RESEARCH ARTICLE

Skin Tenting in Displaced Midshaft Clavicle Fractures

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Received: 14 December 2019 *Accepted: 17 September 2020*

Abstract

Background: The objectives of this study were to (1) identify factors associated with skin tenting in displaced midshaft clavicle fractures and (2) analyze individual surgeon variation in this diagnosis.

Methods: A retrospective cohort study was performed at two Level I trauma centers of 396 patients with displaced midshaft clavicle fractures treated by 47 surgeons with open reduction internal fixation from January 2010 to March 2019. Our main outcome measure was skin tenting, as diagnosed by the treating surgeon and used as an indication for surgical treatment.

Results: Skin tenting was diagnosed by the treating surgeon in 34 out of 396 patients (9%) with displaced midshaft clavicle fractures. Multivariable logistic regression analyses showed that lower BMI (*P=0.002*) and fracture shortening (*P=0.03*) were independently associated with skin tenting in displaced midshaft clavicle fractures. There was wide variation among surgeons in the rate of diagnosis of skin tenting, ranging from 0% to 41% prevalence of skin tenting depending on the treating surgeon (*P<0.0001*).

Conclusion: Although lower BMI and greater fracture shortening were associated with skin tenting, the diagnosis is subjective. We found wide variation in the diagnosis of skin tenting, even among surgeons within a single metropolitan area.

Level of evidence: III

Keywords: Body mass index, Displaced clavicle fracture, Midshaft clavicle fracture, Skin tenting, Surgeon variation

Introduction

The optimal treatment of displaced midshaft clavicle fractures is controversial. Multiple randomized clinical trials have shown similar functional outcomes after nonoperative and surgical treatment of displaced midshaft clavicle fractures. Surgical fixation yields higher rates of fracture union, but is associated with surgical risks and a higher rate of secondary surgery for hardware removal (1-5).

Skin tenting may occur in the setting of a displaced midshaft clavicle fracture when a fracture fragment threatens the integrity of the skin and overlying soft tissue envelope. Skin tenting is traditionally cited as an indication for expedient surgical treatment of displaced midshaft clavicle fractures to preempt an open fracture (6, 7). The diagnosis of skin tenting is subjective. The incidence and variation in the diagnosis of skin tenting are not well-described.

The primary objective of this study was to identify factors associated with skin tenting in displaced midshaft clavicle fractures. The secondary objective of this study was to analyze individual surgeon variation in the diagnosis of skin tenting. Our null hypothesis was that no identifiable risk factors exist for skin tenting in displaced midshaft clavicle fractures.

Materials and Methods

Study design

This study was performed with institutional review board approval. A retrospective chart review was conducted of all clavicle fractures surgically treated at two

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Level I Trauma centers and affiliated satellite hospitals in a single metropolitan area from January 2010 to March 2019. The hospital billing records database was queried using the Common Procedural Terminology (CPT) code 23515 (open treatment of clavicular fracture, includes internal fixation, when performed) for patients within the study period.

The medical records and available radiographs of 634 patients who underwent surgical treatment of a clavicle fracture were screened. One hundred eight patients were excluded for distal third clavicle fracture, 81 patients for age less than 18 years, 38 patients for delay from injury to presentation of more than 2 weeks, 9 patients for proximal third clavicle fracture, 7 patients for open fracture, 4 patients for revision surgery, and 2 patients for nondisplaced fracture in the setting of a floating shoulder injury pattern. Eleven patients met more than one exclusion criteria. One patient underwent bilateral clavicle surgeries under the same anesthesia, and only one side was included to maintain the assumption of independence. A final cohort of 396 patients who underwent surgical treatment of a displaced midshaft clavicle fracture were included in the study.

Outcome measurement and explanatory variables

Our primary outcome was skin tenting in the setting of a displaced midshaft clavicle fracture, as diagnosed by the treating surgeon and used as an indication for surgical treatment. A total of 396 displaced midshaft clavicle fractures treated by 47 surgeons comprised our cohort.

The following explanatory variables were studied: age, body mass index (BMI), sex, dominant upper extremity injury, diabetes mellitus, smoking status, American Society of Anesthesiologists Physical Status Classification (ASA), fracture comminution, superior-inferior fracture displacement, and medial-lateral fracture shortening. BMI closest to date of surgery, within 1 year before or after treatment, was used for analysis. Medical comorbidities were assessed by a thorough review of the electronic medical record. Fracture comminution, displacement, and shortening were measured on the preoperative upright frontal clavicle plain radiographs showing the greatest displacement.

Statistical analysis

Descriptive statistics for explanatory variables were calculated for the study cohort. All explanatory variables had greater than 90% data completeness. All variables were analyzed using the data available and missing data were excluded [Table 1]. Bivariate analysis was used to screen for factors associated with skin tenting. Student's t-test was used for continuous variables, Mann-Whitney U test was used for ordinal variables, and Fisher's exact test was used for categorical variables. We included variables with $P < 0.1$ in our multivariable logistic regression model. Analysis of variance (ANOVA) was used for parametric data, and the Kruskal-Wallis test was used for nonparametric data in the analysis of surgeon variation in the diagnosis of skin tenting.

Table 1. Baseline characteristics of displaced midshaft clavicle fracture patients (n=396)

	Mean (Standard Deviation)
Age	37 (15)
BMI*	25 (3.8)
Displacement (mm)*	16 (8)
Shortening (mm)*	15 (10)
	Median (Interquartile Range)
ASA classification	1.5 (1 – 2)
	n (%)
Male sex	299 (76)
Diabetes mellitus	4 (1)
Current smoker	44 (11)
Dominant upper extremity*	179 (50)
Comminution*	296 (75)

*BMI was available for 386 (97%) patients, displacement for 366 (92%), shortening for 373 (94%), dominant upper extremity for 358 (90%), and comminution for 395 (99%).

A convenience sample was used. The standard significance criterion of $\alpha = 0.05$ and standard power criterion of $(1-\beta) = 0.80$ was employed for all statistical tests. *A priori* power analysis showed that with a sample size of 393 had 80% power to detect a 5% difference in rates of skin tenting between groups assuming a 25% standard deviation.

Results

Descriptive results

This study included 396 patients who underwent surgical treatment of displaced midshaft clavicle fractures. Two hundred ninety-nine patients (76%) were of male sex. Mean age at time of surgery was 37 years. Mean BMI was 25. Median ASA classification was 1.5. Forty-three patients (11%) were smokers. One hundred seventy-nine patients (50%) had a clavicle fracture of the dominant upper extremity. Comminution was present in 75% of cases. Mean superior-inferior fracture displacement was 16 mm and mean medial-lateral fracture shortening was 15 mm [Table 1].

Factor associated with skin tenting

Skin tenting was diagnosed in 34 out of 396 patients (9%) with displaced midshaft clavicle fractures. In all cases, the presence of skin tenting served as sufficient indication for surgical treatment. Bivariate analyses showed that lower BMI (P = 0.001), fracture shortening ($P = 0.01$), and ASA classification ($P = 0.04$) were associated with skin tenting [Table 2].

Multivariable logistic regression analyses showed that lower BMI ($P = 0.002$) and fracture shortening ($P = 0.03$) were independently associated with skin tenting in displaced midshaft clavicle fractures [Table 3].

Table 2. Bivariate analyses of variables associated with skin tenting in displaced midshaft clavicle fractures (n=396)

	Comparison group (n=362)	Skin tenting (n = 34)	*P value*
	Mean (Standard Deviation)	**Mean (Standard Deviation)**	
Age	37 (15)	36 (20)	0.7
BMI	25 (4)	23 (3)	**0.001**
Displacement (mm)	16 (8)	16 (7)	0.7
Shortening (mm)	15 (10)	19 (12)	**0.01**
	Median (Interquartile Range)	**Median (Interquartile Range)**	
ASA classification	2 (1 – 2)	1 (1 – 2)	**0.04**
	n (%)	**n (%)**	
Male sex	277 (77)	22 (65)	0.1
Diabetes mellitus	4 (1)	0 (0)	0.9
Current smoker	43 (12)	1 (3)	0.2
Dominant upper extremity	166 (51)	13 (41)	0.4
Comminution	270 (75)	26 (76)	0.9

Number of non-missing values per variable indicated in Table 1. Bold indicates statistical significance.

Surgeon variation in the diagnosis of skin tenting

Twelve surgeons treated 10 or more displaced midshaft clavicle fractures (range 10 to 47) in our cohort. Six sports medicine surgeons treated 128 fractures, four orthopaedic trauma surgeons treated 89 fractures, and two hand and upper extremity surgeons treated 64 fractures. Wide variation existed among these surgeons in the rate of diagnosis of skin tenting, ranging from 0% to 41% prevalence of skin tenting depending on the treating surgeon [Figure 1]. The differences among surgeons for the diagnosis of skin tenting was statistically significant (*P<0.0001*). There was no statistically significant difference in the diagnosis of skin tenting by subspecialty training among sports medicine, orthopaedic trauma, and hand and upper extremity surgeons. *Post hoc* Fisher's exact tests showed that surgeon #5 (*P<0.0001*) and surgeon #12 (*P=0.007*) varied from the mean of the other surgeons by a statistically significant amount. Fracture parameters (displacement and shortening) were not significantly greater for surgeon #5 and surgeon #12 compared with the remaining cohort.

No significant difference was seen among treating surgeons with regards to patient BMI, sex, diabetes mellitus, smoking status, ASA classification, fracture comminution, superior-inferior fracture displacement, or medial-lateral fracture shortening. Patient age significantly differed among treating surgeons (*P = 0.03*).

Table 3. Multivariable logistic regression analysis for variables associated with skin tenting in displaced midshaft clavicle fractures (n=396)

	Multivariable logistic regression	
	Odds ratio	**confidence interval 95%**
†BMI	**0.81**	**(0.93 ,0.71)**
Shortening	**1.04**	**(1.07 ,1.00)**
ASA classification	0.82	(1.61 ,0.42)

Number of non-missing values per variable indicated in Table 1. **Bold** indicates statistical significance.

† Reference groups for continuous and ordinal variables are minus 1 unit.

Discussion

Skin tenting is traditionally cited as a clear indication for surgical treatment of a displaced midshaft clavicle fracture (6). In theory, a clavicle fracture with skin tenting is an impending open fracture, and in fact, there have been case reports of initially closed clavicle fractures with skin tenting that have converted to open fractures when the overlying soft tissue envelopes necrosed (7). However, the diagnosis of skin tenting is subjective, and there is no agreed upon definition of skin tenting that is practically applied. As a result, there is wide variation in the diagnosis of skin tenting among surgeons.

The incidence of skin tenting in displaced midshaft clavicle fractures is not well-described in the literature. Kirmani et al. reported a 4% incidence of skin tenting in a retrospective case series comprising only five cases of skin tenting (8). Our present study showed a 9% incidence of skin tenting. A possible reason for the higher rate of skin tenting observed in our study may be that the patient populations at our two Level I trauma centers sustain higher energy injuries. Alternatively, it may be the case that the surgeons in our study more readily apply the diagnosis of skin tenting.

In this study, we have found medial-lateral fracture shortening and lower BMI to be independent risk factors

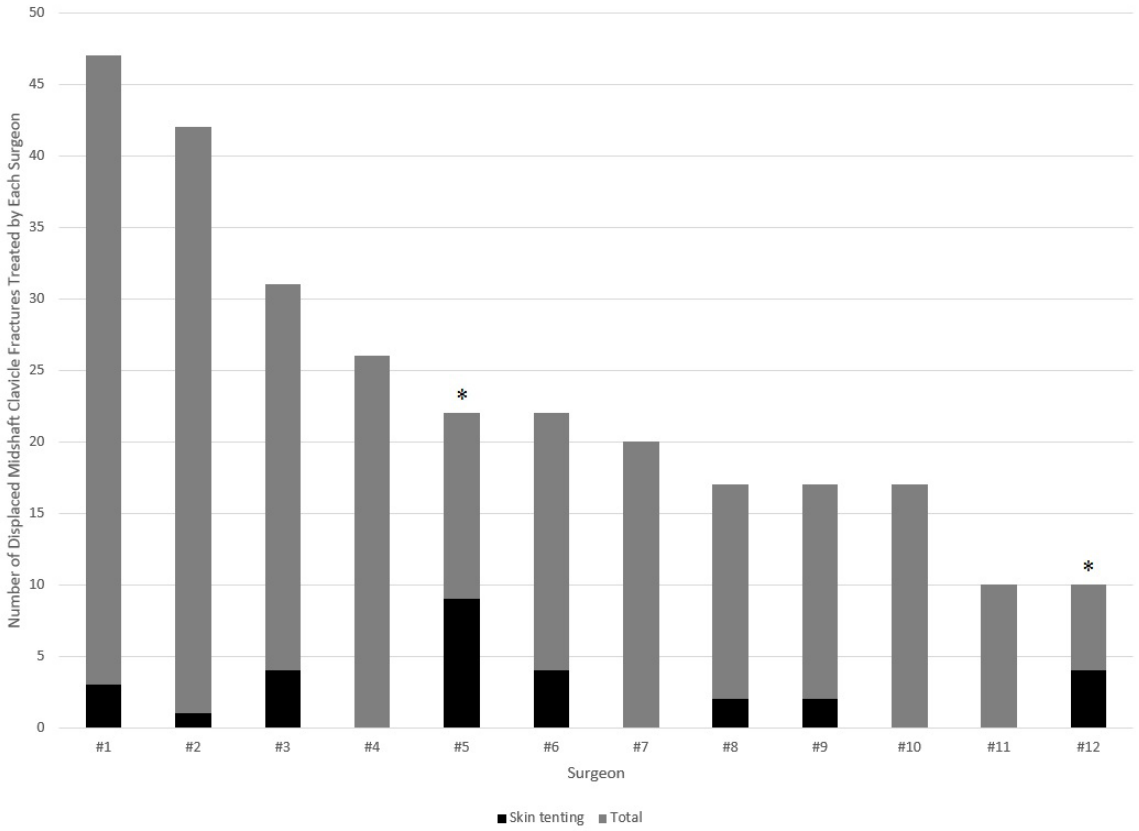

Figure 1. Bar graph showing the number of displaced midshaft clavicle fractures treated by each surgeon. The full gray bar represents the total number of clavicle fractures treated by each surgeon. The black bar represents the number of clavicle fractures diagnosed with skin tenting by each surgeon. Asterisks (*) denote surgeons with significantly varying rates of diagnosis of skin tenting.

for skin tenting. Fracture comminution was not found to be a risk factor for skin tenting as previously posited (8). Similarly, superior-inferior fracture displacement was not associated with skin tenting, as superior-inferior displacement of midshaft clavicle fractures is primarily caused by the inferior displacement of the lateral fracture fragment along with the upper extremity. Shortening of the shoulder girdle, however, brings the medial fracture edge closer to the skin and predisposes to skin tenting. Lower BMI is likely associated with skin tenting due to a thinner soft tissue envelope overlying the fracture site. ASA was weakly but significantly correlated with BMI (Spearman's $\rho = 0.19$, $P = 0.0002$) and fell out of significance in our multivariable logistic regression analysis, suggesting that it was a proxy for BMI.

The incidence of skin tenting diagnosed by individual surgeons ranged from 0% to 41% in our study. The wide variation in surgeon diagnosis of skin tenting reflects the challenging and subjective nature of the diagnosis and the lack of a reference standard. While part of the variation can likely be attributed to differing surgeon thresholds for what amounts to skin tenting, part of the variation may be due to differences in patient population and mechanism of injury seen by different surgeons. It may be the case that trauma surgeons, hand and upper extremity surgeons, and sports surgeons in our hospital system treat dissimilar patient populations with injuries of differing acuity and severity. However, risk factors for skin tenting, namely BMI and fracture shortening, were not significantly different among treating surgeons. Patient age was significantly different among treating surgeons, but this was not significantly associated with skin tenting.

The subjectivity in the diagnosis of skin tenting is compounded by a deficiency of the English language, as surgeons may refer to different physical examination findings when using the term "skin tenting." Some surgeons may use skin tenting to mean an angular contour of the skin overlying the fracture, while other surgeons may imply that the fracture has pierced the fascia into the subcutaneous tissue. Still others may use skin tenting to mean blanching of the overlying skin, or even impending necrosis of the overlying skin. These scenarios occur with different frequencies and carry different implications for impending open fracture, and yet may all be called skin tenting by different, reasonable surgeons. More precise terminology regarding what is tented and what is threatened skin would be helpful for

communication and clinical management.

There are limitations to our study. First, our study was retrospectively performed. Assessment of skin tenting was based on retrospective review of the medical record. However, we expect good documentation of skin tenting by the treating surgeon, especially when used as an indication for surgery. In a retrospective study on skin tenting, it can be difficult to differentiate between threatened skin and a sharp change in skin contour; however, in our cases of skin tenting, the skin tenting was notable such that the treating surgeons used it as part of their rationale for surgical treatment. Moreover, it is precisely this ambiguity and lack of a reference standard that is one of the central points of our study. Second, fracture parameters, such as displacement and shortening, were measured on plain radiographs. Dependent on the direction of the beam, these parameters may differ. In this study, we used the preoperative frontal plain radiographs that showed the greatest displacement for our measurements. Although we relied on an imperfect two-dimensional representation of a three-dimensional fracture, we believe this method is true to real-life surgeon practice. Third, we were unable to account for mechanism of injury and severity of trauma as a risk factor for skin tenting. Fourth, we were unable to comment on the timing and expediency of treatment after formal diagnosis. Finally, our study was performed at two Level I trauma centers in a major metropolitan area, which may limit the generalizability of our results to other settings.

Skin tenting in displaced midshaft clavicle fractures is uncommon. BMI and fracture shortening are significant, independent risk factors for skin tenting. The nature of the diagnosis of skin tenting is subjective, and the diagnosis is made more variable by inherent imprecision in our terminology. There is significant practice variation in the diagnosis of skin tenting, even among surgeons within a single metropolitan area. Further study is warranted to understand the cause of this practice variation.

Disclosure: The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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