Radiographic Evidence of Dental Complications after Mandibular Distraction Osteogenesis: Inverted-L versus Oblique Osteotomy

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PATIENT SAFETY

3 THERAPEUTIC

Background: Patients with micrognathia undergoing mandibular distraction osteogenesis (MDO) for functional and aesthetic improvement are at significant risk for dental complications. The authors investigated the association of 2 osteotomy patterns—oblique and inverted-L—with risk to developing dentition.

Methods: A senior orthodontist (H.D.N.) performed a retrospective review of dental radiographs of patients undergoing MDO with confirmed oblique or inverted-L osteotomies between 2012 and 2022. Images were assessed for evidence of missing, damaged, or displaced teeth, and proportion of affected hemimandibles by injury type and median number of affected teeth per hemimandible were compared between groups using appropriate statistical methodology.

Results: Analysis included 44 patients (23 oblique, 21 inverted-L) and 85 hemimandibles (45 oblique, 40 inverted-L). Mean age at surgery was 3.1 ± 4.6 years, and mean time to imaging was 4.9 ± 4.1 years; there was no difference between groups ($P = 0.23$, $P = 0.34$, respectively). Oblique osteotomy was associated with greater odds of missing teeth (odds ratio [OR], 13.3, $P < 0.001$), damaged teeth (OR, 3.2; $P = 0.02$), and any dental injury (OR, 39.9; $P < 0.001$) compared with inverted-L, as well as greater number of missing teeth ($\beta = 0.6$; $P < 0.01$), damaged teeth ($\beta = 0.3$; $P = 0.02$), and total number of affected teeth ($\beta = 0.9$; $P < 0.001$). There was no difference in incidence ($P = 0.5$) or number ($P = 0.4$) of displaced teeth between groups.

Conclusions: Inverted-L osteotomies were associated with fewer dental complications compared with oblique osteotomy at all ages studied. Although longer-term follow-up and prospective data are needed before definitive recommendations can be made, these data are helpful to surgeons as they plan MDO. *(Plast. Reconstr. Surg.* 154: 725e, 2024.)

CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, III.

Patients with micrognathia may undergo mandibular distraction osteogenesis (MDO) for both functional and appearance-related improvement. Studies have demonstrated that MDO can improve airway patency, reverse tracheostomy requirements, and improve craniomaxillofacial symmetry.[1–4] This procedure has risks of complications, including bony nonunion, infection, and temporomandibular joint injury.[5] A recent systematic review reported a total complication rate of near 30%, of which 10% were infectious in nature.[3]

Perhaps the most common noninfectious complication of mandibular distraction is dental injury secondary to the mandibular osteotomy.[3] Previous

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studies have reported long-term dental complications, including morphologic abnormalities, disturbances of eruption, and root abnormalities, in 20% to 100% of patients.[6–10] This wide variability in dental injury rates partially underscores the variability in approaches to mandibular distraction, as the location of the osteotomy may be personalized to fit patients' unique morphology and surgical indication. Patients who require sagittal distraction of a microretrognathic mandible may require osteotomies along the mandibular body or near the mandibular angle.[11] In these patients, osteotomy pattern has been hypothesized to mediate risk of dental injury depending on the proximity to teeth and tooth buds.[12] A common pattern is the oblique mandibular angle, or oblique osteotomy, in which the mandible is separated in a straight, obliquely oriented line from the antegonial notch to the superior, posterior mandibular body, in close proximity to dental structures. In contrast, the inverted-L osteotomy, in which the mandibular separation is accomplished largely in the ramus—with a cranially directed cut from the antegonial notch meeting a posteriorly directed cut from the anterior ramus in a sharp angle—stays farther from dentition.

Although it makes anatomic sense that the inverted-L pattern reduces risk of dental injury, there is a paucity of data comparing the 2 approaches. Dental integrity is important for mandibular and facial development,[13–15] and especially important in children with microretrognathia, who often require orthodontia in childhood to prepare for definitive orthognathic surgery at skeletal maturity.[16] Loss of posterior dentition can introduce significant challenges in preoperative orthodontics, potentially adversely influencing mandibular outcomes. Thus, assessing this risk to dental structures in infant surgery is reasonable. Using radiographic evidence of dental injury after mandibular distraction, this study sought to identify whether there is a difference in dental complication rates between the 2 osteotomy patterns. We hypothesized that the inverted-L pattern would be associated with fewer dental injuries than the oblique osteotomy given its distance from developing dentition.

PATIENTS AND METHODS

Patients

A retrospective review of all patients undergoing MDO by 1 of 3 senior craniofacial surgeons (J.A.T., J.A.N., or J.W.S.) between 2012 and 2022 was performed. Exclusion criteria were not undergoing either oblique or inverted-L osteotomy, or osteotomy could not be determined from operative records or imaging; undergoing distraction at an outside institution; or insufficient postoperative facial or dental imaging. This study was approved by the institutional review board.

Demographic characteristics were collected from the electronic medical record, as were osteotomy pattern, unilateral or bilateral distraction, syndromic status, and evidence of repeated distraction. Orthopantomograms and thin-slice head CTs were used for analysis of dental structures. For standardized radiographic analysis, head CTs were converted into orthopantomograms using Dolphin Imaging software (version 12.0). All orthopantomograms were assessed by a senior craniofacial orthodontist (H.D.N.) for evidence of missing, damaged or dysplastic, or displaced mandibular teeth or dental buds (Fig. 1). Teeth that were considered affected due to underlying diagnosis and not due to osteotomy were not included in the analysis.

Hemimandibles were considered separately, as not all patients were distracted bilaterally. Proportion of affected hemimandibles and median number of affected teeth per hemimandible were compared between groups using chi-square tests and Mann-Whitney *U* tests, as appropriate. Multivariable linear and logistic regressions were used to control for the effects of covariates on total severity (defined as the total sum of affected teeth) and incidence of any dental abnormality. Covariates include age at surgery, age at imaging, syndromic status, and repeated distraction between index surgery and imaging. All statistical analyses were performed in R.[17] An α of 0.05 was considered significant for all measures.

Surgical Technique

Mandibular Angle Oblique Osteotomy

A modified Risdon approach is used to reach the inferior border of the mandibular angle. Subperiosteal elevation of the soft tissues of the angle is performed using electrocautery and periosteal elevators. An ultrasonic scalpel is used to create bilateral inferior and superior third mandibular osteotomies through the antegonial notch and the superior posterior portion of the mandibular body such that they will create a straight line when connected (Fig. 2). The footplates of the mandibular distractor are affixed on both sides of the osteotomy using self-drilling, self-tapping screws, typically 3 to 5 screws per baseplate, with the distractor arm brought out through a retroauricular stab wound. Screw placement for

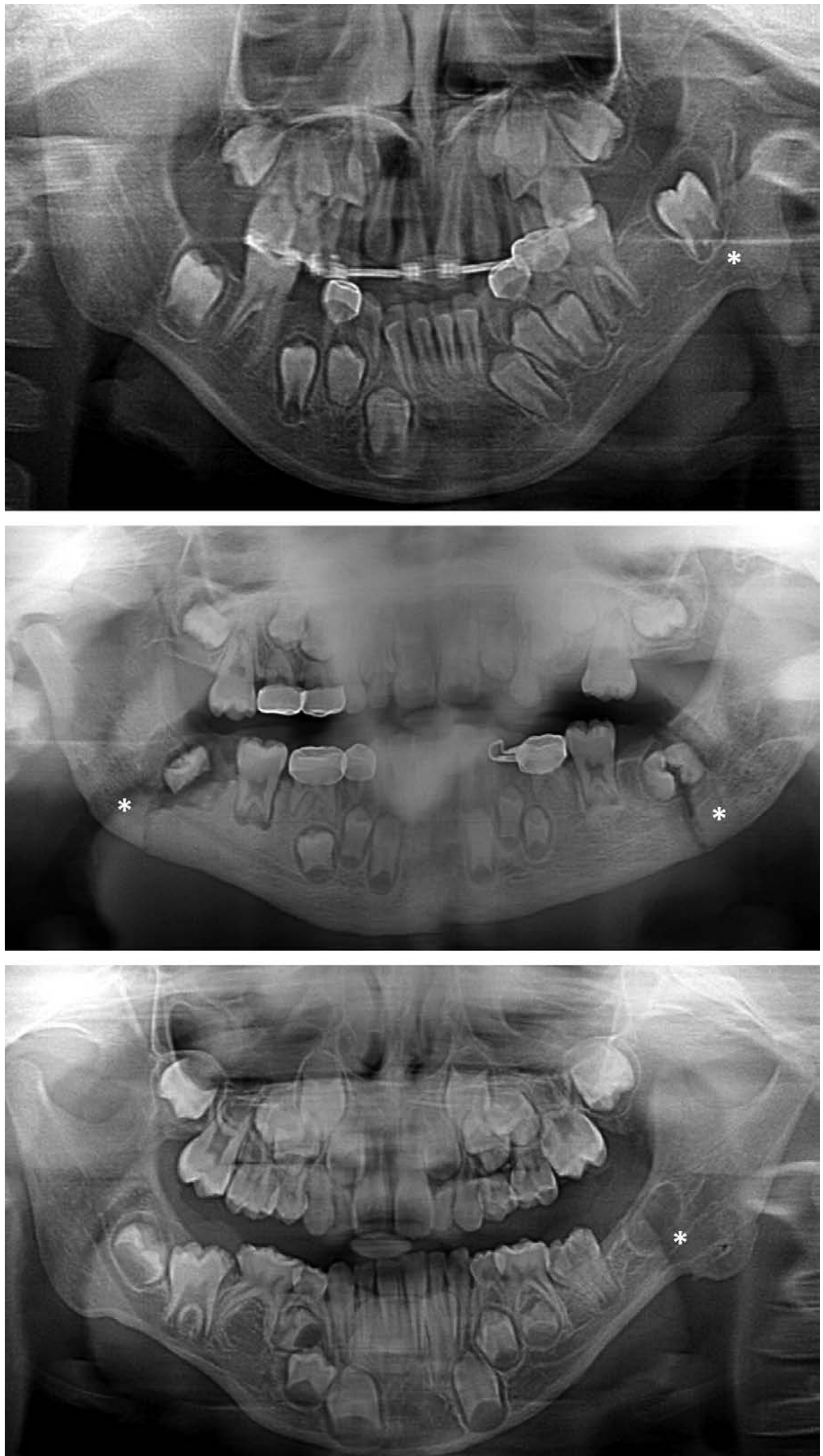

Fig. 1. Representative examples of dental injury patterns. (*Above*) Evidence of dental displacement. The second molar is displaced distally into the ramus. (*Center*) Evidence of dental damage. The unerupted, developing second molar is bisected completely. (*Below*) Evidence of dental agenesis. The *asterisk* demonstrates the expected location of the second molar, which has failed to develop in this patient.

device fixation was generally carried out as close to the basilar bone as possible, thereby minimizing potential injury from screw placement. The osteotomy is then completed, taking care to avoid the inferior alveolar nerve and tooth buds or existing dentition. After ensuring proper functioning of the distractor, the device is returned to its original position and the soft tissue is closed in layers.

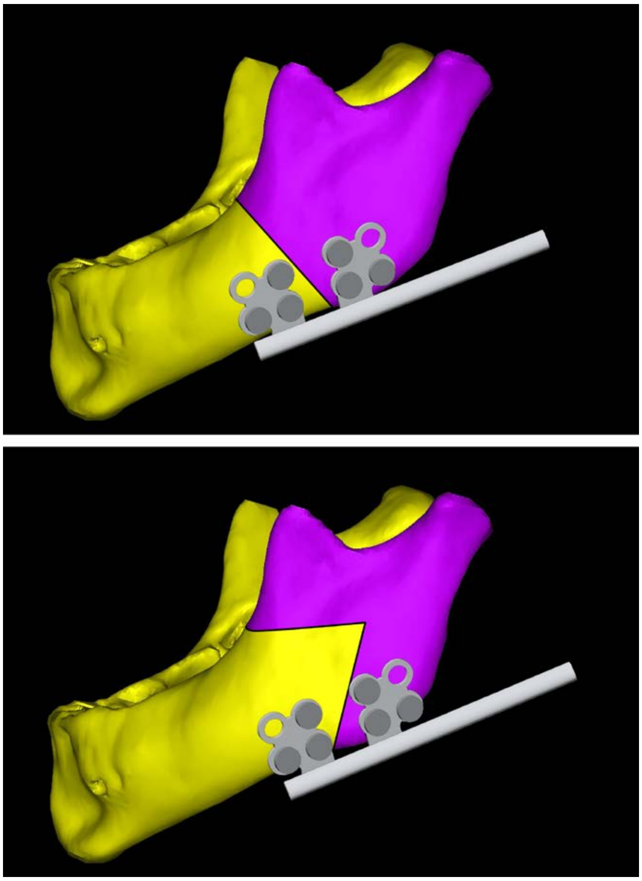

Fig. 2. Examples of inverted-L and oblique osteotomies. (*Above*) The oblique osteotomy is composed of a straight line running from the antegonial notch to the superior posterior portion of the mandibular body. (*Below*) The inverted-L osteotomy is composed of a cranially oriented osteotomy from the antegonial notch and posteriorly oriented osteotomy from the anterior border of the ramus, above the level of the lingula.

Inverted-L Osteotomy

After reaching the mandibular angle using the same approach and dissecting the periosteum as described previously, an inverted-L osteotomy is designed using an ultrasonic scalpel. The mandible is divided cranially from the antegonial notch and posteriorly from the anterior border of the ramus, above the level of the lingula (Fig. 2). Care is taken to avoid the inferior alveolar nerve and tooth buds or existing dentition. Installation of the distractor, completion of the osteotomy, and closure of the incision proceeds as with oblique osteotomy.

RESULTS

Analysis included 44 patients and 85 hemimandibles with near equal distribution between osteotomy types (Table 1 and Fig. 3). Mean age at osteotomy was 3.1 ± 4.6 years, and mean age at imaging was 8.0 ± 4.4 years, with no significant difference between groups ($P = 0.2$ and $P = 0.4$, respectively). Mean time between surgery and imaging was 4.9 ± 4.1 years, again with no difference between groups ($P = 0.3$). Most patients (93%) were bilaterally distracted. There was no difference in the mean number of screws used in device fixation by osteotomy type (7.4 ± 2.3 per hemimandible; $P = 0.2$). Screw placement for device fixation was generally carried out as close to the basilar bone as possible, thereby minimizing potential injury from screw placement. Furthermore, screw placement was standardized across groups, minimizing the chance that screw

Table 1. Clinical and Demographic Information[a]

Characteristics	Inverted-L ($n = 21$)	Straight ($n = 23$)	P	Total ($n = 44$)
Age at surgery, yr	3.03 ± 4.08	3.10 ± 5.03	0.23	3.07 ± 4.55
Age at imaging, yr	7.35 ± 5.05	8.60 ± 3.68	0.40	8.00 ± 4.38
Time since surgery, yr	4.31 ± 5.07	5.50 ± 2.81	0.34	4.94 ± 4.05
Laterality			0.57	
Bilateral	19 (90.5)	22 (95.7)		41 (93.2)
Left	1 (4.8)	0		1 (2.3)
Right	1 (4.8)	1 (4.3)		2 (4.5)
Syndromic			0.22	
No	13 (61.9)	10 (43.5)		23 (52.3)
Yes	8 (36.4)	13 (56.5)		21 (47.7)
Screws used/side in footplate fixation	7.92 ± 3.05	7.00 ± 1.28	0.16	7.44 ± 2.32

[a]Data are presented as mean ± SD or n (%). Groups were nearly equal in size, without significant differences in major clinical and demographic factors.

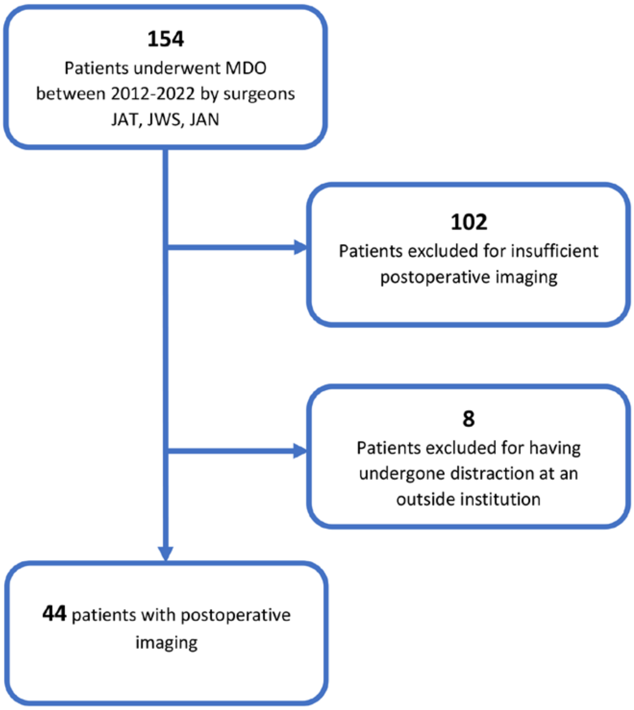

Fig. 3. Flowchart of patient inclusion. A total of 151 patients underwent mandibular distraction, and 45 were ultimately included. Most patients were excluded because of insufficient postoperative imaging.

Table 2. Conditions and Syndromes Represented in the Patient Cohort

Conditions Present[a]	No.	%
Nonsyndromic		
Pierre Robin sequence	21	47.73
Hemifacial microsomia	3	6.82
Syndromic		
Treacher Collins	5	11.36
Nager	3	6.82
Stickler	3	6.82
Crouzon	1	2.27
Auriculocondylar	1	2.27
Beckwith Wiedemann	1	2.27
Catel-Manzke	1	2.27
Cerebrocostomandibular	1	2.27
Coffin-Siris	1	2.27
Cornelia de Lange	1	2.27
Larsen	1	2.27
Unnamed genetic mutation	1	2.27

[a]A large majority of patients had isolated Pierre Robin sequence. The most common syndromic diagnosis was Treacher Collins syndrome.

position, and not osteotomy type, was responsible for the difference in dental problems. Overall, 48% of patients had a diagnosis of isolated Pierre Robin sequence; the remaining patients were diagnosed with another craniofacial-affecting condition or syndrome. Indications for surgery are found in Table 2.

Three patients underwent 2 distractions. All 3 had only inverted-L osteotomies. Two had syndromic diagnoses (1 auriculocondylar, 1 Nager). All 3 patients had dental severity scores of 2 and 1, per hemimandible. All 3 had evidence of damage to 1 tooth, 2 were missing 2 teeth, and 1 had evidence of dental displacement of 2 teeth.

Compared with oblique osteotomies, an inverted-L pattern was associated with fewer hemimandibles showing evidence of missing teeth ($P = 0.002$), damaged teeth ($P = 0.004$), or any injury overall (inverted-L, 55.0%; oblique, 95.6%; $P < 0.001$) in raw analysis (Table 3 and Fig. 4). Similarly, median number of missing ($P < 0.001$) and damaged teeth ($P = 0.003$) was lower in inverted-L osteotomies as compared with oblique osteotomies, as was total severity (inverted-L, 0.8 ± 0.8; oblique, 1.6 ± 0.8; $P < 0.001$) in raw analysis (Fig. 5). There was no difference in proportion of hemimandibles with evidence of displaced teeth ($P = 0.4$) or median number of displaced teeth between groups ($P = 0.4$) (Table 3).

Adjusted models demonstrated similar results as unadjusted comparisons. Oblique osteotomy was associated with significantly greater odds of radiographic evidence of missing teeth (odds ratio [OR], 13.3 [95% CI 3.7–66.1]; $P < 0.001$), damaged teeth (OR, 3.3 [95% CI 1.2–9.5]; $P = 0.02$), and any dental injury per hemimandible than inverted-L osteotomy (OR, 39.9 [95% CI 7.5–342.1]; $P < 0.001$) (Table 4 and Fig. 4). Need for repeated distraction was also significantly associated with evidence of tooth agenesis, whereas older age at surgery (OR, 1.6 [95% CI 1.2–2.4]; $P = 0.003$) and years since surgery at the time of imaging (OR, 1.2 [95% CI 1.0–1.5]; $P = 0.046$) were significantly associated with increased odds of any dental injury. Osteotomy type was not predictive of evidence of displaced teeth, nor were any covariates (Table 4).

Oblique osteotomy was associated with greater median number of missing ($\beta = 0.6$; $P < 0.001$) and damaged teeth ($\beta = 0.3$; $P = 0.02$), as well as total severity ($\beta = 0.9$; $P < 0.001$) compared with usage of an inverted-L pattern (Fig. 5). Repeated distraction was predictive of greater number of missing teeth and total severity, whereas time since surgery was associated with a small increase in total severity only. Osteotomy type was not predictive of number of displaced teeth, nor were any covariates (Table 4).

Subgroup analysis on only patients who underwent surgery before the age of 1 year revealed no significant differences compared with the total

Table 3. Unadjusted Comparisons of Dental Injury by Osteotomy Pattern, per Hemimandible[a]

Incidence of Injury and Teeth Injury Score	Inverted-L (n = 40)	Oblique (n = 45)	P
Incidence of injury, n (%)			
Dental agenesis			0.002[b]
No	31 (77.5)	20 (44.4)	
Yes	9 (22.5)	25 (55.6)	
Damaged			0.004[b]
No	26 (65.0)	15 (33.3)	
Yes	15 (35.0)	30 (66.7)	
Displaced			0.398
No	33 (82.5)	40 (88.9)	
Yes	7 (17.5)	5 (11.1)	
Any injury			<0.001[b]
No	18 (45.0)	2 (4.4)	
Yes	23 (55.0)	43 (95.6)	
Teeth injury score			
Dental agenesis			<<0.001[b]
Median (IQR)	0.0 (0.0)	1.0 (1.0)	
Range	0–1	0–3	
Damaged			0.003[b]
Median (IQR)	0.0 (1.0)	1.0 (1.0)	
Range	0–2	0–2	
Displaced			0.401
Median (IQR)	0.0 (0.0)	0.0 (0.0)	
Range	0–1	0–1	
Severity			<<0.001[b]
Median (IQR)	1.0 (1.0)	2.0 (1.0)	
Range	0–3	0–3	

IQR, interquartile range.
[a]Inverted-L osteotomies were associated with a lower incidence and lower tooth injury score than oblique osteotomies. Here, tooth injury score is defined as the sum of dental structures showing evidence of a given injury type, and severity is the sum of all forms of visible injury, per hemimandible.
[b]Denotes significance at the $P < 0.05$ level.

cohort (Table 5). Incidence of any dental injury with an inverted-L pattern in this cohort was 29%, nearly one-quarter that of patients who underwent oblique osteotomies (93%; $P < 0.001$).

DISCUSSION

This retrospective study found that inverted-L osteotomies were associated with lower incidence of dental injury and fewer injured teeth than oblique mandibular angle osteotomies. An inverted-L pattern was associated with lower incidence of tooth agenesis and tooth damage, and a lower number of missing or damaged teeth. However, there was no difference between the 2 osteotomy patterns for evidence of displaced teeth. This effect was consistent throughout age groups and syndromes studied, leading us to conclude that the observed improved safety profile is, in fact, related to surgical technique.

Previous work has suggested that choice of osteotomy pattern may influence patients' complication profile, by differential proximity to neural and dental structures.[7,8,11,12,18] In an in silico study comparing rates of injury to dentition and the inferior alveolar nerve by simulated osteotomy type, Siska et al.[19] report that the inverted-L pattern was associated with one-third the dental injuries and half the nerve injuries of the oblique pattern. Patterns that strayed farther from dentition, such as vertical, horizontal, and multiangular, all demonstrated lower dental injury rates than either the inverted-L or oblique osteotomy, although all had higher rates of injury to the inferior alveolar nerve.[19] Similar findings were seen in vivo, where the effects of distractor hardware plating may further contribute to dental injury. Indeed, reports of injury vary widely, from zero in patients with preoperative virtual surgical planning[18] to an 85% incidence of any dental injury in patients undergoing oblique mandibular angle osteotomy.[7,11] In this study, we found an inverted-L pattern was associated with a more than 25% lower rate of dental injury and 33 times decreased odds of injury than usage of an oblique osteotomy, reflecting the referenced benefit of the inverted-L pattern at avoiding dental structures.[12,20]

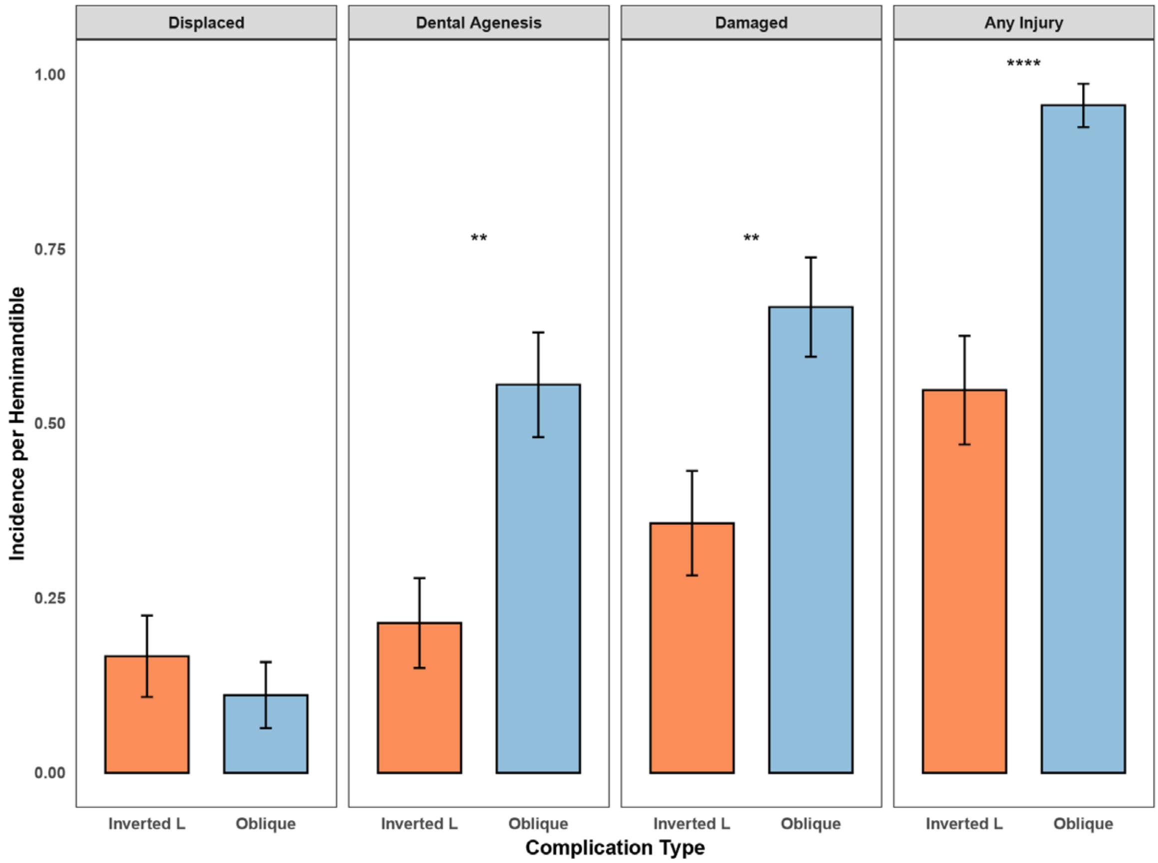

Fig. 4. Incidence of dental injury by osteotomy pattern, per hemimandible. Inverted-L osteotomy was associated with lower incidence of dental agenesis, damaged dentition, and any injury compared with oblique osteotomy. **Significance at the $P < 0.01$ level. ****Significance at the $P < 0.0001$ level.

Given the nonzero incidence of injury with either surgical technique, some surgeons may consider usage of patient-specific cutting guides to further minimize injury.[21–23] Whereas certainly reasonable, the need for preoperative imaging introduces its own set of risks, including radiation exposure and need for sedation in the very young, which may not be considered an appropriate trade-off in certain patients. Thus, usage of customized surgical cutting guides is not a standard part of the 3 lead surgeons' practices, except in patients with particularly severe mandibular dysmorphology where the benefit is believed to be significant.

The nonzero incidence of injury with either osteotomy pattern also underscores the complexity of mandibular and dental development, which is in rapid flux throughout early infancy.[12,18,24] Understanding dental injury in mandibular distraction requires knowledge of both the temporal and spatial patterns of mandibular and dental development. The ramus–condyle complex takes up a relatively smaller proportion of the vertical height of the mandible at birth due to a combination of relative underdevelopment and an obtuse gonial angle.[24] In a process that extends throughout childhood and into adolescence, the ramus is remodeled to accommodate the growing dental arches, producing a more acute gonial angle and incorporation of the anterior ramus into its final portion as the posterior mandibular body.[24] Dental development is similarly complex. At birth, all deciduous teeth have begun to develop,[25] but do not fully mature until as late as 3 to 3.5 years in the case of deciduous first and second molars.[26] In addition, although evidence of the first permanent molar tooth bud is present at birth, the permanent second and third molars do not begin to develop until later in childhood.[27,28]

In patients with craniofacial conditions who require mandibular distraction, these considerations become more nuanced. Conditions such as hemifacial microsomia and Treacher Collins syndrome may result in a severely hypoplastic mandible, making identification of bony landmarks at which to perform the osteotomy difficult, thus

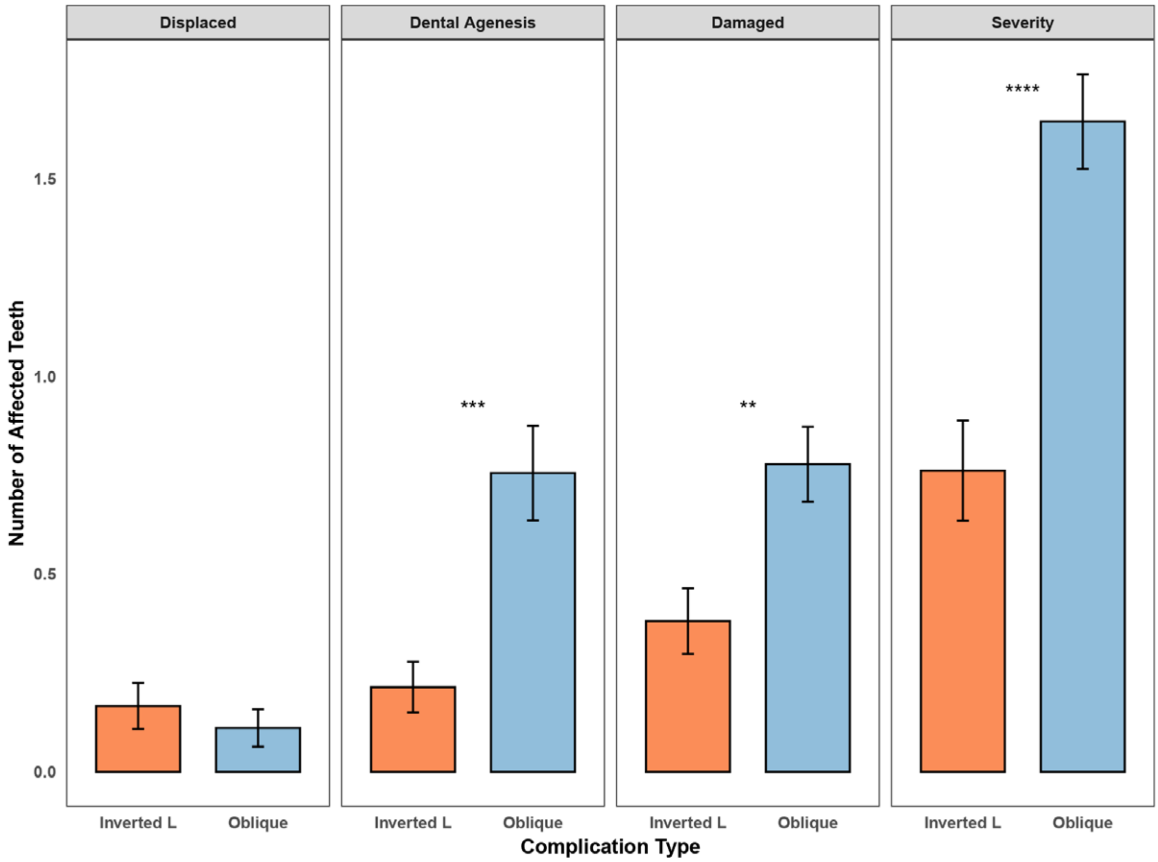

Fig. 5. Teeth injury score by osteotomy pattern, per hemimandible. Inverted-L osteotomy was associated with lower dental agenesis, damaged dentition, and total severity tooth injury scores compared with oblique osteotomy. **Significance at the $P < 0.01$ level. ***Significance at the $P < 0.001$ level. ****Significance at the $P < 0.0001$ level.

increasing the risk of dental injury. In addition, these patients may have dental buds more distal in the ascending ramus than in unaffected patients.[24,29] Although no significant difference in complications was found between syndromic and nonsyndromic cases, the need for special attention to these patients remains. As these patients are already at an increased likelihood of congenital dental anomalies, including agenesis, shape alteration, and displacement,[30–32] optimizing safety for developing dentition is at an increased premium.

Repeated mandibular distraction is not uncommon, and can be indicated for either functional or appearance-related purposes.[33–35] One study found that serial distraction was needed in 46% of tracheostomy-dependent patients with a diagnosis of Treacher Collins syndrome to achieve decannulation.[35] Need for multiple distractions was associated with an increased odds of dental agenesis and greater number of total teeth missing. In these patients, the necessity of repeated mandibular procedures in a surgically altered anatomy reintroduces risk to dentition, likely contributing to the increased rate of dental anomalies, as seen in our cohort. These results provide evidence that in the context of severely affected or syndromic patients who may require repeated distraction, inverted-L osteotomies may be preferable to oblique osteotomies, as the risk to developing teeth is significantly minimized.

Perhaps the most surprising finding in this study was a positive correlation between age at surgery and dental injury rates, contrary to what some authors have previously hypothesized.[12] In one study assessing long-term dental outcomes in patients who underwent mandibular distraction for Pierre Robin sequence, Paes et al.[12] postulate that locating tooth buds may be more difficult in infancy, predisposing younger children to dental injury at the time of osteotomy. Tibesar et al.[2] report similar findings, with patients distracted before 3 months of age having triple the dental injury rate of those distracted later in life. Although this is a reasonable hypothesis, there are limited data assessing the effect of age at distraction on dental

Table 4. Adjusted Effects of Osteotomy Pattern on Dental Injury, per Hemimandible[a]

	Adjusted Odds of Incidence of Injury			Adjusted Teeth Injury Score		
Variables	**OR**	**95% CI**	***P***	**Estimate**	**SE**	***P***
Agenesis						
Intercept	0.01	0–0.15	0.003[b]	–0.31	0.32	0.339
Straight osteotomy	13.26	3.69–66.07	<0.001[b]	0.64	0.16	<0.001[b]
Age at surgery	1.06	0.93–1.23	0.390	0.02	0.02	0.381
Time since surgery	1.09	0.92–1.29	0.291	0.02	0.02	0.281
Syndromic	0.78	0.26–2.30	0.659	–0.06	0.15	0.689
Repeat	34.87	4.08–446.60	0.002[b]	0.67	0.30	0.027[b]
No. of screws	1.28	0.99–1.72	0.075	0.04	0.04	0.282
Model AUC = 0.81						
Damaged						
Intercept	1.33	0.12–16.95	0.819	0.50	0.29	0.089
Straight osteotomy	3.32	1.23–9.52	0.021[b]	0.33	0.14	0.022[b]
Age at surgery	1.11	0.98–1.27	0.111	0.02	0.02	0.193
Time since surgery	1.12	0.97–1.3	0.128	0.02	0.02	0.369
Syndromic	1.21	0.46–3.17	0.695	0.13	0.14	0.344
Repeat	1.93	0.28–13.34	0.489	0.08	0.27	0.772
No. of screws	0.78	0.56–1.02	0.102	–0.04	0.03	0.202
Model AUC = 0.73						
Moved						
Intercept	0.39	0.02–8.12	0.533	0.24	0.17	0.168
Straight osteotomy	0.63	0.15–2.6	0.510	–0.07	0.09	0.445
Age at surgery	1.08	0.9–1.27	0.385	0.01	0.01	0.403
Time since surgery	1.14	0.95–1.38	0.151	0.02	0.01	0.163
Syndromic	0.58	0.13–2.25	0.435	–0.06	0.08	0.455
Repeat	3.93	0.4–34.6	0.211	0.21	0.16	0.208
No. of screws	0.82	0.54–1.13	0.293	–0.02	0.02	0.268
Model AUC = 0.70						
Severity						
Intercept	0.1	0–1.36	0.102	0.44	0.39	0.261
Straight osteotomy	39.89	7.54–342.13	<0.001[b]	0.91	0.19	<0.001[b]
Age at surgery	1.60	1.23–2.37	0.003[b]	0.05	0.02	0.039[b]
Time since surgery	1.20	1.02–1.48	0.046[b]	0.06	0.03	0.030[b]
Syndromic	1.48	0.26–8.66	0.648	0.01	0.18	0.963
Repeat	—	—	0.994	0.96	0.36	0.010[b]
No. of screws	0.99	0.74–1.33	0.951	–0.03	0.04	0.563
Model AUC = 0.94						

AUC, area under the receiver operating characteristic curve; OR, odds ratio.
[a]After adjusting for relevant clinical and demographic factors, an inverted-L pattern was still associated with lower incidence of dental injury than an oblique pattern.
[b]Denotes significance at the $P < 0.05$ level.

outcomes, and the question remains open. In this patient cohort, syndromic patients skewed toward older age at surgery, which may have resulted in increased rates of dental injury secondary to more severe mandibular dysmorphology relative to patients with isolated micrognathia. We are unable to fully assess this risk due to study methodology, and future studies with longitudinal data and more homogenous patient populations may be useful in better elucidating the relationship between age at mandibular osteotomy and dental injury risk.

Given the significant differences in dental complication profiles between osteotomy choices outlined in this study, the question remains: Is there a role for oblique osteotomy in the distraction of the mandibular body? In our opinion, an oblique osteotomy may be considered in patients where the mandible is too small to install distractor hardware safely or effectively. In micrognathic neonates, an inverted-L pattern may lead to a posterior segment too small to hold a distractor base plate, necessitating either modification of the inverted-L or adoption of an oblique pattern to install all necessary hardware safely. The relative difficulties of the 2 techniques may also influence osteotomy choice. The requirement of 2 perpendicular osteotomies with usage of an inverted-L

Table 5. Dental Injury by Osteotomy Pattern in Patients Who Underwent Surgery in the First Year of Life, per Hemimandible[a]

Incidence of Injury and Teeth Injury Score	Inverted L (n = 24)	Oblique (n = 30)	P
Incidence of injury, no. (%)			
Dental agenesis			0.001[b]
No	20 (83.3)	12 (40.0)	
Yes	4 (16.7)	18 (60.0)	
Damaged			<0.001[b]
No	21 (87.5)	9 (30.0)	
Yes	3 (12.5)	21 (70.0)	
Displaced			0.561
No	22 (91.7)	26 (86.7)	
Yes	2 (8.3)	4 (13.3)	
Any injury			<0.001[b]
No	17 (70.8)	2 (6.7)	
Yes	7 (29.2)	28 (93.3)	
Teeth injury score			
Dental agenesis			<0.001[b]
Median (IQR)	0.0 (0.0)	1.0 (1.0)	
Range	0–1	0–3	
Damaged			< 0.001[b]
Median (IQR)	0.0 (0.0)	1.0 (1.0)	
Range	0–1	0–2	
Displaced			0.565
Median (IQR)	0.0 (0.0)	0.0 (0.0)	
Range	0–1	0–1	
Severity			< 0.001*
Median (IQR)	0.0 (1.0)	1.0 (2.0)	
Range	0–2	0–3	

IQR, interquartile range.
[a]Lower incidence of dental injury with an inverted-L pattern was observed in the subset of patients who underwent mandibular distraction in infancy, as in the total cohort.
[b]Denotes significance at the $P < 0.05$ level.

makes it the more operatively challenging of the 2 approaches, which could increase risk of complications for surgeons with comparatively less experience in mandibular distraction. In general, however, it is our belief that when either of the 2 osteotomies may be used safely, it may be preferable to proceed with the inverted-L.

There are important limitations to this study. This is a small retrospective study, which precludes the ability to assign causality. Second, even within osteotomy groups, variations in each patient's unique mandibular anatomy and clinical indication may lead to variability in the exact pattern performed, which may also affect ultimate dental complication rates. Third, as some patients have more limited follow-up, it is possible that further dental complications may surface later, and thus, our results may provide an underestimate of true injury rates. However, given the lack of statistically significant differences in age distributions between groups, this does not significantly affect our ability to compare the 2 techniques, as groups would be affected by this limitation to an equal magnitude. In addition, use of orthopantomograms ameliorates this concern due to the ability to visualize dental structures across developmental stages. The use of both native orthopantomograms and reformatted CTs for analysis introduces heterogeneity, which may also bias our findings, although this is a minor concern. The study is also limited by the available number of postoperative images, given the large number of patients excluded from analysis due to lack of imaging. Indeed, a significantly greater proportion of patients undergoing inverted-L osteotomy were excluded for this reason than patients undergoing oblique osteotomy (inverted-L osteotomy 79% versus oblique osteotomy 55.8%; $P = 0.003$), which may further contribute to our underestimates in true incidence rate. The lack of postoperative imaging in these patients may also reflect lower clinical suspicion of dental and mandibular injury necessitating imaging. We are limited by the available data, and await future studies that may better elucidate the role of osteotomy pattern in postoperative complications. Finally, patients in this study were heterogenous, representing a variety of diagnoses and surgical indications, which may affect the ability to capture dental anomalies due to injury secondary to osteotomy, rather than an underlying syndrome. This may also preclude analysis of age on injury rates, as stated previously. However, all dentition was analyzed by the institutional director of craniofacial orthodontics, with expertise in dentition across clinical syndromes, which may mitigate this concern. Furthermore, the decreased dental injury rates associated with the inverted-L pattern even across a variety of mandibular morphologies may further demonstrate its ability to avoid dentition. Further study and more longitudinal follow-up would be useful in further outlining how osteotomy type in MDO may influence dental sequelae.

CONCLUSIONS

Inverted-L osteotomies were associated with fewer dental complications compared with oblique osteotomies at all ages studied. Although longer-term follow-up and prospective data are needed before making definitive recommendations, these data are helpful to surgeons as they plan MDO.

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DISCLOSURE

Dr. Swanson is a consultant for KLS Martin and Synthes. Dr. Taylor is a cofounder of Ostiio, LLC. The remaining authors have no conflicts of interest to report.

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