

Magnitude of Gonial Angle Influence on the Commonness of Mandibular Angle Fractures

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Abstract

Background: The aim of the study was to review the literature on the influence of gonial angle on mandibular angle fracture. The present systematic review addresses the following focus question: Does the magnitude of gonial angle influence the incidence of mandibular angle fractures? **Materials and Methods:** Electronic and manual literature searches were conducted on databases: PubMed/MEDLINE, Embase, Science direct, the Cochrane Library, and clinicaltrials.gov for studies published up to August 2019 to collect information about the effect of gonial angle, a skeletal morphological parameter with an incidence of fracture of the angle of the mandibular arch. Systematic literature review was performed to identify studies evaluating the effect of gonial angle in patients suffering from mandible fractures. Large retrospective studies were included and case reports were excluded. **Results:** Fifteen hundred articles published before August 2019 were identified. One hundred and sixteen articles met the inclusion criteria. Two articles remained when exclusion criteria were applied. As measured in the two included studies containing 280 panoramic radiographs of mandibular fractures, the mean gonial angle of patients in the angle fracture group ranged from $126.8^\circ \pm 7.9^\circ$ to $128.5^\circ \pm 5.4^\circ$. The mean gonial angle of patients in the nonangle fracture group ranged from $118.5^\circ \pm 4.4^\circ$ to $122.3^\circ \pm 4.9^\circ$. The mean gonial angle of patients in the angle fracture group displayed a range from 118.9° to 134.7° (confidence interval [CI] 95% 5.89–8.05), whereas the mean gonial angle of patients in nonangle fracture group displayed a range from 114.1° to 127.2° (CI 95% 3.89–4.95). **Conclusion:** A high gonial angle is an important factor influencing the occurrence of mandibular angle fractures owing to the poorer quality of bone and reduced height at the ramus angle region, all of which necessitate a modification of osteosynthesis techniques.

Keywords: Database, gonial angle, mandibular angle fracture

INTRODUCTION

Mandibular fractures represent between 35.54% and 44.2% of all fractures in the maxillofacial region.^[1,2] This high incidence is a result of the mandibular anatomy and characteristics.^[2] Mandibular fractures are the second most common fractures occurring after nasal fractures in the facial region.^[1] The mandibular angle is one of the most commonly affected regions with a prevalence of 12%–30% of all mandibular fractures.^[1-3] This region is designated as a triangular area with the superior edge being the junction of the horizontal body and vertical ramus usually where the third molar is or was located.^[4] The higher incidence has been attributed to the curvature at the angle region, the presence of impacted third molar, and height of mandible at the angle.^[1] The poor quality of the bone at the angle region has also been demonstrated as a cause of fracture.^[1]

The mandibular gonial angle is an anthropometric parameter used to assess the growth pattern. It refers to the angle which is

formed by the ramus line (RL) and the mandibular line (ML), where RL is the tangent to the posterior border of the mandible and ML is the lower border of the mandible through the gnathion.^[1,5] On the basis of the measurement of the gonial angle, individuals can be classified as having a high or low gonial angle or a vertical or horizontal grower.

We undertook a systematic review of studies based on determining a possible correlation between the high gonial angle and incidence of mandibular angle fracture using digital panoramic radiographs.

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MATERIALS AND METHODS

Search strategy

The present systematic review addresses the following focus question: Does the magnitude of gonial angle influence the incidence of mandibular angle fractures? Electronic and manual data resources were consulted using the following databases: PubMed/MEDLINE, Embase, Science direct, the Cochrane Library, and clinical trials for studies published until August 2019. The results were limited to studies written in English. The terms which were imported in the search strategy on various databases were gonial angle and mandibular fracture. Literature search on PubMed/MEDLINE was based on terms: Gonial [All Fields] AND angle [All Fields] AND (“mandibular fractures” [MeSH Terms] OR (“mandibular” [All Fields] AND “fractures” [All Fields]) OR “mandibular fractures” [All Fields] OR (“mandibular” [All Fields] AND “fracture” [All Fields]) OR “mandibular fracture” [All Fields]). The following terms were used in the search strategy on the Cochrane library, the database for systematic review: Gonial angle and mandibular fracture. We found the following data: Cochrane Reviews-0, Cochrane Protocols-0, Trials-0, Editorials-0, Special collections-0, Clinical Answers-0, and Other Reviews-0. The Embase database did not reflect any relevant publications. On searching in clinicaltrials.gov, we found a single clinical trial, but it was beyond the relevance of our systematic review design.

Inclusion and exclusion criteria

Eligibility criteria included human randomized and nonrandomized controlled trials and prospective and retrospective cohort studies. Studies that comprised the relationship of gonial angle with an incidence of fracture of the angle of the mandible were included. Studies based on radiomorphometric evaluation using clinical or digital radiographs of patients with evident mandibular angle fractures were considered. The case reports, technical reports, animal studies, cadaver studies, *in vitro* studies, and review papers were excluded from the study. Studies demonstrating mandibular fractures in completely edentulous patients or with pathological changes such as cystic lesions and osteoporosis and mandibular fractures as a part of pan facial trauma were also not considered.

Study selection

A total of 1500 articles were found in the electronic and manual database prior to August 2019. Two independent reviewers were assigned to sort the studies. After the initial screening and exclusion of studies, a total of 116 articles were considered for full-text search. After the final review, only two articles were found to match the inclusion criteria and were included for the systematic review [Flow chart 1].

Quality of the studies

Quality assessment of the selected studies was executed by Newcastle–Ottawa scale. The scale was applied for cohort studies to judge each included study on the selection of studies, comparability of cohorts, and the ascertainment of either the exposure or outcome of interest. Stars were awarded such that the highest quality studies were awarded up to nine stars.

Statistical analysis

Statistical software RevMan (Review Manager [computer program], version 5.3, Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014) was used for the statistical analysis. Differences in means and risk ratios were used as principal summary measures. The overall estimated effect was categorized as significant where $P < 0.05$.

Study characteristics

Both the included studies were retrospective cohort studies using data from patients who underwent treatment for mandibular fractures. The predictor variables for both studies were the presence or absence of a high gonial angle and the presence of impacted third molar and gender, with the exception of the study by Elavenil *et al.* who also considered age, side of fracture, and displacement of fracture fragments. Both studies determined the three-point angular measurement of the gonial angle found by digitally calculating the angular measurement formed by the points connecting Articulare (Ar), Gonion (Go), and Menton (Mn). Elavenil *et al.* classified gonial angle into normal ($121.8^\circ \pm 6.2^\circ$), high ($>121.8^\circ$), and low (below 115.6°), whereas Dhara *et al.* classified it as high ($\geq 125.5^\circ$) and low ($< 125.5^\circ$).

Results of the individual studies

As measured from the two included studies containing 280 panoramic radiographs of mandibular fractures, the mean gonial angle in the angle fracture group ranged from 118.9° to 134.7° , with a standard deviation of 5.869 and mean of 126.80 (95% confidence interval [CI] 5.89–8.05) [Table 1].

The mean gonial angle in the nonangle fracture group ranged from 114.1° – 127.2° , with a standard deviation of 14.566 and a mean of 120.65 (95% CI 3.89–4.95) [Table 2].

Quality of the studies

Quality assessment of the included retrospective cohort studies was executed according to the Newcastle–Ottawa scale. The two studies were of moderate quality, and the risk of bias is present in both. As both were retrospective studies, the total data obtained were dependent on previous records. The study by Elavenil *et al.* included the presence of impacted third molars in the sample and was a variable that could not be controlled in a retrospective study involving trauma. This

Table 1: Included studies

Study	Description	X	Y
Elavenil <i>et al.</i> , 2017	<i>n</i>	70	4
	Mean	126.8	4
	SD	7.9	4
Dhara <i>et al.</i> , 2019	<i>n</i>	32	3
	Mean	128.5	3
	SD	5.4	3
Grand total difference	<i>n</i>	280	1
	Mean	124.05	1
	SD	5.6	1

SD: Standard deviation

Table 2: Mean of Gonial angle (in degrees)

Groups	Minimum	Maximum	Mean ± SD	95% CI	
				Lower	Upper
Mean gonial angle in angle fracture group	118.9°	134.7°	126.80±5.869	5.89	8.05
Mean gonial angle in nonangle fracture group	114.1°	127.2°	120.65±14.566	3.89	4.95
<i>t</i> -test			29.53		
<i>P</i>			0.02*		

One sample *t*-test was done to analyze the level of significance between angle and nonangle fracture groups; which was found to be significant. **P*<0.05 is statistically significant. CI=Confidence interval; SD=Standard deviation

variable was not considered in other studies by Dhara *et al.* In our validity assessment, we found that the study conducted by Dhara *et al.* is at high risk of bias, as it estimated multiple factors for the outcome of mandibular angle fracture.

Synthesis of results

Figure 1 illustrates a forest plot showing a significant association between the high gonial angle and incidence of angle fracture in both the referred studies. The mean gonial angle in the angle fracture group of two included studies containing 280 Orthopantomographs s ranged from 118.9° to 134.7°. The forest plot in Figure 1 demonstrates a highly significant difference between the gonial angle of angle fracture and nonangle fracture group in both the included studies.

DISCUSSION

The predominance of mandibular angle fractures has been greatly attributed to the anatomic weakness of the angle region due to its curvature and change in the osseous grain pattern. Several studies have demonstrated that factors such as impacted third molars, reduced mandibular height, and poor bone quality weaken the mandibular angle further and lead to an increase in the risk of fracture.^[1,6-8]

An important morphologic parameter of the mandible is the gonial angle, which has been considered in both the studies. The mandibular gonial angle has a significant implication to other anthroporadiometric values of the mandible, which include mean cortical thickness, panoramic mandibular index, mandibular height, and intensity of muscle pull.^[4,9,10] It is an important anthropometric feature which contributes to facial esthetics and biodynamics of masticatory musculature. In practice, gonial angle is assessed by radiographic analysis. Although lateral cephalogram is the preferred radiograph used to determine the gonial angle, OPGs were used in both the studies, as they are the established norm of assessing angle fractures and were the only available data.^[1,4] The accuracy of OPG in assessing the gonial angle has been established by a study conducted by Bhullar *et al.*^[11] Studies indicated that OPGs provide more precise measurement of the gonial region, as they do not demonstrate overlap of right and left angles, as observed in lateral cephalograms.^[11,12]

The current systematic review studied the literature on the influence of the gonial angle on mandibular angle fractures. Both the retrospective cohort studies were analyzed separately.

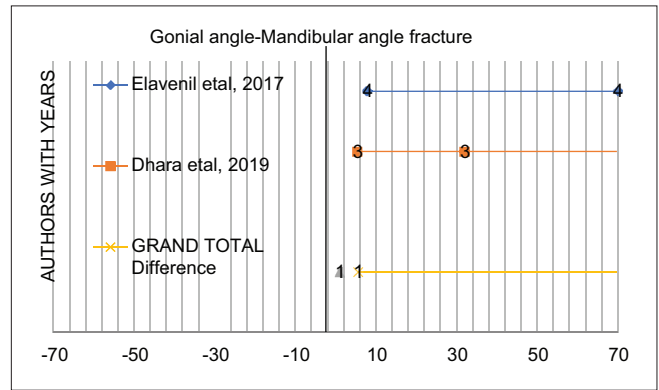
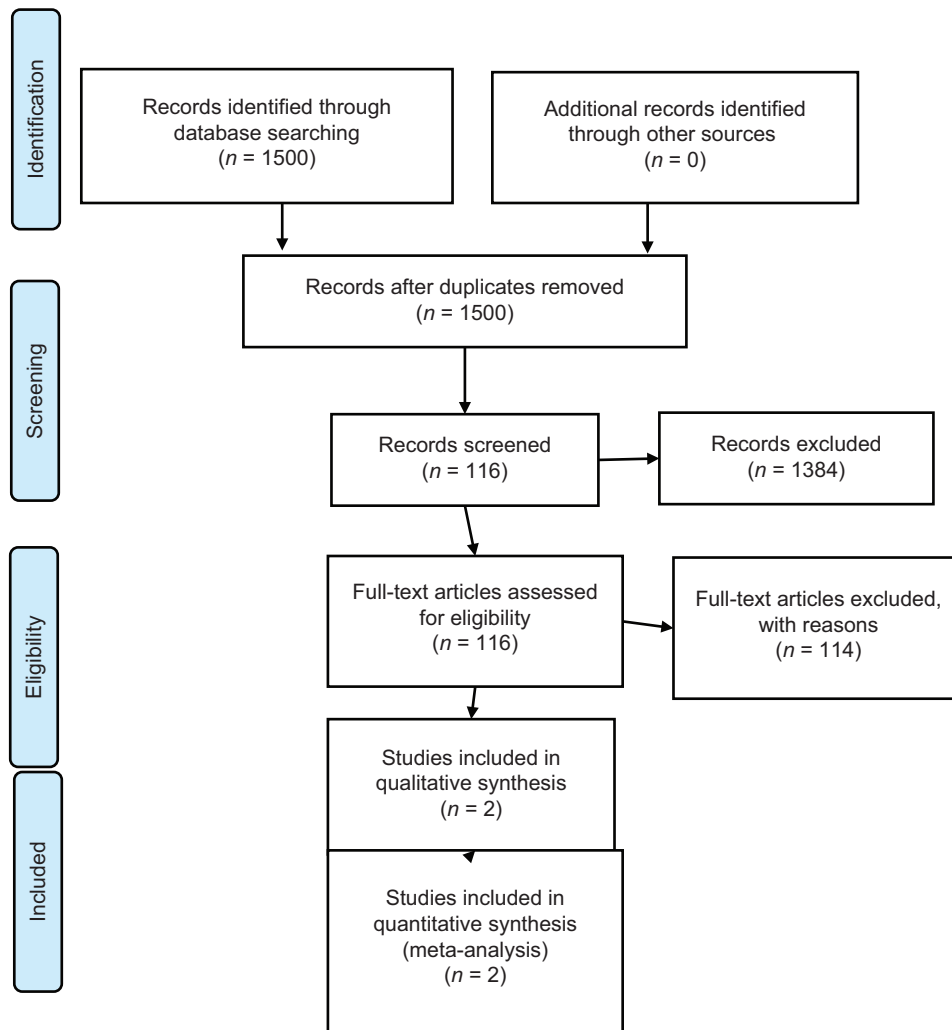


Figure 1: Forest plot graph was plotted to draw inference from two related articles used for systematic review. The articles were named by authors with years. The parameters plotted in graph are *n*, mean and standard deviation of gonial angle in fractured and nonfractured cases

As demonstrated by equality of the risk ratios and on account of the limited amount of included studies, the relevance of obtained information needs to be verified further. Bias is present in the included papers, and this can have a substantial impact on our findings. Dhara *et al.* also included the impact of third molars on mandibular angle fracture, this may affect the result of an association between the angle fracture and gonial angle.^[4] Dhara *et al.* also studied the variables of age; gender, and status of the third molar, which were found to be insignificantly associated with mandibular angle fracture. A study by Larrazabal-Moron and Sanchis-Gimeno also found a significant negative correlation between age and gonial angle values (*r* = -0.365, *P* < 0.001).^[13] However, Panneerselvam *et al.* demonstrated almost twice as many angle fracture cases compared with nonangle fractures.^[1]

Various studies demonstrated that as the gonial angle increases from 90° to 150°, the moment arm of load lengthens by 115% and the mechanical advantage of masticatory muscles, especially temporalis and masseter reduces by 55%.^[14] As observed in the study by Panneerselvam *et al.* in 2017, high gonial angles had an unadjusted 10.3 fold increase in risk for angle fracture over patients with normal or low gonial angles with a relative risk of 10.3.^[1] Patients with high gonial angles were also statistically associated with 11.77 times increased chance for angle fracture.^[1] These results were similar to that of Panneerselvam *et al.*, which also proved that there was a significant risk of mandibular angle fracture in cases of high gonial angle.^[1] The reason for association of high gonial



Flow Chart 1: PRISMA flow diagram

angle with mandibular angle fracture was listed by various studies. The characteristic muscle morphology in a high angle individual generates relatively lower bite forces or masticatory load which, in turn, results in reduced cortical bone thickness at the mandibular angle region. Thus, the mandibular cortical bone width is thinner in high-angle cases than low-angle cases.^[15-17] This feature is also reflected in the thickness of the associated alveolar bone.^[18] Further, it has been established that the height of the mandible at the ramus and angle region in high angle cases is significantly decreased, as compared to normal individuals.^[19,20] On systematic review, both the studies revealed comparatively shorter mandibular height in high gonial angle cases attributing to the higher incidence of angle fractures. As aptly stated by Elavenil *et al.*, patients with a low gonial angle are likely to have a more displaced angle fracture compared to patients with high gonial angle, the reason has been attributed to higher muscular forces, but in their study, the high gonial angle group experienced more displaced pattern of fractures which has been attributed to the low height at the ramus-angle region.

Sirin *et al.*^[21] studied the biomechanical stability of mandibular angle fractures with different gonial angles. Their study on polyurethane mandibles revealed higher displacement in the high gonial angle group as compared to both normal and low-angle groups, both at molar and incisal loading. After molar loading, 80% of the bone plate constructs in the high angle group failed after 130 N. However, there was no statistically significant displacement between the low and the normal gonial angle groups even up to 150 N. After incisal loading, the high gonial angle group had significant displacement as compared to the low gonial angle group starting at 20 N and from normal gonial angle group starting at 100N. The high gonial angle group also required less force magnitude to reach 1-, 3-, and 5-mm displacement as compared to the low gonial angle group. The normal gonial angle group reached the same levels of displacement at lower force magnitudes than the low gonial angle group. The reason for the failure of high gonial angle group after 130N has been attributed to the lower resistance to displacement owing to the altered morphology at the angle region which already has been discussed above.

Ben Said *et al.*^[22] studied the effect of mandibular plane angle on fracture line stability on sheep mandibles. The study concluded that high mandibular plane angles offered lesser resistance to vertical forces applied over the molar region as compared to the normal- and low-angle groups. In his study, no significant difference in displacement was seen among the groups up to 30 N. However, starting at 40 N, statistically significant difference was noted between the high and the other two groups, with no significant difference between the low- and the normal-angle groups up to 150 N. The force magnitude required to reach 3-mm displacement was significantly lower in the high-angle group (48.06 ± 21.39 N) as compared to the low- and normal-angle groups, 78.8 ± 20.68 N and 78.69 ± 21.48 N, respectively. However, there was no difference between the low- and normal-angle groups.

Both the studies have various merits that included (1) use of anthropometric standards (gonial angle), (2) selection of sample consisting of uniform age group, and (3) calibration of OPGs and digital calculation of the gonial angle which reduces the investigator's error and ensures accuracy in measurements.

The systematic review conducted has immense clinical implications; due to the reduced bone stock in the angle region in high gonial angle individuals, the site becomes more prone to a displaced or an unfavorable fracture with reduced anchorage from screws and poorer quality of the bone; a variety of modification needs to be added.

- Use of additional anchorage by either increasing the number of plates or the number of screws
- Providing a form of rigid fixation
- Choosing locking over nonlocking plates as screw loosening might be a factor because of poorer bone quality.

CONCLUSION

With all the literature research within the scope of our systematic review, the conclusion drawn is that individuals with high gonial angle are at a greater risk of sustaining mandibular angle fractures. Osteosynthesis techniques need to be modified by increasing the number of screws to provide additional anchorage, choosing locking over on locking osteosynthesis to prevent screw loosening, and providing a more rigid form of fixation. Keeping in mind that patients with a high gonial angle are more prone to have a displaced angle fracture, precautions need to be taken to prevent such type of injuries, particularly in sports activities by modifying their gears and utilities.

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Conflicts of interest

There are no conflicts of interest.

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