Pesquisa Brasileira em Odontopediatria e Clínica Integrada 2023; 23:e220031
https://doi.org/10.1590/pboci.2023.056
ISSN 1519-0501 / eISSN 1983-4632

ORIGINAL ARTICLE

Assessment of Bite Forces in Restored Teeth with Different Commonly Used Restorative Materials: A Comparative Study

Manay Srinivas Munisekhar[1,2], Bander Fayez Alruwaili[1], Kiran Kumar Ganji[1,3], Mohammad Khursheed Alam[1,4,5], Vinod Bandela[1], Mohammed Ghazi Sghaireen[6]

[1]Department of Preventive Dental Science, College of Dentistry, Jouf University, Sakaka, Saudi Arabia.
[2]Department of Oral Pathology, SVS Institute of Dental Sciences, Appanappally, Mahabubnagar, Telangana, India.
[3]Department of Periodontics & Implantology, Sharad Pawar Dental College & Hospital, Datta Meghe Institute of Higher Education & Research, Nagpur, India.
[4]Department of Public Health, Faculty of Allied Health Sciences, Daffodil International University, Dhaka, Bangladesh.
[5]Department of Dental Research Cell, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamil Nadu, India.
[6]Department of Prosthetic Dental Sciences, College of Dentistry, Jouf University, Sakaka, Saudi Arabia.

Correspondence: Kiran Kumar Ganji, Assistant Professor, Preventive Dental Sciences, College of Dentistry, Jouf University, Sakaka, Al Jouf, KSA. **E-mail:** kiranperio@gmail.com

Academic Editor: Alessandro Leite Cavalcanti

Received: 11 February 2022 / **Review:** 31 August 2022 / **Accepted:** 12 September 2022

How to cite: Munisekhar MS, Alruwaili BF, Ganji KK, Alam MK, Bandela V, Sghaireen MG. Assessment of bite forces in restored teeth with different commonly used restorative materials: a comparative study. Pesqui Bras Odontopediatria Clín Integr. 2023; 23:e220031. https://doi.org/10.1590/pboci.2023.056

ABSTRACT

Objective: To evaluate and compare bite force (BF) in permanent first molars restored with glass ionomer cement (GIC), composite and amalgam, and normal contralateral permanent first molars. **Material and Methods:** BF was recorded in decayed permanent first molars, which were filled with GIC (n=30), composite (n=30), and amalgam (n=30), and in healthy contralateral first molars (n=90) with Force Transducer Occlusal Force Meter and compared. **Results:** BF was significantly higher in normal teeth on the contralateral side compared to teeth restored with GIC and composite. However, in patients with amalgam restoration, though it was less compared to that on the contralateral side, it was not statistically significant ($p>0.05$). **Conclusion:** Restoring teeth with various filling materials may improve bite force. In the present study, it was found that the teeth restored with amalgam had higher bite forces in comparison to the other restorative materials used. However, it was not comparable to that observed in the normal tooth (control) on the contralateral side.

Keywords: Bite Force; Dental Caries; Dental Amalgam; Glass Ionomer Cements; Composite Resins.

Introduction

Mastication is the interaction process between mandibular and maxillary teeth, related bones, and muscles. The force thus generated during mastication is referred to as the biting force [1]. Bite force (BF) can be defined as "the forces applied by the masticatory muscles in dental occlusion" [2]. Under physiologic conditions, it increases with advancing age from childhood, remains relatively constant from 20 yrs to 40 yrs of age, and then gradually decreases with further increase in age [3]. It is a good indicator of the functional state of the masticatory system, which occurs due to the action of the muscles that elevate the mandible and are modified by craniomandibular biomechanics [1]. Maintaining good oral hygiene is key to achieving good general health [4-7]. Studies have stressed that poor oral/dental health affects the quality of life due to several different elements. Various factors may affect BF, such as age, gender, craniofacial morphology, periodontal support, temporomandibular disorders (TMJ), pain, and dental status [8]. Dental status is an important factor that affects the BF. The presence of dental fillings, dentures, number of teeth, and their position in the dental arch may unduly affect BF [9]. The number of teeth and occlusal contact appears to be the most critical parameters affecting maximum BF [10].

Dental caries is the most common dental disease affecting humankind worldwide, both the sexes and all age groups. Dental caries can generally be considered a breakdown of dental hard tissues by acid-producing cariogenic bacteria. Under such circumstances, there is a marked decrease in the occlusal contact which may overtly impact the biting force. There may be other related negative consequences such as discomfort, pain, loss of teeth, development of malocclusion, and TMJ disorders [11]. However, restoring such badly damaged teeth may improve the BF and relieve the patient from other related problems.

Bite force can be measured either by a direct method, where a specific transducer is placed between the teeth, or by an indirect method, by taking other physiological variables known to be functionally associated with the generation of force [12]. Studies measuring BF by different methods available in the past have yielded varied results.

There is very little literature concerning dental decay and its effects on BF and the effect of such teeth restored with various filling/restorative materials on BF. Hence, the present study was undertaken to evaluate the impact of restored carious teeth on maximal bite force (MBF).

In this research, the most commonly used restorative materials such as amalgam, composite, and glass ionomer have been used to restore the badly decayed teeth and the bite forces were evaluated and compared between the various restorative materials used, compared with that in the normal healthy tooth on the contralateral side (control) and assessed the best possible restorative material with better bite force.

Therefore, the aim of this study was to evaluate the MBF in decayed teeth after restoring them with materials such as amalgam, glass ionomer, and composite, to assess the MBF in the natural tooth on the contralateral side, to compare the MBF after restoring carious teeth with materials such as amalgam, glass ionomer and composite and the control teeth and to evaluate the best restorative material among amalgam, GIC and composite in restoring the MBF. The null hypothesis tested was that restoring teeth with different restorative materials, compared to contralateral healthy teeth improves the BF.

Material and Methods

Ethical Clearance

This study was approved by the Ethics Committee, Jouf University (LCBE#1-19-9/39). Written consent was obtained from volunteers after explaining the procedure and nature of the study.

Sample

A total of 133 patients visiting Dental OPD, College of Dentistry, Jouf University, Sakaka, were screened to identify the subjects to be included in the study. The inclusion criteria for our study were: 1) Subjects with occlusal caries affecting enamel and/or dentin in permanent first molars; 2) Subjects free of gingival and periodontal diseases; 3) Subjects free of malocclusion; 4) Subjects without facial asymmetry; 5) Subjects without pain in the region of recording, and 6) Subjects without TMJ disorders. The exclusion criteria were: 1) Differently-abled subjects; 2) Subjects with missing permanent first molars, and 3) Subjects with proximal caries in the permanent first molars. A total of ninety patients with decayed permanent first molar on one side and healthy normal permanent first molar on the contralateral side satisfying the inclusion and exclusion criteria were included in the study.

Clinical Procedures

After the soft caries was removed from the test teeth, 30 patients with decayed first molars were restored with GIC, composite, and amalgam respectively (Figure 1), and the BF was evaluated three weeks after the restoration. The maximal bite force (MBF) was recorded/registered using a bite force registration device (Occlusal Force-Meter GM10; Nagano Keiki Co., Ltd, Japan). The device consists of a hydraulic pressure gauge and an end for the patient to bite on that is enclosed in a plastic casing. When the patient is asked to bite, the reading is displayed digitally in Newtons. During the procedure, the patient was seated upright on the dental chair with Frankfurt's horizontal plane parallel to the floor. The BF was registered on both sides separately by placing the transducer in between the occlusal surfaces of the restored first molars first, and the patient was asked to bite slowly with maximum force till the patient felt pain and to release immediately upon pain, followed by the same process repeated on the contralateral side. The procedure was repeated three times on each side, and the highest value was considered MBF in all the subjects.

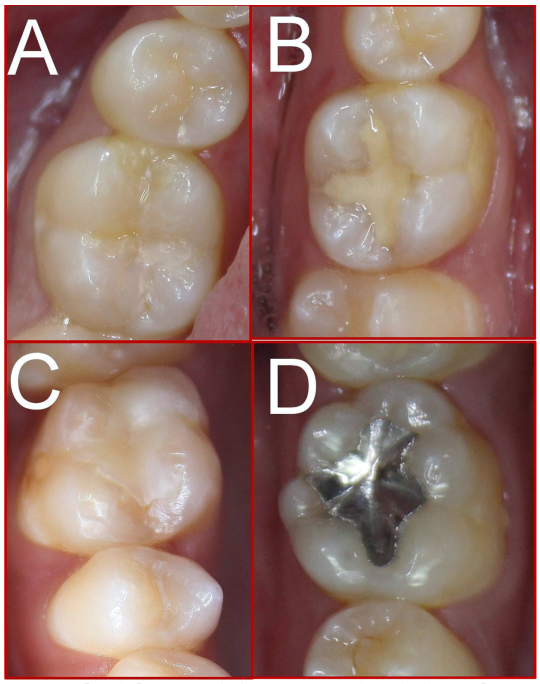

Figure 1. First molars were restored with GIC (B), Composite (C), and Amalgam (D); contralateral side (A) (normal tooth).

Data Analysis

The data was then analyzed using statistical software (SPSS; IBM Corp., Chicago, IL, USA) using 'paired t test' for comparison of the MBF between the test side (restored) and the control side (contralateral) within the groups and for multiple comparisons of MBF between the different restorative materials used and between the controls, one-way Anova post hoc test was used.

Results

The mean bite force registered on the test side (n=90) with the decayed teeth restored with GIC (n=30), composite (n=30), and amalgam (n=30) was lower (492.52±90.21 N) as compared to that on the control side (528.89±93.21 N) (Figure 2).

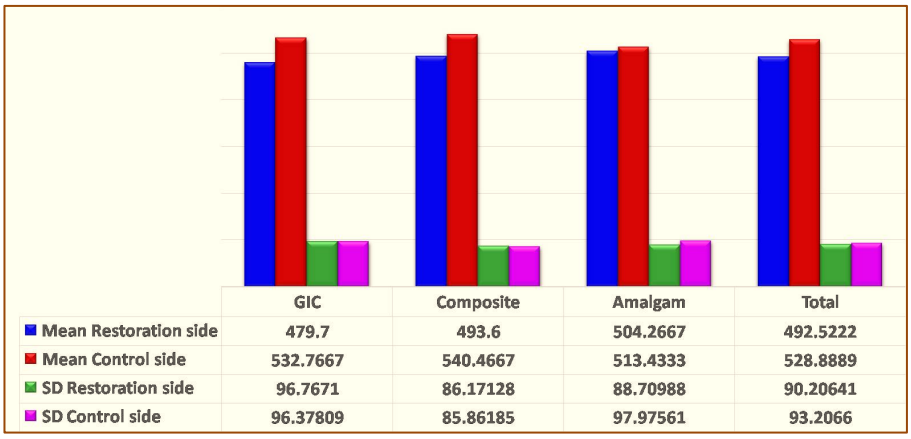

Figure 2. Mean biteforce comparison contralateral side versus restoration side.

The difference in the mean BF in teeth restored with GIC (479.7±96.77 N) and composite material (493.6±86.17 N) was significantly lower in comparison with control (532.77±96.38 N and 540.47+85.86 N, respectively). However, though the mean BF in teeth restored with amalgam (504.27±88.71 N) was lower than that on the control side (513.43±97.98 N), it was not statistically significant (Table 1 and Figure 2).

When the mean BF on the test sides was compared between the different restorative materials used in the study, it was found to be lowest in teeth restored with GIC (479.7±96.77 N), highest in those with amalgam (504.27±88.71 N) and the values for those with composite was between these two values (493.6±86.17 N) (Figure 2). However, there was no statistically significant difference between any of the two given restorative materials compared. Similarly, a similar relationship was found when MBF was compared on the control side between the patients with different restorative materials used in the study (Table 2).

Table 1. Bite force comparison between restoration side *versus* contralateral side.

Restorative Material	Aspect	SE	MD	95% CI		p-value
				Lower	Upper	
GIC	Restoration side	17.67	-53.07	-54.75	-51.38	<0.001
	Contralateral side	17.60				
Composite	Restoration side	15.73	-46.87	-48.50	-45.24	<0.001
	Contralateral side	15.68				
Amalgam	Restoration side	16.20	-9.17	-54.58	36.24	0.68
	Contralateral side	17.89				

MD=Mean Difference; SE=Standard Error; CI=Confidence Interval; GIC=Glass Ionomer Cement.

Table 2. Bite force among the groups: Multiple comparisons using One-way ANOVA post hoc test.

Variables			MD	SE	95% CI		p-value
					Lower Bound	Upper Bound	
Bite force on the Restoration side							
GIC	*vs.*	Composite	-13.90	23.41	-71.04	43.24	1.00
GIC	*vs.*	Amalgam	-24.57	23.41	-81.71	32.58	0.89
Amalgam	*vs.*	Composite	-10.67	23.41	-67.81	46.48	1.00
Bite force on Contralateral side							
GIC	*vs.*	Composite	-7.70	24.16	-66.67	51.27	1.00
GIC	*vs.*	Amalgam	19.33	24.16	-39.64	78.30	1.00
Amalgam	*vs.*	Composite	27.03	24.16	-31.94	86.00	0.80

MD=Mean Difference; SE=Standard Error; GIC=Glass Ionomer Cement.

Discussion

Bite force (BF) is defined as "the capacity of the mandibular elevation muscles to perform a maximum force of lower teeth against the upper teeth, under favorable conditions" [13]. It has been shown that the BF increases with advancing age from childhood fairly remains constant between 20 years and 40 years of age and then gradually decreases with aging. In a healthy adult, the average BF in the first molar region is 500-700 N [14,15]. It is a complex but well-organized systematic process controlled by dental, nervous, and skeletal systems and executed by the elevators of the mandible [16]. BF has been considered an important indicator of masticatory efficiency [17], and it is generally registered as maximum bite force (MBF) [18]. It has been established that bite force is dependent on a variety of parameters such as gender, age, periodontal support, muscle thickness and strength, body size, pain, temporomandibular disorders, facial morphology, dental status, and malocclusion expressed by dental caries.

Dental caries has been associated with negative effects on quality of life, BF and mastication. There is relatively very little research in the existing literature in this regard. Most of the research assessed the impact of restoring decayed teeth in rehabilitating the BF levels in children with deciduous dentition.

The present study evaluated the extent to which the MBF is rehabilitated following restorations of decayed teeth with commonly used restorative materials such as GIC, composite resin material, and amalgam. The overall mean BF recorded on the test side with the decayed teeth restored with GIC, composite, and amalgam was lower (492.52±90.21 N) as compared to that on the control side (528.89±93.21 N). Hence, we reject the null hypothesis. To the best of our knowledge, this study is the first of its kind where the BF was compared in restored teeth to the normal tooth on the contralateral side in fully grown adult patients (20-40 yrs) with decayed teeth. The studies in literature have evaluated BF in children with decayed teeth prior to and after restoring the teeth [3] or in young adults aged 16-18 yrs between the dentition group and fillings groups [19]. The study by Subramaniam and Babu [3] revealed that the BF was less on the restored side as compared to that in normal teeth on the contralateral side, which was similar to our study.

The findings of our study are also compared with similar studies where other types of oral rehabilitation were done and BF was assessed on the test side and the normal contralateral side. In a study by Woodmansey et al. [20] where BF was recorded in implant supported prosthesis and endodontically treated teeth and compared with that on the normal contralateral tooth, the BF on the treated side was less as compared to that on the contralateral side, which is in accordance of our study. These studies suggest that irrespective of the different types of rehabilitation procedures, the BF on the test side is less as compared to the contralateral normal side. The probable explanation for such a difference between the sides could be explained as follows: the patient gets habituated and adjusted to chewing food on the healthy side due to a carious tooth or a missing tooth or any

other cause on the other side with the resultant hypertrophy of the muscles of mastication on that side. This situation persists post-rehabilitation until the patient starts to chew food on the restored side, and it may take about 10 months to regain the BF similar to that on the contralateral side.

Our study also showed that the difference in the mean BF in teeth restored with GIC (479.7±96.77 N) and composite material (493.6±86.17 N) was significantly lower in comparison with control (532.77±96.38 N and 540.47±85.86 N, respectively). However, though the mean BF in teeth restored with amalgam (504.27±88.71 N) was lower than that on the control side (513.43±97.98 N), it was not statistically significant. The reason for such differences between the individual restorative material and the contralateral tooth may be related to the differences in the physical properties and chemical composition of the restorative materials used.

The present study also revealed that when the mean BF on the test sides was compared between the different restorative materials used in the study, it was found to be lowest in teeth restored with GIC (479.7±96.77 N), highest in those with amalgam (504.27±88.71 N) and the values for those with composite was between these two values (493.6±86.17 N). However, there was no statistically significant difference between any of the two given restorative materials compared. Similarly, when the mean MB was compared on the control side between the patients with different restorative materials used in the study, a similar relationship was found. Such differences between restorative materials on the test side could be attributed to the same reasons as explained in the previous section.

Extensive research may be required with a larger sample and different methods of oral rehabilitation in the adult population to confirm the findings of our study.

Conclusion

Restoring decayed teeth with various filling materials may improve bite force. The bite force in the teeth with various restorative materials is not comparable to the bite force on the healthy tooth on the contralateral side, and the bite force in the teeth restored with amalgam is better than glass ionomer cement and composite.

Authors' Contributions

MSM	https://orcid.org/0000-0001-9082-705X	Conceptualization, Validation, Investigation, Data Curation, Writing - Original Draft and Writing - Review and Editing.
BFA	https://orcid.org/0000-0002-8134-6024	Methodology, Investigation and Writing - Original Draft.
KKG	https://orcid.org/0000-0002-3178-9513	Conceptualization, Methodology, Formal Analysis and Writing - Original Draft.
MKA	https://orcid.org/0000-0001-7131-1752	Methodology, Formal Analysis, Investigation, Writing - Review and Editing and Supervision.
VB	https://orcid.org/0000-0002-5228-7133	Methodology, Writing - Original Draft, Supervision and Project Administration.
MGS	https://orcid.org/0000-0001-6702-6879	Methodology, Formal Analysis, Investigation, Writing - Original Draft and Supervision.

All authors declare that they contributed to a critical review of intellectual content and approval of the final version to be published.

Financial Support

None.

Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

References

[1] Bakke M. Bite force and occlusion. Semin Orthod 2006; 12(2):120-6. https://doi.org/10.1053/j.sodo.2006.01.005

[2] Parle D, Desai D, Bansal A. Estimation of individual bite force during normal occlusion using fea. Proceedings of the Altair Technology Conference, Pune, India; 2013.
[3] Subramaniam P, Babu KG. Effect of restoring carious teeth on occlusal bite force in children. J Clin Pediatr Dent 2016; 40(4):297-300. https://doi.org/10.17796/1053-4628-40.4.297
[4] Abanto J, Carvalho TS, Mendes FM, Wanderley MT, Bönecker M, Raggio DP. Impact of oral diseases and disorders on oral health-related quality of life of preschool children. Community Dent Oral Epidemiol 2011; 39(2):105-14. https://doi.org/10.1111/j.1600-0528.2010.00580.x
[5] Gaur S, Nayak R. Underweight in low socioeconomic status preschool children with severe early childhood caries. J Indian Soc Pedod Prev Dent 2011; 29(4):305-12. https://doi.org/10.4103/0970-4388.86375
[6] Paula JS, Leite IC, Almeida AB, Ambrosano GM, Pereira AC, Mialhe FL. The influence of oral health conditions, socioeconomic status, and home environment factors on schoolchildren's self-perception of quality of life. Health Qual. Life Outcomes 2012; 10(1):1-8. https://doi.org/10.1186/1477-7525-10-6
[7] Acharya S, Tandon S. The effect of early childhood caries on the quality of life of children and their parents. Contemp Clin Dent 2011; 2(2):98. https://doi.org/10.4103/0976-237x.83069
[8] Koc D, Dogan A, Bek B. Bite force and influential factors on bite force measurements: a literature review. Eur J Dent 2010; 4(02):223-32. https://doi.org/10.1055/s-0039-1697833
[9] Živko-Babić J, Pandurić J, Jerolimov V, Mioč M, Pižeta I, Jakovac M. Bite force in subjects with complete dentition. Coll Antropol 2002; 26(1):293-302. https://doi.org/10.1111/j.1365-263x.2010.01098.x
[10] Hidaka O, Iwasaki M, Saito M, Morimoto T. Influence of clenching intensity on bite force balance, occlusal contact area, and average bite pressure. J Dent Res 1999; 78(7):1336-44. https://doi.org/10.1177/00220345990780070801
[11] Acs G, Shulman R, Chussid S, Ng M. The effect of dental rehabilitation on the body weight of children with early childhood caries. Pediatr Dent 1999; 21:109-13.
[12] Ferrario VF, Sforza C, Zanotti G, Tartaglia GM. Maximal bite forces in healthy young adults as predicted by surface electromyography. J Dent 2004; 32(6):451-57. https://doi.org/10.1016/j.jdent.2004.02.009
[13] Calderon PdS, Kogawa EM, Lauris JRP, Conti PCR. The influence of gender and bruxism on the human maximum bite force. J Appl Oral Sci 2006; 14(6):448-53. https://doi.org/10.1590/s1678-77572006000600011
[14] Hagberg C. Assessments of bite force: a review. J Craniomandib Disord 1987; 1(3):162-9.
[15] Zarb GA, Bolender CL, Eckert S, Jacob R, Fenton A, Mericske-Stern R. Prosthodontic Treatment for Edentulous Patients. Complete Dentures and Implant-Supported Prostheses. 12th. ed. St Louis: Mosby; 2004.
[16] Ow RK, Carlsson GE, Jemt T. Biting forces in patients with craniomandibular disorders. Cranio 1989; 7(2):119-25. https://doi.org/10.1080/08869634.1989.11678274
[17] Rentes A, Gavião M, Amaral J. Bite force determination in children with primary dentition. J Oral Rehabil 2002; 29(12):1174-80. https://doi.org/10.1046/j.1365-2842.2002.00957.x
[18] Feine J, Lund J. Measuring chewing ability in randomized controlled trials with edentulous populations wearing implant prostheses. J Oral Rehabil 2006; 33(4):301-8. https://doi.org/10.1111/j.1365-2842.2006.01614.x
[19] Kampe T, Haraldson T, Hannerz H, Carlsson GE. Occlusal perception and bite force in young subjects with and without dental fillings. Acta Odontol Scand 1987; 45(2):101-7. https://doi.org/10.3109/00016358709098364
[20] Woodmansey KF, Ayik M, Buschang PH, White CA, He J. Differences in masticatory function in patients with endodontically treated teeth and single-implant–supported prostheses: a pilot study. J Endod 2009; 35(1):10-14. https://doi.org/10.1016/j.joen.2008.10.016