Original Article

Evaluation of occlusal forces using T scan analysis following mandibular fracture fixation

ABSTRACT

Introduction: Mandible receives maximum impact following maxillofacial trauma. The dentate segment in particular is of importance as it has a direct bearing on the occlusive forces. The studies that have been carried out are either based on crude clinical evaluations or make use of elaborate and labor-intensive techniques. This study made use of T-scan analysis for objective identification of occlusive forces following mandibular fracture fixation.

Materials and Methods: Eighty clinic-radiologically diagnosed cases of dentate segments of the mandible were considered, after random sampling method. The occlusion analysis was done by use of a T scan to obtain Relatively Occlusal Force. The procedure was repeated at 04-, 24-, 36-, and 48-weeks intervals. The data was recorded on Excel Spreadsheet (Microsoft Inc) and analysis was done using SPSS software.

Results: The cases were predominantly males with a homogenous distribution of cases of age. The age versus gender distribution was more skewed in the female subgroup with a higher kurtosis value. Both evaluative (Pearson's) and inferential (paired t) tests were applied to reason the study. It was observed that the ROF values decreased in values as compared to pre-operative/post-treatment (Difference of Mean = 2.19, SE = 2.13) compared to 4 (Difference of Mean = -0.40 SE = 0.188),24 (Difference of Mean = -1.22, SE = 0.24) and 36 (Difference of Mean = -3.24, SE = 0.30) weeks, which however surpassed the pre-operative levels at 48 weeks post-operative period. This is suggestive of impending muscular imbalance in the initial periods. The surpass of 48 weeks may be due to optimal forces that were their pre-trauma.

Conclusion: Mandibular fracture fixation is the most widely used and also a time-tested modality in the management of mandibular trauma. The evaluation of occlusive forces needs an understanding of their behavior following such fixation. The present study used T-scan analysis to objectify such forces and added extra insight apart from clinical evaluations of tooth contact and parafunctional movements.

Keywords: Mandibular fracture, occlusal forces, post-trauma, post-fixation, T scan, trauma

INTRODUCTION

The mandible is considered to receive maximum impact during any trauma, and hence it is the most widely recognized form of fracture owing to its sustenance as a result of such.[1] Precise statistical and factual information is hard to acquire as there are numerous variables associated with the studies. There additionally exists diversity in data when studies are analyzed from various nations all through the world.[2] Despite the diversity of statistical data on the incidence of mandibular fractures and their cause, the primary etiology is attributed to vehicular mishaps (43%) trailed by assaults (34%), work-related injuries (7%), falls (7%), sport-related injuries (4%), and rest were due to random causes.

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The high occurrence of mandibular fracture is ascribed to a variety of variables with the more slender cross-sectional area, muscle attachments that modify the biomechanics of fracture crack propagation, and the presence of third molars, as some of the cited determinants.[3]

The fractures of the dentate segment of the mandible need special attention, as they have a direct bearing on the masticatory system in the case of nondisplaced cases, and even more so in cases of displacement.

The role of any surgery done to manage a fracture is to primarily rehabilitate the occlusion to its pre-trauma levels as much as can be achieved. Be that as it may, there are scant studies available where the occlusal analysis has been carried out following mandibular fracture fixation.

The occlusal tactile sensibility for natural teeth can be as low as 8-10 μm.[4] Patients may be able to feel occlusal discrepancies of that dimension when the teeth are restored. Accurate methods of locating the altered occlusal contact points in maximum intercuspation clinically are essential during the rehabilitation of maxillofacial trauma patients.[5]

In the determination of occlusal tooth contacts that require corrections, shim stock foil in combination with articulating paper marks has been recommended.[6] The articulating paper markings are the major guide for the operator to selecting which contacts require adjustment because the shim stock foil does not label the selected teeth. The indicated area has been supported in occlusion textbooks as a reflection of the load contained within the mark.[7] The T-Scan III computerized occlusal analysis system (Tekscan Inc., South Boston, MA, USA) overcomes articulating the paper's acknowledged limitations.[8] It measures and shows relative occlusal force information, allowing the physician to avoid making the same occlusal contact selection mistakes over and over again, which are common when depending exclusively on the combination of dental articulating paper and patient feel. T-Scan III can assist guarantee that clinical occlusal therapy produces high-quality, full occlusal end outcomes that are predictable. The T-Scan III calculates contact time sequencing and percentages of relative occlusal force between several occlusal contacts, then displays them for all dynamic analyses.[9]

Currently, there is scant evidence where the use of such scans is used to demonstrate the occlusal analysis. The available data is limited to in-vitro or animal studies. Therefore, the present study was carried out to evaluate the relative forces of occlusion following mandibular fracture fixation.

MATERIALS AND METHODS

Study design

This prospective cohort study was conducted at a tertiary-level maxillofacial center from 01 Mar 2019 to 31 Dec 2021. Cases that were clinical-radiologically diagnosed as cases of mandibular fracture involving the dentate segment (Symphysis, parasymphysis, body, and angle) were considered for the study. Inclusion criteria consisted of adult patients in the age range of 18-65 years, who had consented to the conduct of the study. Exclusion criteria considered the elimination of cases with edentulism that would affect the occlusion, individuals with neuromuscular in-coordination, cases where the fracture displacement had caused open bite leading to an inability to record occlusal forces and individuals who were incapable of follow-up. After considering the inclusion and exclusion criteria a total of 80 cases were shortlisted for the conduct of the study. Ethica Clearence obtained from Command Military Dental Centre Ref No. 0003/21 dt 14 Nov 2021.

Study variable and collection methods

The predictor variables were assembled into the following accompanying sets: demographic (age and gender), anatomic (fracture location and displacement), and post-injury/pre-treatment occlusal status.

The fracture fixation was carried out by a single operator using Champy's principles of fracture fixation using Titanium plates and screws (Stryker Inc). At 0, 04, 24,36, and 48 weeks after fracture fixation, the individuals were evaluated for occlusion using the T scan III system (Tek scan, Inc) [Figure 1] which is expressed as the relative occlusal force (ROF) of each tooth as the percentage of overall ROF. The occlusal forces generated by the centric relation mode on the software dropdown menu were considered as indexes of maximum intercuspation. The data was recorded in a win.rar format for dynamic readings [Figure 2].

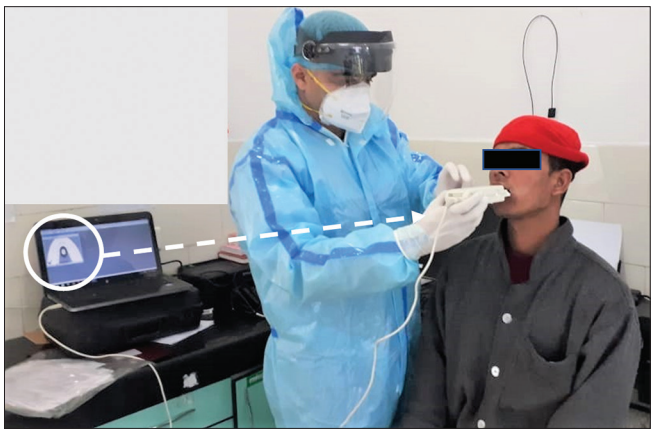

Figure 1: Recording of T scan

The range of forces of occlusion was compared with values as per studies conducted by Agbaje JO *et al*.[10]

Data management

All data were collected and analyzed statistically using a software program (SPPS inc). The data was logged onto an Excel spreadsheet (Microsoft Inc). Descriptive statistical analyses were used for evaluations. The measures were expressed in numerical values correct to two decimal places, with means and standard deviations. The resultant values were subjected to appropriate statistical analyses.

RESULTS

Demographics

Eighty documented cases that were operated for mandibular fractures were considered for the study taking into the laid down inclusion and exclusion criteria. The sample consisted of males predominantly (n = 69, 86.25%) and the rest females (n = 19, 23.75%) [Figure 3]. There was a homogenous distribution of samples concerning age, the overall age distribution had a range from 19 to 60 years (Mean = 29.59, Std Deviation = 9.55), were male (28.22 ± 7.81), female (38.18 ± 14.54), which shows higher age distribution in case of female patients although, the number of female cases reported was lesser comparatively. The male population shows a smaller age deviation from the mean, but it consists of a few out layers which may affect the outcome of the analysis [Figure 4]. The probability distribution of age in the case of males and females is shown in Table 1 which shows a skewed with higher kurtosis value in males (2.13 ± 0.57) (Skewness: 1.56 ± 0.29), the same is also for females with kurtosis (-0.97 ± 1.28) (Skewness: 0.92 ± 0.66), which indicates that both distributions are not showing the properties of normal distribution but the sample is drawn from the larger population which normal.

Percentile age distribution as per gender is described in Figure 5. The graph represents that in both genders the age distribution is concentrated at the 50th percentile with minimal age disparity, beyond the 50th percentile, causes of fracture may vary from case to case.

Analytical interpretation

Bite forces

Initial comparisons of maximum voluntary bite forces were considered between the first and second molars in both arches bilaterally. The maximum intercuspation forces were recorded as a percentage of ROF. The distribution of the fracture based on the location of fracture site had a higher predominance at the parsymphysis (n = 42, 52.5%) [Fig- fracture location), however, the bite forces did not have any significant changes (p = 0.12) [Figure 6].

Evaluative statistics

Pearson's correlation coefficient was evaluated and no co-relations were noticed, the co-relations that were observed between observations were not present suggesting the observations are independent of each

Table 1: Demographic distribution of cases

	Male		Female	
	Statistic	Std. error	Statistic	Std. error
Age (in Years)				
Mean	28.22	0.940	38.18	4.383
95% Confidence interval for mean				
Lower Bound	26.34		28.41	
Upper Bound	30.09		47.95	
5% Trimmed Mean	27.50		37.70	
Median	25.00		35.00	
Variance	61.026		211.364	
Std. Deviation	7.812		14.538	
Minimum	19		25	
Maximum	51		60	
Range	32		35	
Interquartile Range	7		35	
Skewness	1.557	0.289	0.919	0.661
Kurtosis	2.126	0.570	-0.967	1.279

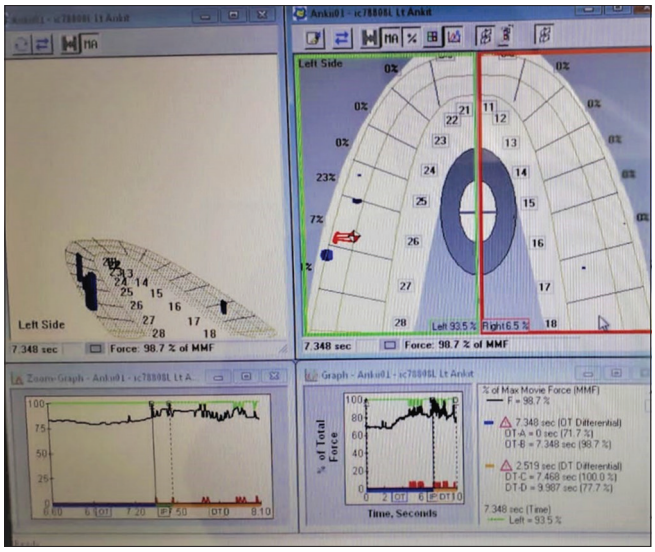

Figure 2: Recording of T scan analysis

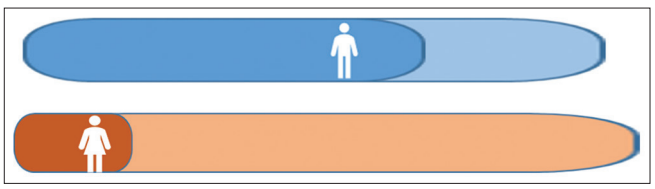

Figure 3: Distribution of males and females in the sample selected

other. Thereby, this avoids the presence of identification bias.

Inferential statistics

The paired test was considered fit to evaluate the differences of combined means at each appointment. The assumption that the sample considered is a subset of a normally distributed population as proved by descriptive statistics holds well here also [Table 2].

The sample seems to be homogenous based on the 50th percentile where the distribution of age is at 25 years (Male) and 35 years (Female).

Pre-operative and Post-operative evaluation:

Pre-operative versus 04 weeks

The ROF had shown significant changes (p = 0.000) wherein there was a decrease in the percentage of force generated during maximum intercuspation (Difference of Mean = 2.19, SE = 2.13) (95%CI; LL = 1.77 UL = 2.62). The clinical attribution to a decrease in ROF may be due to post-operative adjustments of musculature. The other attributable cause could be because the individuals had either inter-maxillary fixation systems (IMF screws or arch bars). The individuals were also advised to consume a soft diet, and occlusive forces did not have full strength [Figure 7].

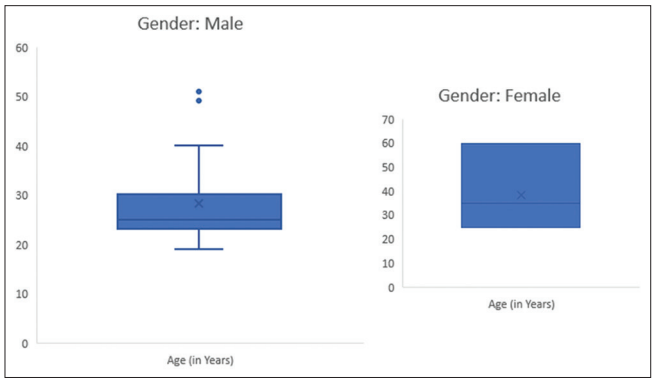

Figure 4: Demographic distribution of samples

04 weeks to 24 weeks post-operative

There were significant changes (p = 0.036) in the ROF during this period (Difference of Mean = -0.40 SE = 0.188) (95% CI, LL = 0.78, UL-0.03). Indicating that the individuals now were adapting to newer muscular forces and increasing their ability to occlude. They were also free of any intra-oral hardware that could interfere with the maxilla-mandibular movements.

24 to 36 weeks post-operative

There was an improvement in ROF compared to 04 weeks post-operative, however, were much lesser than pre-operative values. The values were significant (Difference of Mean = -1.22, SE = 0.24) (95% CI: LL = -1.69, UL = -0.74). The improvement of ROF may be attributable to individuals shifting gradually to a coarser diet, which might have improved their masticatory efficacy to some extent.

36 weeks to 48 weeks post-operative

The changes in mean ROF had shown significant improvements (p = 0.000) (Difference of Mean = -3.24,

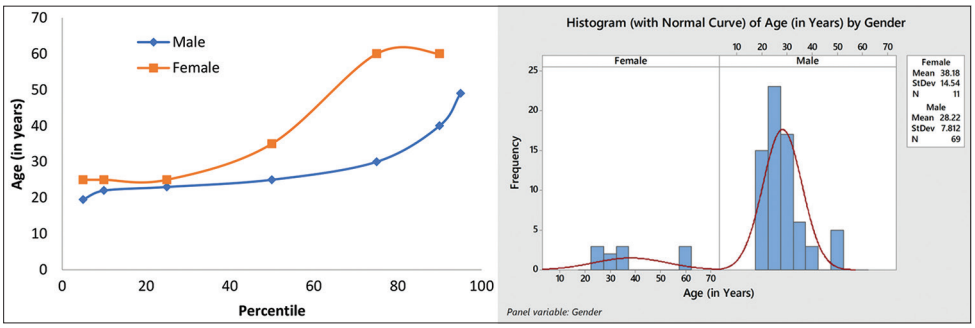

Figure 5: Frequency Distribution polygon of samples (Age and Gender)

Table 2: Pairwise distribution on time intervals

Paired Samples Test									
	Paired differences	Mean	Std. deviation	Std. error mean	95% Confidence interval of the difference		*t*	df	*P***
					Lower	Upper			
Pair 1	Pre OP Mean - 04 Weeks Mean	2.193	1.909	0.213	1.768	2.618	10.275	79.000	0.000
Pair 2	04 Weeks Mean - 24 Weeks Mean	-0.399	1.670	0.187	-0.770	-0.027	-2.134	79.000	0.036
Pair 3	24 Weeks Mean - 36 Weeks Mean	-1.216	2.139	0.239	-1.692	-0.740	-5.085	79.000	0.000
Pair 4	36 Weeks Mean - 48 Weeks Mean	-3.225	2.704	0.302	-3.827	-2.623	-10.668	79.000	0.000

**Level of significance α=0.05

SE = 0.30) (95% CI: LL = -3.83 UL = -2.62). The ROF had shown greater improvements as compared to pre-operative values. The occlusal forces could have been approaching pre-trauma values. However, due to the lack of available data on pre-trauma values, the findings can only be conceptualized.

The comparative evaluation of the range of forces has been depicted in Figure 8.

DISCUSSION

If it is so postulated that the integrity of the mandibular bone has a direct impact on the ability to generate optimal occlusal forces, then patients treated with open reduction and internal fixation might be expected to differ in their abilities to generate such optimal occlusal forces.[11] In the cases that were selected based on laid out inclusion and exclusion criteria, the forces that were generated to reach pre-operative/post-trauma state were seen to be achieved after almost 48 weeks postoperative (Difference of Mean = -3.24, SE = 0.30), in comparison with the forces that were sub-optimal during the 4, 12 and 36-week interval post-operative.

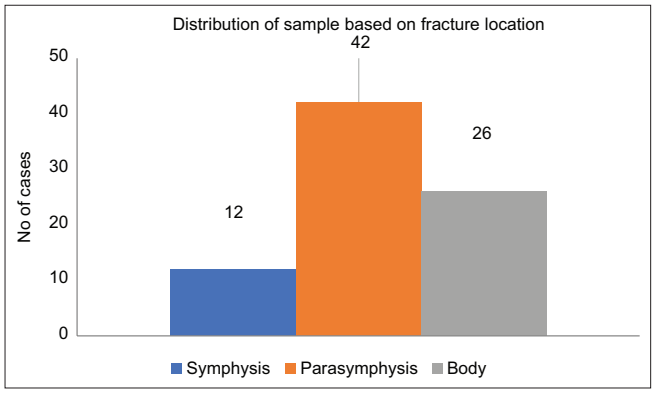

Figure 6: Distribution of samples based on frature location

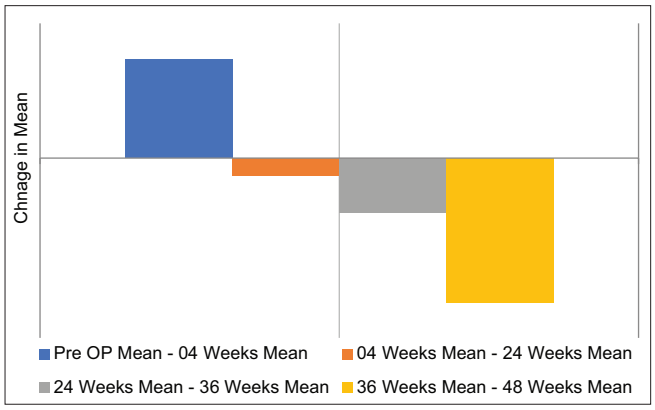

Figure 7: Differences in mean

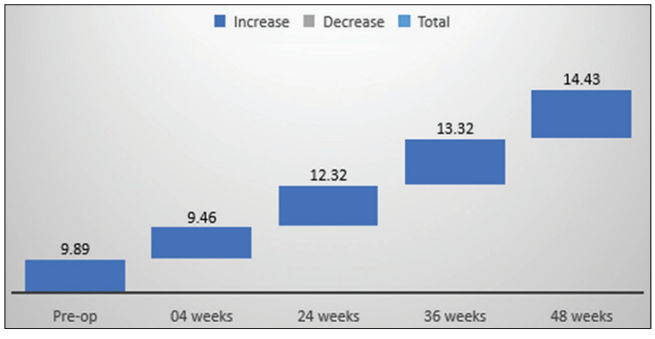

Figure 8: Comparative evaluation of range of forces as per Pre-op, 4, 24, 36 and 48 weeks

The measurement of bite forces using various devices has been expressed in literature. The studies conducted by Ellis E and Throckmorton GS[12] made use of the single-tooth transducer and electromyographic (EMG) studies to arrive at objective conclusions, the study was carried out in patients with condylar fractures only. It is also understood that the biting forces on the fracture side molar tooth, the ratios presented by EMG studies were relatively normal with an equal amount of electrical activity of masseter bilaterally.[13] In our cases the forces generated were sub-optimal even on maximum intercuspation, especially 04 weeks post-operatively (Difference of Mean = 2.19, SE = 2.13) which could be due to discomfort on exertion of jaw muscles after surgery, and also may be due to the presence of IMF devices intra-orally in some cases. This finding is consistent with the concept that a variety of muscle activity patterns can be used to generate a given submaximal bite force as a compensatory mechanism to reduce the load on the contralateral TMJ.[14,15]

The study was made considering that the forces generated after fixation of mandibular fracture would bring about an increase in ROF was rather not suggestive, it was on the contrary that the ROF values seem to have reduced. The plausible explanation seems unavailable, one can only hypothesize based on studies conducted by Greves,[16] Throckmorton,[12] and Spencer[17] that the submaximal effort could modify the recruitment of muscles at the fracture site and therefore limit loading of the fracture segment as a compensatory mechanism.

The use of T scan for evaluation of occlusive forces in fracture patients has scantly been reported in the literature. A similar analysis was carried out in comparison to the use of articulating paper; however, the study has not evaluated the cases on a long-term basis as in our study. The cases are also compared to occlusal forces generated by those of normal patients.[18] The other studies seem to revolve around the use of T scans in Orthodontic, prosthodontic, and implant placement analyses, or *in vitro* studies.[19,20] The

use of T scan in the present study was utilized to analyze the forces generated by dentate segments following mandibular fracture which has been scantly analyzed. One such study reported has used such analysis, however, it is used in the analysis of condylar fracture.[21] T-Scan is one of the most reliable methods to assess occlusion. Values obtained using T-scan, comparison with subjective assessment, and statistical derivations help us to understand the following: The center of force does not alter significantly in the post-trauma period. T-Scan seems sensitive and reliable in evaluating the occlusal forces in repeated post-operative assessments.

CONCLUSION

Mandibular fracture fixation is the most widely used and also a time-tested modality in the management of mandibular trauma. The evaluation of occlusive forces needs a thorough understanding of their behavior following such fixation. There is an interplay of various muscle forces that determine the achievement of optimal forces that provide the individual with appropriate form and function. The present study used T-scan analysis to objectify such forces and added extra insight apart from clinical evaluations of tooth contact and parafunctional movements. The study, within the ambit of its limitations, has tried to focus on the use of sensitive yet user-friendly equipment to repeatedly follow and document changes in forces and tried to justify the cause of such changes. The study can be extended to a plethora of applications in the maxillomandibular complex.

Declaration of consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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