J Shoulder Elbow Surg (2019) 28, 1308–1315

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Comparison of the effectiveness of oblique and transverse incisions in the treatment of fractures of the middle and outer third of the clavicle

Renbin Li, MS[a,*,1], Tie Ke, MS[b,1], Shengren Xiong, MS[a], Guosheng Xiong, MS[a], Zheng Lin, MD[c], Fengfei Lin, BS[a,*]

[a]*Department of Orthopedics, the Second Fuzhou Hospital Affiliated to Xiamen University, Fuzhou, Fujian, China*
[b]*Department of Emergency Surgery, Fujian Provincial Hospital; Emergency Center of Fujian Province; Provincial Clinical Medical College, Fujian Medical University, Fuzhou, Fujian, China*
[c]*Department of Epidemiology and Health Statistics, Fujian Provincial Key Laboratory of Environment Factors and Cancer, School of Public Health, Fuzhou, Fujian, China*

Background: Iatrogenic supraclavicular nerve injury is frequent during surgical repair of clavicle fractures through a transverse incision. The use of an oblique incision may be a potential approach to avoiding this complication. This study compared the clinical effectiveness of oblique and transverse incisions in the treatment of fractures in the middle and outer thirds of the clavicle.
Methods: This prospective observational study included patients with fracture of the mid-to-outer third of the clavicle between August 2011 and August 2016. We allocated the patients into 2 groups based on their choice of treatment: oblique incision (n = 62) and transverse incision (n = 64). We compared the following parameters between the 2 groups: operative time, intraoperative blood loss, postoperative fracture healing time, incision size, clinical complications, postoperative subjective satisfaction, and shoulder function.
Results: Operative time, postoperative fracture healing time, postoperative shoulder function (Constant-Murley and disabilities of the arm, shoulder and hand [DASH] scores), and clinical complications did not differ significantly between groups (all $P > .05$). The oblique incision group had less intraoperative blood loss (41.4 ± 16.4 vs. 65.3 ± 10.4 mL, $P < .001$) and smaller surgical incisions (3.6 ± 1.6 vs. 10.3 ± 2.6 cm, $P < .001$). The oblique incision group showed better outcomes for postoperative satisfaction (85.5% vs. 64.1%, $P = .015$), absence of shoulder numbness at the last follow-up (89.3% vs. 70.3%, $P = .010$), and satisfaction with the scar (90.3% vs. 3.1%, $P < .001$).
Conclusion: Oblique incisions have several advantages over transverse incisions: less bleeding, smaller incisions, less iatrogenic injury to supraclavicular nerves, and higher patient satisfaction. These 2 approaches have equivalent effects on recovery of shoulder joint function.

This study was approved by the ethics committee of the Second Fuzhou Hospital Affiliated to Xiamen University (Approval No. FZSE2011-06-09). Written informed consent was obtained from all participants.

[1] These authors contributed equally to this work.

*Reprint requests: Renbin Li, MS, and Fengfei Lin, BS, Department of Orthopaedics, the Second Fuzhou Hospital Affiliated to Xiamen University, Fuzhou, Fujian, 350007, China.

E-mail addresses: 892675411@qq.com (R. Li); 596558644@qq.com (F. Lin).

https://doi.org/10.1016/j.jse.2019.03.021

Level of evidence: Level II; Prospective Cohort Design; Treatment Study

Keywords: Surgery; surgical incision; clavicle fracture; plate; internal fixation

Clavicle fractures account for 2.6% to 5.0% of all human fractures, and nearly 80% of clavicle fractures occur in the middle and outer third segments.[12,18] Most clavicle fractures heal uneventfully without serious consequences with nonoperative treatment, but several patients with complex fractures experience residual deformity, impaired function, or unsightly appearance.[11,15] Therefore, surgery has become the main treatment strategy for displaced fractures in the middle and outer thirds of the clavicle.[8,12,14,18]

Nail fixation is a good option with few complications for simple fractures[8-10,13,20] but is not appropriate for comminuted factures, and the anatomic plate is still considered the first choice treatment method.[7,22] Precontoured locking plates have advantageous biomechanical properties and low complication rates in the elderly,[2-4,22] but supraclavicular neuropathy and numbness may occur because of damage to the supraclavicular nerve.[5]

The incision can be made longitudinally along the subcutaneous border of the clavicle or as a necklace incision along the Langer lines. Although such incisions achieve satisfactory outcomes, a surgical scar and iatrogenic injury of the supraclavicular nerve are possible,[1] which occurs with a frequency of 10% to 29%.[19] Several authors attempted to use a necklace incision with a transverse incision to reveal the supraclavicular nerve and avoid iatrogenic supraclavicular nerve injury.[5,17]

The line running between the condyle tip and the midpoint of the sternocleidomastoid muscle is located on the lateral side of the lateral branch of the supraclavicular nerve middle group. We used this anatomic feature to design a new type of incision that is located where the line joining the lateral border of the condylar process apex and the posterior border of the sternocleidomastoid muscle intersects with the clavicle. The lateral side of the lateral branch of the supraclavicular nerve middle group often runs parallel to the location of this incision, so the use of this oblique incision could theoretically reduce damage to the supraclavicular nerve. We hypothesized that this incision can be performed easily and would reduce the risk of iatrogenic supraclavicular nerve injury. Hence, the aim of the present study was to examine the effectiveness and clinical outcomes of the oblique incision and transverse incision in the treatment of fractures in the middle and outer thirds of the clavicle.

Materials and methods

Study design and patients

This prospective cohort study enrolled patients with fractures in the middle and outer thirds of the clavicle treated at the Second Fuzhou Hospital Affiliated to Xiamen University between August 2011 and August 2016.

The inclusion criteria were: (1) confirmed clavicle fractures in the middle and outer third, Robinson types 2A2, 2B1, and 2B2;[16] (2) >18 years of age; (3) time interval between injury and surgery ≤ 2 weeks; and (4) unilateral clavicle fracture. The exclusion criteria were: (1) pathological fracture; (2) open fracture; (3) preoperative ipsilateral shoulder and upper limb dysfunction; (4) multiple fractures; (5) other organ injuries; and (6) follow-up duration of <12 months.

Grouping

We carefully explained the possible surgical approaches to each patient and answered all their questions. We explained to the patients that both surgical procedures can be implemented successfully but that there are differences between them. We highlighted the following aspects: (1) the traditional transverse incision results in a large postoperative scar, which can affect appearance postoperatively; (2) the traditional transverse incision is associated with the possibility of supraclavicular nerve injury during surgery, which would result in postoperative sensory dysfunction in the skin overlying the affected shoulder and upper chest (with symptoms such as dry skin, keratinization and exfoliation, and dysfunction of touch, pain, temperature, and position sensation); (3) the oblique incision is smaller than the transverse incision, which may improve postoperative appearance; (4) the oblique incision is theoretically associated with a lower risk of supraclavicular nerve injury during surgery; and (5) the oblique incision is a new technique that is technically more demanding and thus might be associated with other risks not yet fully characterized, such as a higher risk of plate loosening. The patient selected the approach he or she preferred.

Intervention

The same team of 3 surgeons (1 senior orthopedist and 2 senior attending surgeons), all of whom had previous experience of 20 operations using oblique incisions for clavicle fractures, carried out the surgeries in the oblique incision group. Two groups of surgeons (4 senior orthopedists and 2 senior surgeons), all of whom perform more than 50 operations for clavicle fractures annually, performed the surgeries in the transverse incision group.

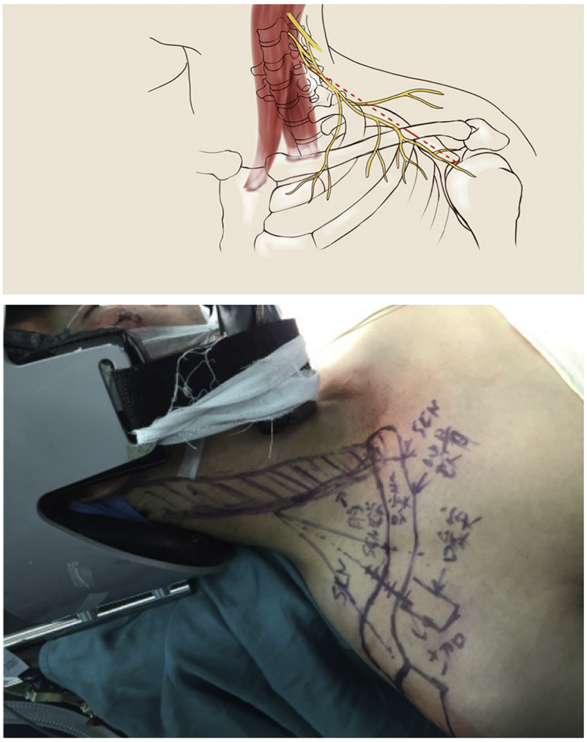

Figure 1 The oblique incision technique. The oblique incision is located on the line connecting the lateral border of the condylar process apex and the posterior border of the sternocleidomastoid muscle and intersects with the clavicle. The oblique incision can be extended proximally and distally.

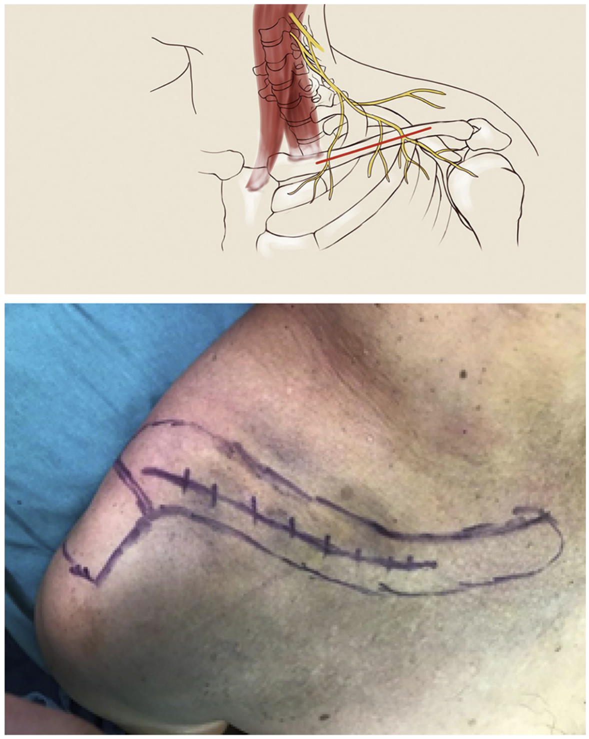

Figure 2 The transverse incision technique. The transverse incision is located along the subcutaneous border of the clavicle and can be extended medially and laterally as necessary.

The oblique incision was located along the line between the lateral border of the condylar process apex and the posterior border of the sternocleidomastoid muscle and intersected with the clavicle; the oblique incision could be extended toward the proximal and distal ends as necessary (Fig. 1). The transverse incision was parallel to the long axis of the clavicle (Fig. 2). We used anatomical plates (3.5 mm) in both groups. For both approaches, we made no specific efforts to look for the supraclavicular nerve, and we adopted no specific protective measures against supraclavicular nerve injury.

For the oblique incision, fracture reduction, and anatomical plate fixation, we positioned the patient in the beach chair position, under general anesthesia and side cervical plexus anesthesia. We designed a surgical incision (Fig. 1), incised the platysma in the direction of the incision, and separated the soft tissue in the gap between the trapezius and deltoid muscles to expose the fracture. We reset the fracture under direct vision and temporarily fixed it with a 1.5-mm Kirschner wire. We made a periosteal detachment along the surface of the clavicle to the proximal end of the clavicle and placed an appropriate length on the upper surface of the clavicle. We placed a steel plate along the clavicle through the incision. The length of the plate had to be at least 3 screws per proximal end of the fracture. We confirmed the position of the steel plate using C-arm X-ray. The distal end of the anatomic plate had to be as close as possible to the distal end of the clavicle. We used the skin window movement technique to implant ordinary cortical screws percutaneously, 3.5 mm proximal to the proximal end of the fracture. We performed fluoroscopy to confirm fracture reduction and the plate/screw position. We closed the wound after irrigation without the use of a drain. We provided routine postoperative treatment and functional exercises.

We managed the transverse incision group in the same way as the oblique incision group, except for the following. We made the incision (8-12 cm) along the longitudinal axis of the clavicle around the fractured end (Fig. 2). After electrocoagulation had been used to fully stop the bleeding, we exposed the broken end of the fracture, cleaned up the hematoma, and preserved the blood supply of the soft tissue at the broken end. We removed the broken end of the fracture under direct vision, placed the bone plate above the clavicle, and inserted the inner fixing screw. After observing that the broken end of the fracture was in a suitable position and the length of the screw was appropriate, we washed and closed the incision.

Effectiveness assessment

We evaluated the following parameters in both groups: operative time, intraoperative blood loss, postoperative fracture healing time, incision size, subjective satisfaction survey, and shoulder function. We estimated intraoperative blood loss by weighing the gauzes before and after surgery (we considered 1 g of blood to represent 1 mL of blood); the amount of blood in the aspirator bottle was added. We defined the healing time of the fracture as the time from surgery to the time when the clavicle was locally pain free and percussive pain free and the patient was able to maintain a 1 kg weight for 1 minute with the upper extremity extended. The imaging index for fracture healing was callus spanning 50% of the fracture end. We measured the incision size when the stitches were taken out.

We evaluated shoulder joint function based on the Constant-Murley and DASH scores. We conducted a subjective patient satisfaction survey using a questionnaire that included the following items: (1) Did you experience numbness in your shoulder or anterior chest after surgery (yes/no)? (2) Do you currently feel numbness in your shoulder or anterior chest (severe/obvious/moderate/slight/no)? (3) Are you satisfied with the appearance of the scar (satisfied/unsure/dissatisfied)? (4) Are you generally satisfied with this surgery (satisfied/unsure/dissatisfied)?

Follow-up

The follow-up time points were 1, 2, 3, 6, 12, 18, and 24 months, and then yearly for a total of 5 years.

Statistical analysis

We performed the statistical analysis using SPSS 20.0 (IBM, Armonk, NY, USA). We used the Shapiro-Wilk test to determine whether continuous data were normally distributed. Age, operative time, intraoperative blood loss, time of fracture healing, incision size, DASH score, and Constant-Murley score were found to be normally distributed and are presented as the mean ± standard deviation. We analyzed continuous data with equal variances using the independent-samples *t*-test, and continuous data with unequal variances using the Satterthwaite *t*'-test. We analyzed categorical data using the chi-squared test. We performed linear regression analysis to identify factors influencing DASH scores and surgical blood loss. We considered $P < .05$ to indicate a statistically significant difference.

Results

Characteristics of the patients

We screened 176 patients for participation between August 2011 and August 2016, and we enrolled 138 patients in the study: 67 in the oblique incision group and 71 in the transverse incision group (Fig. 3). We included 126 patients with sufficient follow-up in the final analysis: 62 in the oblique incision group (follow-up time: 2.8 ± 1.5 years) and 64 in the transverse incision group (follow-up time: 2.7 ± 1.4 years) (Fig. 3). Age, sex, body mass index, follow-up duration, injury-to-operation time, fracture classification, and cause of injury were not significantly different between the 2 groups (Table I).

Surgical characteristics

There were no significant differences between the 2 groups in terms of operation time, fracture healing time, DASH score, and Constant-Murley score. The surgical incision was significantly smaller in the oblique incision group than in the traditional transverse incision group. Intraoperative blood loss was significantly different between the 2 groups (Table II).

Follow-up

The final function of the shoulder and upper limbs was not related to gender, age, dominant upper limb, type of fracture, or surgical method (all $P > .05$). The amount of bleeding was not associated with gender, age, and body mass index ($P > .05$). The amount of bleeding was associated with the surgical method and the type of fracture. The amount of bleeding was smaller in the oblique incision group than in the transverse incision group. Blood loss was greater for more complicated fracture types (Table III).

Complications

Complications occurred in 8 of 62 patients in the oblique incision group (a complication rate of 12.9%). The complications included poor wound healing (n = 2), and loosening of the internal fixation requiring shoulder immobilization for fracture healing (n = 2). The functional scores of 3 patients were lower than those of the other patients. The internal fixation caused local symptoms in 4 patients, but without infection and nonunion.

Eleven of the 64 patients in the transverse incision group had complications (a complication rate of 17.2%): poor wound healing (n = 2), postoperative superficial tissue infection (n = 4), and local symptoms from the internal fixation, but without internal fixation loosening and healing failure (n = 5). There was no significant difference between the 2 groups in complication rate ($P = .502$).

Patient satisfaction

The results of the questionnaire assessing numbness in the shoulder or chest area and patient satisfaction were better in the oblique incision group than in the transverse incision group (Table IV).

Discussion

The use of an oblique incision may be a potential approach to address iatrogenic supraclavicular nerve injury and poor cosmetic appearance. Therefore, the aim of the present study was to compare the clinical effectiveness of oblique and transverse incisions in the treatment of fractures in the middle and outer thirds of the clavicle. The results showed that oblique incisions have several advantages over transverse incisions: less bleeding, smaller incisions, less injury to iatrogenic supraclavicular nerves, and higher patient satisfaction. These 2 treatments have equivalent therapeutic effects on shoulder joint function recovery.

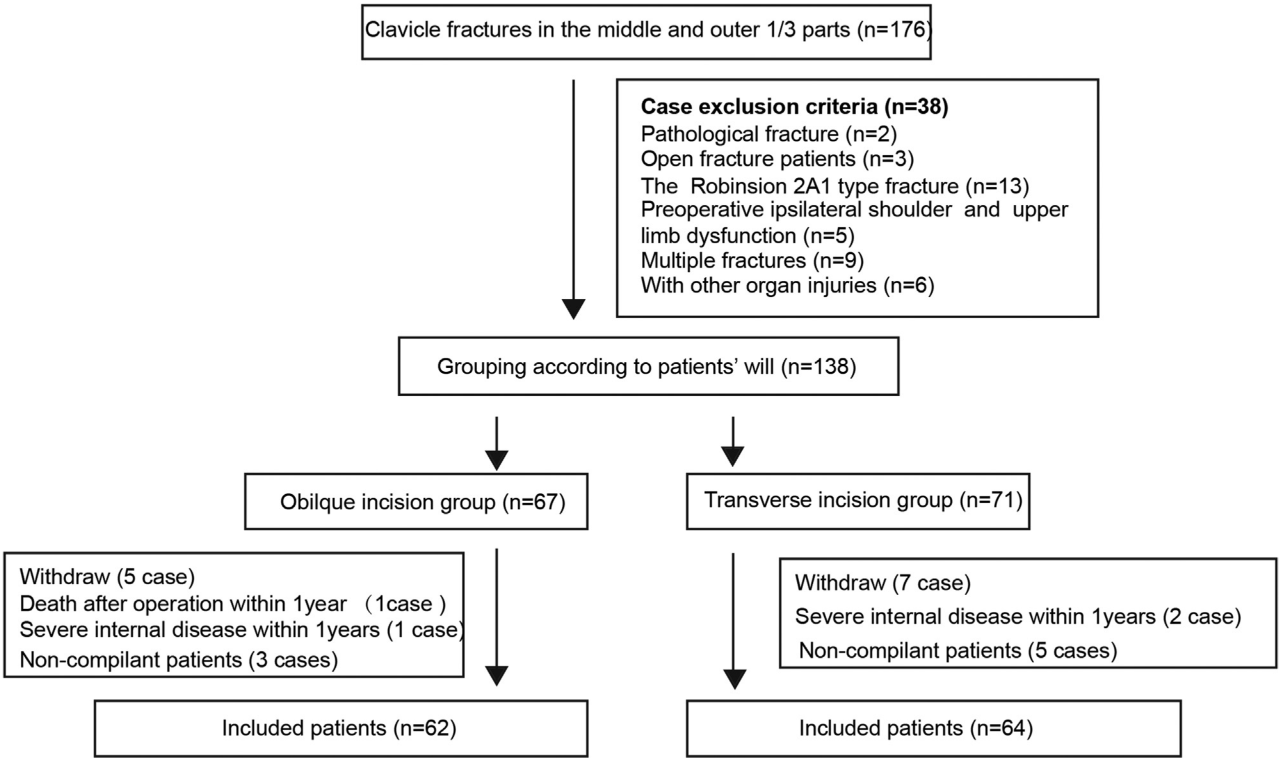

Figure 3 Study flowchart.

Steel plates are considered a "gold standard" treatment for midclavicular fractures[21] and can provide rigid fixation and strong antirotation stability.[7,22] Plate treatment of fractures in the middle and outer thirds of the clavicle yields good results,[7,22] Anatomically locking reconstructive steel plates have biomechanical advantages for the healing of fractures because they can be used to pressurize the fracture ends to promote healing.[2-4,22]

Transverse incisions are usually used in the treatment of fractures of the middle and outer thirds of the clavicle, but these incisions are usually long (10.3 ± 2.6 cm in the present study), leading to more extensive surgical trauma and bleeding and a higher risk of supraclavicular nerve injury. The use of a transverse incision was associated with high rates of postoperative traumatic neuroma formation and numbness/discomfort of the skin overlying the shoulder

Table I Characteristics of the patients

	Oblique incision (n = 62)	Transverse incision (n = 64)	*P*
Age (yr)	35.9 ± 10.3	37.6 ± 11.0	.393
Sex: male (n, %)	37, 59.7	40, 62.5	.901
Body mass index (kg/m^2)	24.1 ± 2.9	24.0 ± 2.9	.473
Follow-up (yr)	2.8 ± 1.5	2.7 ± 1.4	.699
Dominant hand (n, %)	27, 43.5	31, 48.4	.582
Duration (injury to surgery, d)	4.6 ± 1.5	3.5 ± 1.6	.586
Fracture (Robinson type, n, %)			.626
2A2	14, 22.6	11, 17.2	
2B1	30, 48.4	30, 46.9	
2B2	18, 29.0	23, 35.9	
Injury causes (n, %)			.694
Motorcycle injury	21, 33.9	24, 38.1	
Bicycle injury	14, 22.6	18, 28.6	
Sports injury	17, 27.4	13, 20.6	
Others	10, 16.1	8, 12.7	

Table II Surgical characteristics of the patients

	Oblique incision (n = 62)	Transverse incision (n = 64)	*P*
Surgical time (min)	60 ± 11	61 ± 8	.582
Intraoperative blood loss (mL)	41 ± 16	65 ± 10	<.001*
Fracture healing time (mo)	4.5 ± 1.6	4.7 ± 1.4	.456
Incision size (cm)	3.6 ± 1.6	10.3 ± 2.6	<.001
DASH score	6.7 ± 2.1	7.3 ± 1.8	.066
Constant-Murley score	88.0 ± 5.4	87.2 ± 4.2	.348
Complications (n, %)	8, 12.9	11, 17.2	.502
Poor wound healing	2	2	
Loosening of the internal fixation	2	0	
Local symptoms caused by internal fixation	4	5	
Postoperative superficial tissue infection	0	4	

DASH, disabilities of the arm, shoulder and hand.
* The differences in bleeding between the 2 groups were determined using the Satterthwaite *t*'-test.

and thorax. In the transverse incision group, the incidence of supraclavicular nerve injury was as high as 85.9% (55 of 64) at 1 month after the operation, and 30.0% (19 of 64) of patients had symptoms of supraclavicular nerve injury at their final follow-up. The incision size (3.6 ± 1.6 cm) and bleeding amount (41.4 ± 16.4 mL) in the oblique incision group were significantly smaller than the corresponding values in the transverse incision group. Our results strongly suggest that the rate of postoperative supraclavicular nerve injury in the oblique incision group was only 21.0% (13 of 62) and that the rate of residual supraclavicular nerve symptoms at the last follow-up was 8.1% (5 of 62). Considering the anatomical variations of the supraclavicular nerve during surgery and the intraoperative tension, the oblique and transverse incision groups differed significantly in the occurrence of supraclavicular nerve

Table III Constant-Murley score, DASH score, and intraoperative blood loss analysis

	Regression coefficient	*P*
Constant-Murley score		
Sex (female vs. male)	1.044	.260
Age	−0.069	.080
Dominant hand (yes vs. no)	−1.782	.061
Fracture type		
(2B1 vs. 2A2)	−1.647	.172
(2B2 vs. 2A2)	−2.115	.125
Surgery (oblique incision vs. transverse incision)	−0.613	.475
DASH score		
Sex (female vs. male)	0.143	.703
Age	0.016	.323
Dominant hand (yes vs. no)	0.582	.130
Fracture type		
(2B1 vs. 2A2)	0.337	.490
(2B2 vs. 2A2)	0.942	.092
Surgery (oblique incision vs. transverse incision)	0.557	.111
Intraoperative blood loss		
Sex (female vs. male)	2.457	.267
Age	−0.194	.074
Dominant hand (yes vs. no)	0.114	.759
Fracture type		
(2B1 vs. 2A2)	16.299	<.001
(2B2 vs. 2A2)	22.582	<.001
Surgery (oblique incision vs. transverse incision)	23.020	<.001

DASH, disabilities of the arm, shoulder and hand.

Table IV Patient satisfaction

Variable	Oblique incision	Transverse incision	P*
Postoperative shoulder or chest numbness			<.001
Yes	13 (21.0)	55 (85.9)	
No	49 (79.0)	9 (14.1)	
Current shoulder or chest numbness			.010
Yes	3 (4.8)	8 (12.5)	
Slight	2 (3.2)	11 (17.2)	
No	54 (89.3)	45 (70.3)	
Satisfaction of the scar			<.001
Yes	56 (90.3)	2 (3.1)	
Unsure	3 (4.8)	36 (56.3)	
No	3 (4.8)	26 (40.6)	
Satisfaction for this surgery			.015
Yes	53 (85.5)	41 (64.1)	
Unsure	6 (9.7)	11 (17.2)	
No	3 (4.8)	12 (18.8)	

Data are presented as n (%).
* The chi-square test was used to compare the 2 groups.

injury. Nevertheless, both approaches resulted in similar fracture healing time, DASH score, Constant-Murley score, and clinical complication rates. The overall satisfaction was higher in the oblique incision group than in the transverse incision group. Hence, despite similar biomechanical and complication outcomes, we believe that the lower occurrence of iatrogenic supraclavicular nerve damage and the smaller incisions in the oblique incision group are clinically significant.

In our study, the size of the oblique incision was smaller than that of the transverse incision. An oblique incision of this size would only be suitable for fractures in the middle segment of the clavicle and would not be suitable for fractures of the lateral and medial ends of the clavicle. However, the length of the incision (proximal and distal) and the position of the incision (medial to lateral) could be adjusted as necessary to accommodate the fracture type, fraction location, and length of plate required. Thus, the surgical technique could potentially be adapted to allow management of fractures of the lateral and medial ends of the clavicle.

Another issue that requires consideration is that the use of an oblique incision is a more demanding surgical technique with regard to plate positioning and screwing. The collarbone is an irregular bone, and the curvatures of the proximal and distal concaves of the clavicle are not always the same among individuals. Surgeons without experience in this approach may find it difficult to place the steel plate. Thus, the oblique incision might be associated with a higher risk of plate loosening. Although there was no significant difference between groups in overall complication rate, it was noticeable that loosening of the internal fixation occurred in 2 patients in the oblique incision group and no patients in the transverse incision group. Because of the small sample size of this study, a larger-scale study is needed to confirm whether or not an oblique incision is associated with a higher risk of internal fixation loosening as compared with a transverse incision. Our experience is that the beach chair position is better than the supine position for placement of the steel plate, because the fracture ends can be reset under direct vision. After satisfying reduction, a Kirschner wire is used for temporary fixation[6] and an anatomical plate is placed along the upper surface of the clavicle from the distal end to the proximal end.

In summary, compared with the traditional transverse incision, an oblique incision has the following advantages in the treatment of midclavicular fracture: (1) small incisions in the range of 2 to 5 cm, which can significantly reduce postoperative wound skin contracture and scar size, allowing the patient to easily conceal the scar with clothing; (2) reduced supraclavicular nerve injury and postoperative numbness, because the direction of the oblique incision is essentially parallel to that of the lateral branch of the supraclavicular nerve and away from the middle and medial branches; (3) adoption of the skin window movement technique during the operation; and (4) the incision is located in the middle and outer thirds of the clavicle and is obliquely shaped, enabling the midclavicular fractured ends to be well revealed and reset temporarily.

Of course, the present study is not without limitations. The sample size was small and from a single hospital. Different teams of experienced surgeons operated on the patients in the 2 groups. Finally, the patients were able to choose which surgical approach was used, so we did not randomize patients to the study groups; this may have introduced some selection bias. Additional studies with a more robust design are necessary to confirm our results.

Conclusion

Compared with transverse incisions, oblique incisions have several advantages: less bleeding, smaller incisions, less injury to iatrogenic supraclavicular nerves, and higher patient satisfaction. These 2 treatments have equivalent therapeutic effects on shoulder joint function recovery.

Disclaimer

This study was funded by Social Development Project of Fuzhou Science and Technology Bureau (2016-S-123-16) and Fujian Provincial Health Planning Program for Young and Middle-Aged Talents (2017-ZQN-73).

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References

1. Al-Sadek TA, Niklev D, Al-Sadek A. Midshaft clavicular fractures—osteosynthesis with minimally invasive technique. Open Access Maced J Med Sci 2016;4:647-9. https://doi.org/10.3889/oamjms.2016.136
2. Asadollahi S, Hau RC, Page RS, Richardson M, Edwards ER. Complications associated with operative fixation of acute midshaft clavicle fractures. Injury 2016;47:1248-52. https://doi.org/10.1016/j.injury.2016.02.005
3. Burnham JM, Kim DC, Kamineni S. Midshaft clavicle fractures: a critical review. Orthopedics 2016;39:e814-21. https://doi.org/10.3928/01477447-20160517-06
4. Chan G, Korac Z, Miletic M, Vidovic D, Phadnis J, Bakota B. Plate versus intramedullary fixation of two-part and multifragmentary displaced midshaft clavicle fractures—a long-term analysis. Injury 2017;48(Suppl 5):S21-6. https://doi.org/10.1016/s0020-1383(17)30734-9
5. Christensen TJ, Horwitz DS, Kubiak EN. Natural history of anterior chest wall numbness after plating of clavicle fractures: educating patients. J Orthop Trauma 2014;28:642-7. https://doi.org/10.1097/bot.0000000000000095
6. Dan J, Kim BK, Lee HJ, Kim TH, Kim YG. Supplementary technique for unstable clavicle shaft fractures: interfragmentary wiring and temporary axial K-wire pinning. Clin Orthop Surg 2018;10:142-8. https://doi.org/10.4055/cios.2018.10.2.142
7. Fritz EM, van der Meijden OA, Hussain ZB, Pogorzelski J, Millett PJ. Intramedullary fixation of midshaft clavicle fractures. J Orthop Trauma 2017;31(Suppl 3):S42-4. https://doi.org/10.1097/bot.0000000000000906
8. Houwert RM, Smeeing DP, Ahmed Ali U, Hietbrink F, Kruyt MC, van der Meijden OA. Plate fixation or intramedullary fixation for midshaft clavicle fractures: a systematic review and meta-analysis of randomized controlled trials and observational studies. J Shoulder Elbow Surg 2016;25:1195-203. https://doi.org/10.1016/j.jse.2016.01.018
9. Houwert RM, Wijdicks FJ, Steins Bisschop C, Verleisdonk EJ, Kruyt M. Plate fixation versus intramedullary fixation for displaced mid-shaft clavicle fractures: a systematic review. Int Orthop 2012;36:579-85. https://doi.org/10.1007/s00264-011-1422-4
10. Hussain N, Sermer C, Prusick PJ, Banfield L, Atrey A, Bhandari M. Intramedullary nailing versus plate fixation for the treatment displaced midshaft clavicular fractures: a systematic review and meta-analysis. Sci Rep 2016;6:34912. https://doi.org/10.1038/srep34912
11. Kihlstrom C, Moller M, Lonn K, Wolf O. Clavicle fractures: epidemiology, classification and treatment of 2 422 fractures in the Swedish Fracture Register; an observational study. BMC Musculoskelet Disord 2017;18:82. https://doi.org/10.1186/s12891-017-1444-1
12. Lenza M, Faloppa F. Surgical interventions for treating acute fractures or non-union of the middle third of the clavicle. Cochrane Database Syst Rev 2015;(5)::Cd007428. https://doi.org/10.1002/14651858.CD007428.pub3
13. Liu HH, Chang CH, Chia WT, Chen CH, Tarng YW, Wong CY. Comparison of plates versus intramedullary nails for fixation of displaced midshaft clavicular fractures. J Trauma 2010;69:E82-7. https://doi.org/10.1097/TA.0b013e3181e03d81
14. Naveen BM, Joshi GR, Harikrishnan B. Management of mid-shaft clavicular fractures: comparison between non-operative treatment and plate fixation in 60 patients. Strategies Trauma Limb Reconstr 2017;12:11-8. https://doi.org/10.1007/s11751-016-0272-4
15. Paladini P, Pellegrini A, Merolla G, Campi F, Porcellini G. Treatment of clavicle fractures. Transl Med UniSa 2012;2:47-58.
16. Robinson CM. Fractures of the clavicle in the adult. Epidemiology and classification. J Bone Joint Surg Br 1998;80:476-84.
17. Shukla DR, Rubenstein WJ, Barnes LA, Klion MJ, Gladstone JN, Kim JM, et al. The influence of incision type on patient satisfaction after plate fixation of clavicle fractures. Orthop J Sports Med 2017;5:2325967117712235. https://doi.org/10.1177/2325967117712235.
18. van der Linde RA, Beetz I, van Helden SH. Plating for midshaft clavicular fractures: the impact on quality of life and functional outcome. Injury 2017;48:2778-83. https://doi.org/10.1016/j.injury.2017.10.032
19. Wang L, Ang M, Lee KT, Naidu G, Kwek E. Cutaneous hypoesthesia following plate fixation in clavicle fractures. Indian J Orthop 2014;48:10-3. https://doi.org/10.4103/0019-5413.125478
20. Wang YC, Fu YC, Chou SH, Liu PC, Tien YC, Lu CC. Titanium Elastic Nail versus plate fixation of displaced midshaft clavicle fractures: a retrospective comparison study. Kaohsiung J Med Sci 2015;31:473-9. https://doi.org/10.1016/j.kjms.2015.07.008
21. Wilson DJ, Scully WF, Min KS, Harmon TA, Eichinger JK, Arrington ED. Biomechanical analysis of intramedullary vs. superior plate fixation of transverse midshaft clavicle fractures. J Shoulder Elbow Surg 2016;25:949-53. https://doi.org/10.1016/j.jse.2015.10.006
22. Woltz S, Stegeman SA, Krijnen P, van Dijkman BA, van Thiel TP, Schep NW, et al. Plate fixation compared with nonoperative treatment for displaced midshaft clavicular fractures: a multicenter randomized controlled trial. J Bone Joint Surg Am 2017;99:106-12. https://doi.org/10.2106/jbjs.15.01394