Observational Study

Medicine®

OPEN

Open reduction and internal fixation of mandibular condylar fractures

A national inpatient sample analysis, 2005–2014

Shi-Jun Kuang, MD*, Yi-Qing He, MD, You-Hua Zheng, MD, Zhi-Guang Zhang, MS

Abstract

The purpose of this study was to compare outcomes of open reduction and internal fixation (ORIF) versus closed reduction (CR) for mandibular condylar fractures.

Patients included in the National Inpatient Sample (NIS) database (2005–2014) who were admitted to the hospital for unilateral mandibular condylar fracture were included in the analysis. Patient characteristics and clinical outcomes were compared between those who received ORIF and those receiving CR. Logistic regression analysis was performed to estimate odds ratios (ORs) for each aspect of the main observed events.

NIS data of 12,303 patients who underwent ORIF and 4310 patients who underwent CR were analyzed. Compared to CR, ORIF had an increased risk of longer hospital stay (adjusted OR [aOR] = 1.78, 95% confidence intervals [CIs] = 1.51–2.09), higher total medical cost (aOR = 2.57, 95% CI = 2.17–3.05), and hematoma development (aOR = 10.66, 95% CI = 1.43–75.59), but had a lower risk of having wound complications (aOR = 0.86, 95% CI = 0.79–0.93).

Patients with mandibular condylar fractures who receive ORIF have greater risk of having an extended hospital stay, higher total medical costs, and hematoma development but lower risk of experiencing wound complications compared to those who receive CR.

Abbreviations: CIs = confidence intervals, CR = closed reduction, HCUP = Healthcare Cost and Utilization Project, ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification, NIS = National Inpatient Sample, ORIF = open reduction and internal fixation, ORs = odds ratios, TMJ = temporomandibular joint.

Keywords: closed reduction, mandibular fracture, open reduction

1. Introduction

Mandibular fractures are the most common facial fracture.[1] Mandibular condylar fractures are the most common mandibular fractures, with an overall incidence of 18% to 57%, and incidence of 24% to 72% in children.[2–4] Mandible fractures are more common in males,[5] and common causes of traumatic facial injury include motor vehicle accidents, violence, sports-related trauma, falls, and industrial incidents.[2,3,5]

As children may sustain minimal condylar process fractures, and because they have an increased ability for bone regeneration and remodeling, numerous studies have reported favorable results following closed reduction (CR) in children.[4] CR is mostly performed by stabilizing the fracture site using a lingual splint and circummandibular wires, intermaxillary fixation with arch bars or interdental fixation, or maxillomandibular fixation.[4,6] However, totally dislocated or commuted fractures may require open fixation and internal fixation (ORIF) to obtain optimal realignment.[2,4,7]

Nevertheless, the optimal treatment of mandibular condylar fractures is still debatable.[1,8–13] No general consensus has been reached regarding the clinical indications of ORIF and CR, except that adults with bilateral condylar fractures, including displacement or moderate to severe unilateral displacement with a dislocated condylar neck, may benefit from ORIF.[14–16] Advocates for conservative treatment cite the safety of CR, especially for avoiding surgical complications, but others prefer surgery for quick restoration of function.[1,17] Some studies have indicated that the 2 approaches produce equivalent outcomes, whereas other studies report that ORIF results in greater mobility, a lower incidence of malocclusion incidence, and earlier restoration of function.[4,17–19] Kotrashetti et al have indicated that an equal number of studies support ORIF and CR.[17] However, ORIF is more technically demanding and is associated with certain postoperative complications.[20] Recent meta-analyses favor ORIF over CR with respect to mobility, malocclusion, pain, and chin deviation on mouth opening, but ORIF is associated with a higher risk of infection.[8,12,21]

Thus, the purpose of this study was to compare outcomes of ORIF and CR for the treatment of mandibular condylar fractures

Editor: Leonardo Roever.

The authors report no conflicts of interest.

Source of Funding: This work was supported by Guangdong Provincial Science & Technology Research Grants, China (No.2009B030801200).

Department of Oral and Maxillofacial Surgery, Guanghua School of Stomatology, Hospital of Stomatology, Sun Yat-sen University, Guangzhou, People's Republic of China.

* Correspondence: Shi-Jun Kuang, Guanghua School of Stomatology, Hospital of Stomatology, Institute of Stomatology, Sun Yat-sen University, 56 Ling Yuan Road West, Guangzhou, Guangdong 510055, People's Republic of China (e-mail: kqksj@163.com).

How to cite this article: Kuang SJ, He YQ, Zheng YH, Zhang ZG. Open reduction and internal fixation of mandibular condylar fractures. Medicine 2019;98:37 (e16814).

Received: 26 November 2018 / Received in final form: 23 April 2019 / Accepted: 22 July 2019

http://dx.doi.org/10.1097/MD.0000000000016814

using patient data from the large population-based National Inpatient Sample (NIS) database (2005–2014). The effectiveness of ORIF and CR was evaluated based on length of hospital stay, total medical costs, malocclusion, postoperative infection, hematoma development, and wound complications.

2. Methods

2.1. Study population

This cross-sectional study included all patients who were admitted to a hospital for treatment of unilateral mandibular condylar fracture identified in the 2005 to 2014 NIS database. The NIS is the most extensive all-payer database in the United States, and is maintained by the Agency for Healthcare Research and Quality as part of the Healthcare Cost and Utilization Project (HCUP).[22] Data available in the NIS include admission diagnosis, demographic characteristics, procedures explicitly performed during that admission, comorbidities, a disease severity evaluation, and costs.[22]

2.2. Ethical considerations

Because the NIS originally received permission from all patients to participate in data collection, and patient data in the NIS database were deidentified, secondary analysis of the NIS data did not require institutional review board approval or the participants' signed informed consent. This study obtained the certificate number, HCUP-842GUR29I, and conforms to the data-use agreement of the NIS of the HCUP.[23]

2.3. Inclusion and exclusion criteria

Inpatients with an *International Classification of Diseases, Ninth Revision* (*ICD-9*) diagnostic code indicating a mandibular fracture (*International Classification of Diseases, Ninth Revision, Clinical Modification* [ICD-9-CM] code 80220–80237) and treated with open reduction/ORIF (code 7676) or CR (code 7675) for mandibular fractures were included.

Patients with bilateral mandibular condylar fractures were excluded to eliminate the possibility of including the same patient who might have undergone two different surgical treatments (ie, one procedure on each side). In addition, patients who had undergone both ORIF and CR were excluded. Additional exclusion criteria included polytrauma cases (defined as an additional fracture outside the mandible), severe respiratory distress requiring intubation, a concurrent neurological injury with an altered mental status, being comatose, or having an intracranial hemorrhage. Patients >88 years of age were excluded, and if specific demographic information such as sex, race, annual income, and insurance type was missing, then these patients were also excluded.

3. Study design

The design of the NIS changed over time. Between 2005 and 2011, NIS data included all discharges from a sample of 20% of acute-care hospitals in the United States; from 2012 to 2014 it included a sample of 20% of all discharges from United States hospitals, stratified by hospital, census division, ownership status, urban versus rural location, teaching status, and bed size. For all patient-level analyses, the newly developed trend weight by the NIS was used. From 1993 to 2012, the original discharge weight was used to facilitate the patient-level trend analysis. Hospital-level trend analysis was limited to 2005–2011 so that the sampling methodology would remain constant. In 2012, the NIS data lacked a sampling methodology for hospital-level trends, so the 20% fraction of patients extracted from each sampling hospital inevitably resulted in missing data.

3.1. Variable definitions

Patient demographic data examined included age, sex, race, annual household income, and insurance type. Race was defined as white, black, and others. Annual income was categorized into quartiles. Insurance types included Medicare/Medicaid, private, and self-pay/others/no charge.

Patient comorbidities were identified using either the Chronic Comorbidity Indicator provided by the NIS, or the following ICD-9-CM codes: alcohol abuse (CM_ALCOHOL), diabetes (CM_DM), and hypertension (CM_HTN_C). For hospital-level characteristics, we analyzed the number of hospitals treating patients with ORIF, ORIF procedures per hospital (median), bed size (small, medium, or large), teaching hospital, ownership (government, private nonprofit, or private for-profit), and hospitals in urban locations. Patient-level outcomes were total hospital cost, length of stay, and postoperative complications.

3.2. Statistical analysis

Categorical variables were summarized as frequencies and weighted percentages, and the mean and standardized error of the mean were presented for continuous variables. Tests for distributions of factors between the ORIF and CR groups were performed using a Rao-Scott χ^2 test for categorical variables. An analysis of variance was performed for continuous variables. A logistic regression model was used to estimate the odds ratio (OR) with 95% confidence intervals (CIs) for the main observed events in the study. Other than operation type, factors that were significant in the univariate model were included in a multiple regression model. A 2-tailed value of $P<.05$ was considered significant. All analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC).

4. Results

A study population selection flowchart is shown in Figure 1. A total of 16,613 patients hospitalized for unilateral mandibular fractures were identified in the 2005 to 2011 NIS database and included in the analysis. A total of 12,303 patients underwent ORIF and 4310 patients underwent CR.

The demographic characteristics, comorbidities, and hospitalization data of the patients are summarized in Tables 1 and 2. Of the total patients, 13,762 were male (82.83%). No differences were found in admission year between patients who underwent ORIF and those who underwent CR ($P=.28$). During the study period, the ratio of ORIF to CR ranged from 2.39 to 3.30 and no dramatic alterations were noted. More females received CR than ORIF (21.38% vs 15.68%, respectively; $P<.0001$). Patients in the ORIF group were older than those in the CR group (32.54 ± 0.16 vs 30.25 ± 0.27 years, respectively; $P<.0001$). Other between-group differences are summarized in Tables 1 and 2. Regarding the hospital-level analyses for hospitals in which patients underwent the procedures, differences were demonstrated in distributions of annual ORIF count ($P=.0002$), bed size

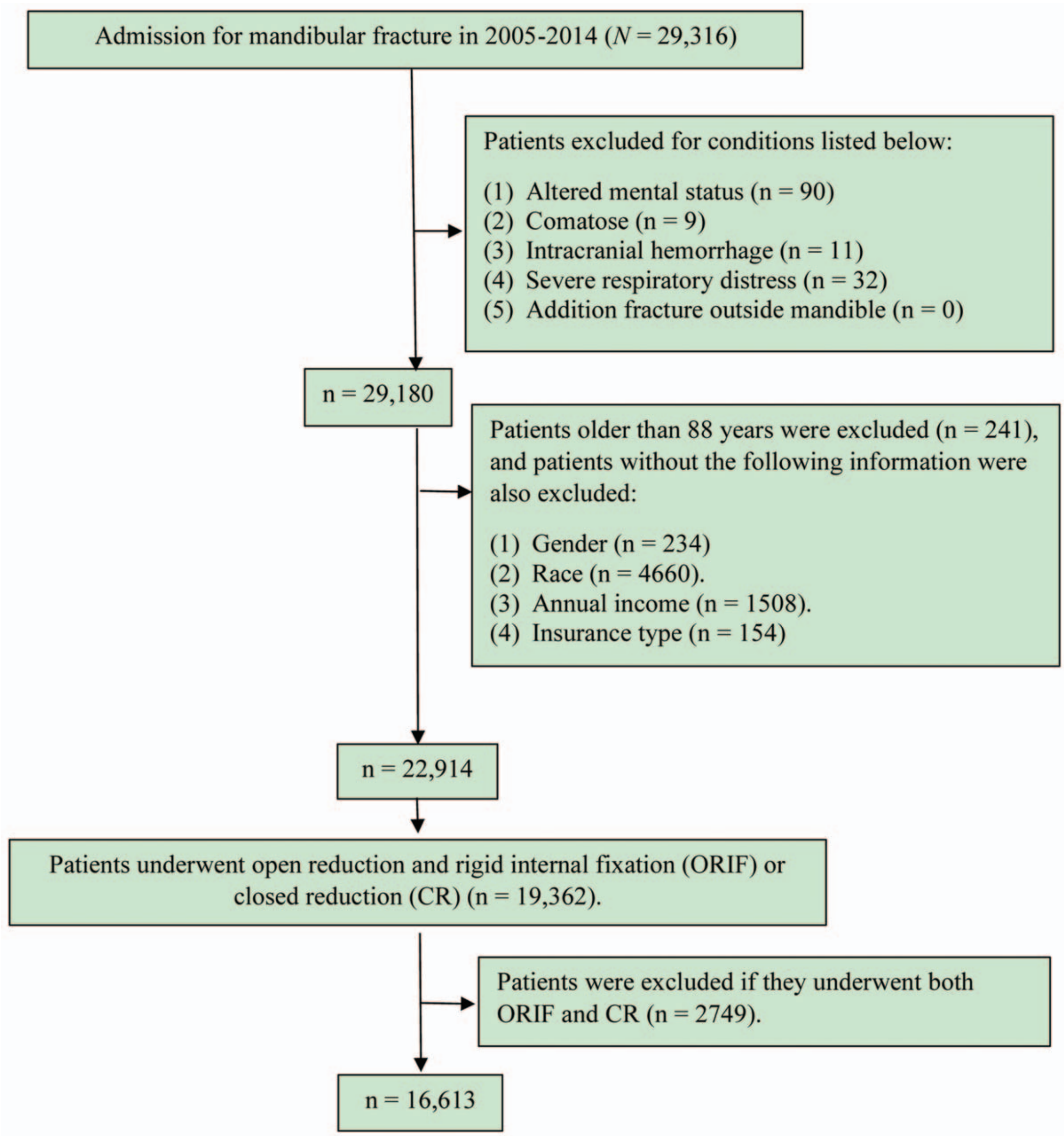

Figure 1. A Flowchart of Study Population Selection.

($P=.0001$), hospital location and teaching status ($P<.0001$), ownership ($P=.004$), and hospital census region ($P<.0001$) (Table 1).

Length of hospital stay (3.73±0.08 vs 2.70±0.07, respectively; $P<.0001$) and total medical costs ($51,145±$1094.59 vs $32,091±$765.47, respectively; $P<.0001$) were significantly higher in the ORIF group than in the CR group (Table 3). The ORIF group had a lower probability of wound complications than the CR group (27.86% vs 31.12%, respectively; $P=.0002$).

Results of univariate logistic regression analysis are shown in Tables 4 and 5. Overall, the odds for length of hospital stay ≥90th percentile, total medical cost ≥90th percentile, and hematoma formation were higher in the ORIF group than in the CR group. In contrast, patients in the ORIF group had lower odds of wound complications (crude OR=0.86, 95% CI=0.79–0.93). Other significant associations are shown in Tables 4 and 5.

Results of multiple logistic regression analysis after adjusting for the significant factors in the univariate regression model are shown in Table 6. ORIF was associated with increased odds for a longer hospital stay (adjusted OR [aOR]=1.78, 95% CI=1.51–2.09), higher total medical costs (aOR=2.57, 95% CI=2.17–3.05), and hematoma development (aOR=10.66, 95% CI=1.43–75.59). However, ORIF was associated with lower odds of wound complications (aOR=0.86, 95% CI=0.79–0.93).

5. Discussion

Results of the present cross-sectional study demonstrate that patients who undergo ORIF have an increased risk of longer hospital stays, higher medical costs, and hematoma development, but a lower risk of wound complications than patients who undergo CR. This may be an important finding in support of

Table 1

Baseline characteristics of patients hospitalized for mandibular fractures, 2005–2014.

	ORIF	CR	*P*
	N=12303	N=4310	
	Weighted N=60,930 (%)	Weighted N=21,441 (%)	
Admission year			
2005	1017 (8.01)	425 (9.68)	0.28
2006	1137 (9.11)	428 (10.06)	
2007	1149 (9.33)	463 (10.78)	
2008	1167 (9.24)	412 (9.28)	
2009	1211 (9.98)	425 (10.01)	
2010	1530 (12.91)	502 (11.98)	
2011	1231 (9.73)	407 (9.11)	
2012	1381 (11.33)	419 (9.77)	
2013	1264 (10.37)	402 (9.37)	
2014	1216 (9.98)	427 (9.96)	
Female	1931 (15.68)	920 (21.38)	<.0001
Age, y	32.54±0.16	30.25±0.27	<.0001
Race			
White	6135 (49.71)	2290 (52.95)	.007
Black	3514 (28.72)	1158 (27.10)	
Others	2654 (21.57)	862 (19.96)	
Annual income			
Q1	5091 (41.46)	1602 (37.16)	<.0001
Q2	2927 (23.74)	1058 (24.44)	
Q3	2451 (19.88)	910 (21.09)	
Q4	1834 (14.92)	740 (17.31)	
Primary payer			
Medicare/Medicaid	3407 (27.84)	1228 (28.59)	<.0001
Private including HMO	3620 (29.42)	1461 (33.90)	
Self-pay/no charge/other	5276 (42.75)	1621 (37.52)	
Comorbidities			
Alcohol abuse	1954 (15.88)	573 (13.30)	<.0001
Diabetes	425 (3.47)	140 (3.21)	.43
Hypertension	1508 (12.30)	456 (10.52)	.004

Continuous variables are presented as mean±standard error; categorical variables are presented as number and weighted percentages.

Table 2

Baseline characteristics of patients hospitalized for mandibular fractures, 2005–2014.

	ORIF	CR	*P*
	n=12303	n=4310	
	Weighted N=60,930 (%)	Weighted N=21,441 (%)	
Hospital-level analysis			
Annual ORIF count	45.57±4.63	32.59±2.30	.0002
Q1	2425 (19.67)	1335 (30.86)	<.0001
Q2	3336 (27.17)	1090 (25.30)	
Q3	3286 (26.87)	905 (21.30)	
Q4	3256 (26.29)	980 (22.55)	
Bed size			
Small	595 (4.57)	291 (6.39)	.0001
Median	2404 (19.58)	899 (20.97)	
Large	9178 (74.84)	3104 (72.28)	
Unknown	126 (1.01)	16 (0.36)	
Hospital location and teaching status			
Urban teaching	6356 (51.84)	2100 (49.26)	<.0001
Urban non-teaching	1719 (13.53)	842 (18.92)	
Rural	4228 (34.62)	1368 (31.81)	
Ownership			
Government	7039 (57.07)	2520 (58.60)	.004
Private, nonprofit	870 (6.95)	375 (8.54)	
Private, for profit	407 (3.28)	151 (3.40)	
Unknown	3987 (32.69)	1264 (29.46)	
Hospital census region			
Northeast	2776 (23.33)	1266 (30.46)	<.0001
Midwest or North central	1588 (13.02)	628 (14.79)	
South	5411 (43.27)	1536 (34.80)	
West	2528 (20.39)	880 (19.95)	

CR=closed reduction, ORIF=open reduction and internal fixation. Categorical variables are presented as number and weighted percentages.

Table 3

Prognosis of patients hospitalized for mandibular fractures, 2005–2014.

	ORIF	CR	*P*
	n=15,052	n=4310	
	Weighted N=74,539 (%)	Weighted N=21,441 (%)	
Length of stay, day			
N	8437	3061	
Mean±SE	3.73±0.08	2.70±0.07	<.0001
≥90th percentile	1282 (15.26)	261 (8.47)	<.0001
Total medical cost			
N	12131	4270	
mean±SE	$51,145±$1094.59	$32,091±$765.47	<.0001
≥90th percentile	1488 (12.34)	208 (4.88)	<.0001
Malocclusion	359 (2.88)	118 (2.84)	.92
Postoperative infection	19 (0.16)	2 (0.05)	.10
Hematoma	29 (0.23)	1 (0.02)	.003
Wound complications	3441 (27.86)	1343 (31.12)	.0002

CR=closed reduction, ORIF=open reduction and internal fixation. Continuous variables are presented as mean±standard error; categorical variables are presented as number and percentages.

decision making, as no consensus has been reached to date regarding the treatment of mandibular condylar fractures by open vs. CR.[14]

Condylar fractures are the most common facial fracture, but great debate still exists regarding the most appropriate treatment.[1,8–13] In a meta-analysis involving 23 published studies, Al-Moraissi et al[12] determined that patients treated with ORIF had less pain and improved occlusion than those treated with CR. Shiju et al[2] compared ORIF and CR in 50 randomized patients with mandibular condylar fractures and demonstrated that both treatments had acceptable results. Among 21 patients with displaced subcondylar fractures, ORIF was associated with better clinical and radiological results.[17] Vesnaver et al[24] compared outcomes of patients with unilateral, extra-articular mandibular condyle fractures, treating 42 surgically and 20 conservatively. In that study, surgical management was associated with fewer ipsilateral chin deflections on mouth opening, smaller asymmetry of lateral movements and condylar motion, fewer occlusal disturbances, less facial asymmetry, faster chewing rehabilitation, and smaller bite force asymmetry between the injured and uninjured sides. However, no differences were found between the 2 groups in maximal mouth opening or joint pain.

While recognizing that the management of mandibular condylar process fractures remains controversial, several recent studies have investigated whether ORIF or CR offers a more beneficial approach. In an evaluation of long-term outcomes of 21 pediatric patients with mono- and bicondylar fractures who received oral reduction and external fixation, good recovery was

Table 4

Odds ratios for prognosis of patients hospitalized for mandibular fractures, 2005–2014.

	Length of stay ≥90%	Total medical cost ≥90%	Malocclusion
	Crude OR (95% CI)	Crude OR (95% CI)	Crude OR (95% CI)
ORIF vs CR	1.95 (1.67–2.27)‡	2.74 (2.32–3.24)‡	1.02 (0.78–1.33)
Male vs female	0.57 (0.49–0.65)‡	0.79 (0.69–0.91)†	1.11 (0.86–1.44)
Age, y	1.03 (1.03–1.04)‡	1.02 (1.02–1.03)‡	0.99 (0.98–0.99)‡
Race (vs white)			
Black	0.96 (0.81–1.13)	0.78 (0.66–0.93)*	1.13 (0.90–1.42)
Others	0.99 (0.85–1.16)	1.14 (0.96–1.36)	0.98 (0.73–1.31)
Annual income (vs Q4)			
Q1	1.26 (1.04–1.53)*	0.80 (0.67–0.96)*	0.84 (0.62–1.13)
Q2	1.11 (0.92–1.34)	0.95 (0.67–1.14)	1.05 (0.79–1.40)
Q3	1.10 (0.90–1.36)	0.86 (0.71–1.04)	0.86 (0.64–1.17)
Primary payer (vs private including HMO)			
Medicare/medicaid	1.61 (1.40–1.85)‡	1.30 (1.13–1.50)†	1.04 (0.82–1.32)
Self-pay/no charge/other	1.01 (0.86–1.19)	0.73 (0.64–0.84)‡	1.30 (1.04–1.62)*
Comorbidities			
Alcohol abuse	1.87 (1.61–2.16)‡	1.91 (1.68–2.18)‡	0.97 (0.75–1.26)
Diabetes	2.89 (2.29–3.65)‡	1.73 (1.37–2.19)‡	0.42 (0.20–0.89)*
Hypertension	2.57 (2.22–2.97)‡	1.87 (1.64–2.15)‡	0.84 (0.62–1.15)
Hospital-level analysis annual ORIF count (vs Q1)			
Q2	1.39 (1.08–1.78)*	1.17 (0.96–1.41)	1.03 (0.76–1.40)
Q3	1.58 (1.26–1.98)‡	1.04 (0.79–1.35)	1.39 (0.98–1.97)
Q4	1.48 (1.15–1.92)*	0.61 (0.44–0.85)*	1.44 (0.96–2.15)
Bed size (vs large)			
Small	0.47 (0.31–0.70)†	0.49 (0.36–0.68)‡	0.27 (0.14–0.54)†
Median	0.91 (0.75–1.11)	0.67 (0.55–0.83)†	0.80 (0.56–1.15)
Hospital location and teaching status (vs rural)			
Urban non-teaching	0.98 (0.71–1.36)	0.48 (0.38–0.60)‡	0.96 (0.72–1.29)
Urban teaching	0.78 (0.56–1.10)	0.47 (0.38–0.60)‡	0.84 (0.52–1.37)
Ownership (vs government)			
Private, nonprofit	0.81 (0.64–1.01)	1.16 (0.80–1.68)	0.82 (0.47–1.42)
Private, for profit	1.07 (0.78–1.47)	1.76 (1.15–2.68)*	0.85 (0.48–1.51)
Hospital census region (vs Northeast)			
Midwest or North central	1.16 (0.90–1.50)	1.01 (0.70–1.45)	0.71 (0.44–1.16)
South	1.35 (1.09–1.67)*	1.10 (0.80–1.51)	1.19 (0.77–1.83)
West	1.27 (1.001–1.61)*	2.45 (1.73–3.48)‡	1.05 (0.65–1.69)

* $P < .05$.
† $P < .001$.
‡ $P < .0001$.
CI = confidence interval, CR = closed reduction, HMO = health maintenance organization, OR = odds ratio, ORIF = open reduction and internal fixation.

reported in maximal mouth opening, lateral excursion, and vertical height of ramus, and preinjury occlusion was restored in all patients.[25] No permanent facial nerve palsy was noted, no referred pain or stiffness at the operative site and minimal scarring. The authors emphasized that good functionality of the temporomandibular joint (TMJ) structures and the absence of permanent hardware with external fixation was especially important in children because it allowed symmetrical growth. Still another study examined the outcomes of functional treatment (usually reserved for children) versus ORIF in subjects aged 15 years and older, finding that the functional treatment provided satisfactory clinical results but that ramus height could not easily be restored in fractures that were exceptionally displaced or dislocated, making surgical treatment still necessary.[26] However, as in our study and those of other authors, overall results still supported the safety and efficacy of ORIF.

Garcia-Guerrero et al[27] reviewed the main intra- and postoperative complications in ORIF versus conservative treatment, finding that differences in asymmetry, residual pain, TMJ and articular imbalance, and malocclusion were minimal and infrequent. Facial nerve damage was only found in ORIF patients and complications of conservative treatment were associated with delayed mobilization and functional limitations. In the present study, patients in the ORIF group had significantly lower odds of wound complications than those receiving CR. In a 2015 study of open versus CR for bilateral condylar fractures, overall superior functional and radiographic outcomes were noted in the ORIF procedures compared to CR with intermaxillary fixation; 11 of 85 CR patients had persistent malocclusion, leading to additional orthognathic surgery and orthodontic treatment, which increased patient dissatisfaction.[28]

Other previous meta-analyses also noted specific differences between ORIF and CR. Yao et al[29] included 13 studies with a total of 859 patients (409 received surgical treatment and 450 nonsurgical management), finding that maximal mouth opening of the surgical group was higher than that in the nonsurgical group, and at 1-year follow-up, the incidence of malocclusion in the surgical group was less than that in the nonsurgical group. No differences were found in the incidence of temporomandibular joint pain, facial symmetry, or mandibular activity between the 2

Table 5

Odds ratios for prognosis of patients hospitalized for mandibular fractures, 2005–2014.

	Postoperative infection	Hematoma	Wound complications
	Crude OR (95% CI)	Crude OR (95% CI)	Crude OR (95% CI)
ORIF vs CR	3.16 (0.73–13.69)	10.77 (1.47–79.08)*	0.86 (0.79–0.93)†
Male vs female	3.94 (0.53–29.45)	2.87 (0.68–12.13)	0.63 (0.57–0.69)‡
Age, y	1.03 (1.02–1.05)‡	1.01 (0.99–1.03)	1.002 (1.00–1.004)
Race (vs white)			
Black	1.23 (0.50–3.02)	1.71 (0.75–3.89)	0.70 (0.64–0.76)‡
Others	0.96 (0.30–3.11)	1.47 (0.54–4.04)	0.94 (0.85–1.03)
Annual income (vs Q4)			
Q1	0.74 (0.22–2.48)	0.89 (0.31–2.57)	0.74 (0.66–0.82)‡
Q2	0.63 (0.16–2.51)	0.94 (0.28–3.19)	0.87 (0.77–0.97)*
Q3	0.92 (0.24–3.44)	1.08 (0.34–3.43)	0.96 (0.86–1.08)
Primary payer (vs private including HMO)			
Medicare/Medicaid	3.21 (1.01–10.22)*	0.99 (0.38–2.58)	0.69 (0.63–0.76)‡
Self-pay/no charge/other	0.89 (0.24–3.33)	1.12 (0.46–2.69)	0.65 (0.60–0.71)‡
Comorbidities			
Alcohol abuse	3.24 (1.30–8.09)*	0.89 (0.31–2.57)	1.30 (1.19–1.43)‡
Diabetes	2.70 (0.61–11.92)	4.62 (1.60–13.38)*	1.05 (0.88–1.26)
Hypertension	1.74 (0.57–5.26)	1.48 (0.56–3.93)	1.07 (0.97–1.18)
Hospital-level analysis annual ORIF count (vs Q1)			
Q2	1.28 (0.36–4.53)	1.35 (0.48–3.77)	0.91 (0.82–1.01)
Q3	1.004 (0.27–3.70)	1.32 (0.48–3.67)	0.93 (0.83–1.05)
Q4	1.34 (0.35–5.16)	0.94 (0.28–3.17)	0.79 (0.69–0.90)†
Bed size (vs large)			
Small	1.50 (0.34–6.60)	0.65 (0.09–4.93)	0.90 (0.74–1.10)
Median	0.43 (0.10–1.91)	1.24 (0.52–2.93)	1.004 (0.90–1.12)
Hospital location and teaching status (vs rural)			
Urban non-teaching	0.77 (0.31–1.95)	0.81 (0.36–1.83)	0.86 (0.79–0.95)*
Urban teaching	0.26 (0.03–2.05)	0.98 (0.34–2.83)	1.05 (0.93–1.18)
Ownership (vs Government)			
Private, nonprofit	1.55 (0.33–7.19)	1.60 (0.46–5.59)	1.43 (1.22–1.66)‡
Private, for profit	1.91 (0.24–14.87)	2.60 (0.58–11.67)	1.22 (0.96–1.54)
Hospital census region (vs Northeast)			
Midwest or North central	0.73 (0.19–2.84)	5.35 (1.52–18.85)†	1.61 (1.38–1.89)‡
South	0.47 (0.15–1.45)	2.19 (0.65–7.41)	1.43 (1.38–1.89)‡
West	0.66 (0.19–2.33)	3.90 (1.09–13.97)*	1.65 (1.45–1.88)‡

* $P < .05$.
† $P < .001$.
‡ $P < .0001$.
CI = confidence interval, CR = closed reduction, HMO = health maintenance organization, OR = odds ratio, ORIF = open reduction and internal fixation.

groups. A 2015 meta-analysis that included 8 studies found better results for open treatment in terms of mouth opening, protrusion, laterotrusion, pain, and malocclusion.[21] However, the authors noted that differences in study protocols and lack of information on classification, follow-up time, and inclusion criteria made direct comparison of the studies difficult. A more recent study of 15 condylar fracture patients treated with endoscopic-assisted ORIF reported notable gradual improvement in mean mouth opening at the end of 1 week, 6 weeks, and 6 months, with few complications and reduced immediate postoperative morbidity.[30] The authors emphasized that the endoscopic ORIF procedure took longer and had an especially steep learning curve to master the challenging intraoperative technique, although they still recommended this alternative endoscopic procedure for its decrease in patient morbidity.

In addition, Wang et al [31] studied 547 patients with 654 condylar injuries to identify factors associated with the decision to perform ORIF. Approximately 21% of the patients received ORIF. Factors associated with an increased likelihood of performing ORIF were the presence of extracondylar mandibular injuries, condylar neck or subcondylar region injuries, increasing dislocation, and treatment by plastic and reconstructive surgeons or oral and maxillofacial surgeons. Patient selection appears to be a primary factor in decision-making between ORIF and CR.

New approaches have been explored as well. Seeking to develop a "safe, sound, and effective protocol for surgical management of mandibular subcondylar fractures under local anesthesia," Howlader et al[32] assessed feasibility of this novel procedure in 7 patients, finding that the local anesthesia, along with adequate central muscle relaxation to reduce masticatory muscle spasm, contributed to conducting a safe, efficacious procedure with no major complications or long-term sequelae. The authors pointed out that general anesthesia, by contrast, is noted for greater metabolic stress and intraoperative blood loss compared to regional or local anesthesia, which have a lower incidence of nausea, vomiting, and procedural complications.

Regarding medical costs, a cross-sectional study using the 2009 NIS database and 1481 patients with isolated mandibular fractures[5] reported that the average per-patient treatment cost was $35,804, and that patients with a history of mental illness, cardiovascular disease, increased age, and substance abuse had higher costs; most patients with an isolated mandibular fracture

Table 6

Multiple logistic model for prognosis of patients hospitalized for mandibular fractures, 2005–2014.

	ORIF vs CR Adjusted OR (95% CI)
Length of stay, day ≥90th percentile	1.78 (1.51–2.09)*,†
Total medical cost ≥90th percentile	2.57 (2.17–3.05)*,‡
Malocclusion	1.02 (0.78–1.33)§
Postoperative infection	2.92 (0.69–12.41)‖
Hematoma	10.66 (1.43–79.59)¶,#
Wound complications	0.86 (0.79–0.93)**,††

CI = confidence interval, CR = closed reduction, OR = odds ratio, ORIF = open reduction and internal fixation.
¶ $P < .05$.
* $P < .0001$.
** $P < .001$.
Model adjusted for:
† Operation type, sex, age, annual income, primary payer, alcohol abuse, diabetes, hypertension, annual ORIF frequency, bed size, and hospital census region.
‡ Operation type, sex, age, annual income, primary payer, alcohol abuse, diabetes, hypertension, annual ORIF frequency, bed size, hospital location and teaching status, ownership, and hospital census region.
§ Operation type, age, primary payer, diabetes, bed size, and hospital census region.
‖ Operation type, age, primary payer, and alcohol abuse.
Operation type and hospital census region.
†† Operation type, sex, age, annual income, primary payer, alcohol abuse, annual ORIF frequency, hospital location and teaching status, ownership, and hospital census region.

requiring treatment were uninsured (47%) males with lower socioeconomic status; the incidence of alcohol abuse was 12% and mental illness incidence was 5.5%. The average hospital stay of alcoholics was 1 day longer, and their medical costs were $10,000 more than those of nonalcoholics. Further, patients with cardiovascular disease stayed at least 1 day longer, and their costs were $9000 more than patients without cardiovascular disease. Findings of the present study were similar: patients with a history of alcohol abuse or hypertension were more likely to have extended hospital stays and higher total medical costs.

The main strength of the present study is the inclusion of a large number of patients from all geographical regions in the United States. The NIS encompasses 20% of all discharges in the United States, and is thus a good representative sample of the United States population. Second, although the NIS database is cross-sectional and cause cannot be inferred, data regarding the length of stay, total medical costs, malocclusion, postoperative infection, hematoma development, wound complications, and clinical outcomes along with treatments (ORIF or CR) were available during the same hospital admission for each patient, allowing the identification of prognostic factors.

6. Limitations

This study also had some limitations. The diagnoses in this study were identified based on *ICD* codes only, and coding and misclassification errors may have occurred. The NIS, an *ICD*-coded system, does not indicate the severity of comorbidities, so acuity was unknown and may have confounded the results. Moreover, as the NIS is based on *ICD-9* codes, the complication rate may have been underestimated.[5] Furthermore, Pena et al[5] pointed out that motor vehicle accidents and sports injuries have a higher likelihood of causing poly-trauma injuries, and an isolated mandibular trauma is most likely the result of an assault. Therefore, because the present study excluded polytrauma, a higher proportion of injuries resulting from assaults may have been included versus other causes of mandibular fractures.

7. Future directions

The lack of consensus between studies still does not allow recommendations for a "best approach" for treating condylar fractures. However, results of the present study may provide additional perspective regarding the ongoing dilemma of choosing between ORIF and CR for mandibular condylar fractures. Findings of this US NIS-based study need to be confirmed by population-based studies conducted in other countries, and more multicentric randomized controlled trials are needed to help develop standardized treatment protocols. In addition, large-scale cohort studies should be conducted to explore the long-term outcomes of open reduction and internal fixation in greater depth.

8. Conclusion

Analysis of the data of 16,613 patients hospitalized for unilateral mandibular fractures indicates that patients who undergo ORIF have an increased risk of a longer hospital stay, higher medical costs, and developing a hematoma, but have a lower risk of wound complications than patients who undergo CR.

Author contributions

Conceptualization: Shi-Jun Kuang, Zhi-Guang Zhang.
Data curation: Shi-Jun Kuang, Yi-Qing He, You-Hua Zheng, Zhi-Guang Zhang.
Formal analysis: Shi-Jun Kuang, Yi-Qing He, You-Hua Zheng.
Funding acquisition: Zhi-Guang Zhang.
Writing – original draft: Shi-Jun Kuang, Yi-Qing He, Zhi-Guang Zhang.
Writing – review & editing: Shi-Jun Kuang, You-Hua Zheng, Zhi-Guang Zhang.

References

[1] Monnazzi MS, Gabrielli MAC, Gabrielli MFR, et al. Treatment of mandibular condyle fractures. A 20-year review. Dent Traumatol 2017;33:175–80.
[2] Shiju M, Rastogi S, Gupta P, et al. Fractures of the mandibular condyle—open versus closed—a treatment dilemma. J Craniomaxillofac Surg 2015;43:448–51.
[3] Rastogi S, Sharma S, Kumar S, et al. Fracture of mandibular condyle—to open or not to open: an attempt to settle the controversy. Oral Surg Oral Med Oral Pathol Oral Radiol 2015;119:608–13.
[4] Deleyiannis FW-B, Vecchione L, Martin B, et al. Open reduction and internal fixation of dislocated condylar fractures in children: long-term clinical and radiologic outcomes. Ann Plast Surg 2006;57:495–501.
[5] Pena IJr, Roberts LE, Guy WM, et al. The cost and inpatient burden of treating mandible fractures: a nationwide inpatient sample database analysis. Otolaryngol Head Neck Surg 2014;151:591–8.
[6] Kim JH, Nam DH. Closed reduction of displaced or dislocated mandibular condyle fractures in children using threaded Kirschner wire and external rubber traction. Int J Oral Maxillofac Surg 2015;44:1255–9.
[7] Xu X, Shi J, Xu B, et al. Treatment of mandibular symphyseal fracture combined with dislocated intracapsular condylar fractures. J Craniofac Surg 2015;26:e181–5.
[8] Liu Y, Bai N, Song G, et al. Open versus closed treatment of unilateral moderately displaced mandibular condylar fractures: a meta-analysis of randomized controlled trials. Oral Surg Oral Med Oral Pathol Oral Radiol 2013;116:169–73.

[9] Gupta M, Iyer N, Das D, et al. Analysis of different treatment protocols for fractures of condylar process of mandible. J Oral Maxillofac Surg 2012;70:83–91.
[10] Landes CA, Day K, Lipphardt R, et al. Closed versus open operative treatment of nondisplaced diacapitular (Class VI) fractures. J Oral Maxillofac Surg 2008;66:1586–94.
[11] Singh V, Bhagol A, Goel M, et al. Outcomes of open versus closed treatment of mandibular subcondylar fractures: a prospective randomized study. J Oral Maxillofac Surg 2010;68:1304–9.
[12] Al-Moraissi EA, Ellis EIII. Surgical treatment of adult mandibular condylar fractures provides better outcomes than closed treatment: a systematic review and meta-analysis. J Oral Maxillofac Surg 2015;73:482–93.
[13] Steed MB. Where are the advancements in the management of mandibular condylar process fractures? Atlas Oral Maxillofac Surg Clin North Am 2017;25:ixdoi: 10.1016/j.cxom.2016.12.001.
[14] Schneider M, Erasmus F, Gerlach KL, et al. Open reduction and internal fixation versus closed treatment and mandibulomaxillary fixation of fractures of the mandibular condylar process: a randomized, prospective, multicenter study with special evaluation of fracture level. J Oral Maxillofac Surg 2008;66:2537–44.
[15] Snyder SK, Cunningham LLJr. The biology of open versus closed treatment of condylar fractures. Atlas Oral Maxillofac Surg Clin North Am 2017;25:35–46.
[16] Kanno T, Sukegawa S, Tatsumi H, et al. Does a retromandibular transparotid approach for the open treatment of condylar fractures result in facial nerve injury? J Oral Maxillofac Surg 2016;74:2019–32.
[17] Kotrashetti SM, Lingaraj JB, Khurana V. A comparative study of closed versus open reduction and internal fixation (using retromandibular approach) in the management of subcondylar fracture. Oral Surg Oral Med Oral Pathol Oral Radiol 2013;115:e7–11.
[18] Jensen T, Jensen J, Nørholt SE, et al. Open reduction and rigid internal fixation of mandibular condylar fractures by an intraoral approach: a long-term follow-up study of 15 patients. J Oral Maxillofac Surg 2006;64:1771–9.
[19] Ouyang D, Gu XM, Lei DL. Open reduction and rigid internal fixation of dislocated condylar fractures: a long-term follow-up of 25 patients. Chin J Dent Res 2011;14:147–50.
[20] Eckelt U, Schneider M, Erasmus F, et al. Open versus closed treatment of fractures of the mandibular condylar process-a prospective randomized multi-centre study. J Craniomaxillofac Surg 2006;34:306–14.
[21] Berner T, Essig H, Schumann P, et al. Closed versus open treatment of mandibular condylar process fractures: a meta-analysis of retrospective and prospective studies. J Craniomaxillofac Surg 2015;43:1404–8.
[22] NIS Description of Data Elements (August 2017). Healthcare Cost and Utilization Project (HCUP). Agency for Healthcare Research and Quality, Rockville, MD. Available at: https://www.hcup-us.ahrq.gov/db/nation/nis/nisdde.jsp. Accessed November 2017.
[23] Overview of the Nationwide Inpatient Sample (NIS). HCUP Databases. Healthcare Cost and Utilization Project (HCUP). Agency for Healthcare Research and Quality, Rockville, MD. Available at: http://www.hcup-us.ahrq.gov/nisoverview.jsp. Accessed December 2012.
[24] Vesnaver A, Ahčan U, Rozman J. Evaluation of surgical treatment in mandibular condyle fractures. J Craniomaxillofac Surg 2012;40:647–53.
[25] Cascone P, Marra Marcozzi M, Ramieri V, et al. Mandibular condylar fractures in children: morphofunctional results after treatment with external fixation. J Craniofac Surg 2017;28:1742–5.
[26] Merlet FL, Grimaud F, Pace R, et al. Outcomes of functional treatment versus open reduction and internal fixation of condylar mandibular fracture with articular impact: a retrospective study of 83 adults. J Stomatol Oral Maxillofac Surg 2018;119:8–15.
[27] García-Guerrero I, Ramírez JM, Gómez de Diego R, et al. Complications in the treatment of mandibular condylar fractures: surgical versus conservative treatment. Ann Anat 2018;216:60–8.
[28] Ho SY, Liao HT, Chen CH, et al. The radiographic and functional outcome of bilateral mandibular condylar head fractures: a comparison between open and closed treatment. Ann Plast Surg 2015;74(suppl 2): S93–98.
[29] Yao S, Zhou J, Li Z. Contrast analysis of open reduction and internal fixation and non-surgical treatment of condylar fracture: a meta-analysis. J Craniofac Surg 2014;25:2077–80.
[30] Anehosur V, Joshi A, Rajendiran S. Endoscopic-assisted intraoral open reduction internal fixation of mandibular subcondylar fractures: initial experiences from a tertiary-care maxillofacial center in India. Craniomaxillofac Trauma Reconstr 2018;11:183–91.
[31] Wang HD, Susarla SM, Mundinger GS, et al. Which factors are associated with open reduction of adult mandibular condylar injuries? Plast Reconstr Surg 2016;137:1813–21.
[32] Howlader D, Ram H, Mohammad S, et al. Surgical Management of Mandibular Subcondylar Fractures Under Local Anesthesia: A Proposed Protocol. J Oral Maxillofac Surg 2019;pii:S0278-2391(19)30013-8.