long-term functional improvement may be influenced by other factors related to healing and rehabilitation processes. Similar findings have been reported in other studies, where rehabilitation stages contribute to both functional and sensory improvements in the shoulder area (Huang et al., 2021). Based on this discussion, where DASH scores did not differ significantly between groups in the sixth month, hypothesis 1 is not accepted.

Analysis of DASH Score Differences in the Preserved and Non-preserved Groups Between the Third and Sixth Months

In the preserved supraclavicular nerve group, a significant reduction in DASH scores was observed between the third and sixth months ($p<0.001$). This result indicates sustained and significant arm function improvement after surgery. The significant decrease in DASH scores suggests that patients with preserved supraclavicular nerves experience continuous functional improvement, supporting the importance of nerve preservation for better long-term functional outcomes. Studies also report similar findings on shoulder function improvement using conventional clavicle fracture fixation techniques (Longo et al., 2011).

In the non-preserved supraclavicular nerve group, a significant reduction in DASH scores was also observed between the third and sixth months ($p<0.001$). This suggests that, although without nerve preservation,

arm function improves over time. However, this improvement may not be as substantial as in the preserved group, indicating that nerve preservation may provide additional functional benefits. Differences in post-operative shoulder function outcomes were also reported by Robinson et al., showing improvement in sixth-month follow-ups (Robinson et al., 2013). Based on this discussion, where DASH scores differed significantly between groups in the third and sixth months, hypothesis 1 is accepted.

Analysis of DN4 Score Differences in the Preserved and Non-preserved Groups Between the Third and Sixth Months

In the preserved supraclavicular nerve group, DN4 scores also showed a significant decrease between the third and sixth months ($p<0.001$). This indicates a continued reduction in neuropathic pain, supporting the effectiveness of nerve preservation in reducing long-term pain. The significant pain reduction between the third and sixth months shows that preserved nerves play an essential role in reducing neuropathic pain over time. A study by Wang et al. demonstrated that vertical incision techniques reduce post-operative sensory disturbances and increase patient satisfaction at the six-month follow-up (Wang et al., 2010). Based on this discussion, where DN4 scores differed significantly between groups in the third and sixth months, hypothesis 1 is accepted.

In the non-preserved supraclavicular nerve group, DN4 scores also showed a significant decrease between the third and sixth months ($p=0.004$). This indicates that neuropathic pain reduction occurs in this group as well, though perhaps not as effectively as in the preserved group. This suggests that, although neuropathic pain decreases over time in both groups, nerve preservation provides additional benefits in reducing neuropathic pain. Based on this discussion, where DN4 scores differed significantly between groups in the third and sixth months, hypothesis 1 is accepted.

This study shows that preserving the supraclavicular nerve in clavicle ORIF surgery provides significant benefits in reducing neuropathic pain and improving long-term arm function. These results align with the existing literature, such as studies by Lemieux et al. and Li et al., showing that nerve preservation can reduce the incidence of neuropathic pain and improve functional outcomes in post-operative patients (Lemieux et al., 2021).

CONCLUSION

Preserving the supraclavicular nerve during ORIF for clavicle fractures significantly reduces neuropathic pain (DN4 score) and improves arm function (DASH score) at specific time intervals, notably at six months post-operation. The findings emphasize the importance of nerve preservation for achieving better long-term functional outcomes and reducing neuropathic complications in clavicle fracture surgery. For future research, it is recommended to conduct prospective studies with a longer follow-up to evaluate the prolonged benefits of supraclavicular nerve preservation. Additionally, implementing a double-blind sampling method could minimize bias, thereby providing more robust data. Further exploration into other factors affecting functional and neuropathic outcomes in these patients would also be valuable.

Declaration by Authors

Ethical Approval: This study was approved by the Research Ethics Committee Faculty of Medicine Udayana University, Denpasar, Bali, Indonesia. The Ethical Clearance is provided under the approval of the Chairman of the Committee

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