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Comparison and Optimization of Wear Rates of Two Types of Dental Composites On The Basis Of Micro Hardness

Dr. ChaitaliUmesh Hambire[1], Dr. Umesh Vishnu Hambire[2], Subodh Ashok Shirsath[3]

1(Department of Pediatric Dentistry, Maharashtra University of Health Sciences, Nashik)
2,3 (Department of Mechanical Engineering, Government College of Engineering, Aurangabad)

ABSTRACT: *In this current study, two types of dental filler materials are tested for their respective micro hardness and wear rate- Micro filled and Fibre reinforced. The specimens were prepared in Aluminium moulds and cured using LED light torch. The micro hardness was tested on Micro hardness Tester, (Reichert Austria Make, Sr.No.363798). Then they were weighed on Precision Digital Balance machine (LWL Germany Make Model: LB 210S, Least count of 0.0001gm). Then they were mounted on Two Body Wear Tester (Metaserv Grinder/Polisher with wear test set up) for testing of wear rate. The variables considered for the research work were no. of cycles, load and ball diameter. Various combinations of these variables were made. Pre-experimentation was also carried to find out the most influencing values of these variables. The variables were so chosen that they would represent actual conditions under which the dental composites were supposed to work. The results were put into Minitab 14 software for further analysis. It was found that at extreme conditions of loading and ball diameters, the fibre reinforced composite showed better wear resistance than the micro-filled composite. At medium levels of the variables, the micro-filled composite was superior over fibre reinforced one. The optimum levels of the variables were also found.*

KEYWORDS: *dental filler materials, micro hardness, wear rate.*

I. INTRODUCTION

The dental filler or restorative materials have to face various kinds of forces and stresses like chemical, thermal and mechanical [1]. The functions concerned with functional, biological and aesthetic aspects are greatly influenced by the excessive wear of teeth and restorative materials [2]. In this scenario, the wear rate becomes an area of concern as far as the restorative materials are concerned. The normal aging process is the major cause of tooth wear. Although, the entity of teeth is independent of the rate of tooth wear in most of the people [3]. This uncertain life-span of tooth leads to the use of dental restorative materials. The wear resistance and aesthetics of dental restorative materials have raised the interest in greater applications of resin composites [4]. Still their poor wear resistance limits their applications. The stress induced due to the abrasive action and occlusal loads during mastication are the major aspects of these limitations [5-8]. This current study gives the comparison of two types of dental restorative materials, namely micro filled and fibre reinforced, on the basis of micro hardness and wear rates for different values of variables like no. of cycles, load and ball diameter. Each of these variables represents the normal working conditions of the restorative materials. The no. of cycles shows the durability of the composites. It is the function of the chewing and biting action by a human. The more are the no. of cycles, the more is the durability of the composite.The varying load in the research work is the significance of the variable force a human tooth tolerates while chewing and biting. The chewing force is more for the harder food materials and less for the softer food materials. The composite must withstand both kinds of forces. Also the chewing force changes with person to person. It also changes with the age group. The other factors which affect the chewing force are physique of the person the chewing habits, the type of food he chews, environmental conditions where he lives etc.

The varying ball diameter is a significance of the varying area of the different teeth within a jaw. The molar teeth have larger cutting radius than the canines and incisors. This geometry of teeth will affect the amount of force that is going to be act on a tooth. The Hardness may be defined as the resistance of a material to permanent penetration by another harder material. Hardness testing is done by applying a standardized force or weight to an indenter. This produces a symmetrically shaped indentation that can be measured under a microscope for depth, area, or width of the indentation produced. The indentation dimensions are then related to tabulated hardness values. With a fixed load applied to a standardized indenter, the dimensions of the indentation vary inversely with the resistance to penetration of the material tested. Thus lighter loads are used for softer materials [1].

The Vickers hardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a square base and an angle of 136 degrees between opposite faces subjected to a load of 1 to 100 Kg-f. The load is normally applied for 10 to 15 seconds. The two diagonals of the indentation left in the surface of the material after removal of the load are measured using a microscope and their average calculated. The area of the sloping surface of the indentation is calculated. It is suitable to be applied to determine the hardness of small areas and for very hard materials [9].

II. MATERIALS AND TEST METHOD

The materials chosen for the present study was ESPE 3M Z350 (micro filled) and GC Ever X (fibre reinforced).

Sample preparation : The samples were prepared in aluminium mould [10]. The size of samples was 15 mm in diameter and 2 mm thick. The flow able composites were inserted in the cavity. The quantity taken actually for the sample preparation was somewhat more than the cavity in order to ensure that the cavity was filled completely every time. The surfaces were covered with the glass slides to ensure the flatness of the specimen. Care any was taken to ensure that there will not be any air bubble in the specimens.

Curing : The specimens were cured using LED light torch for the time suggested by the manufacturer. The torch was held about 2 to 3 cm away from the specimen. The hardened specimens were then placed under water at room temperature for a week. After a week, they were taken out, dried with soft cotton cloth and placed in dry environment at room temperature.

Hardness measurement : The Vickers micro hardness test was conducted on samples. The micro hardness of the specimens was tested on the Micro hardness Tester, (Reichert Austria make, Sr.No.363798). The effective time of measurement of micro hardness was 10 sec. per specimen.

Fig. 2.1- Microstructure of 3M-Z350 under load 500 gm (5000x)

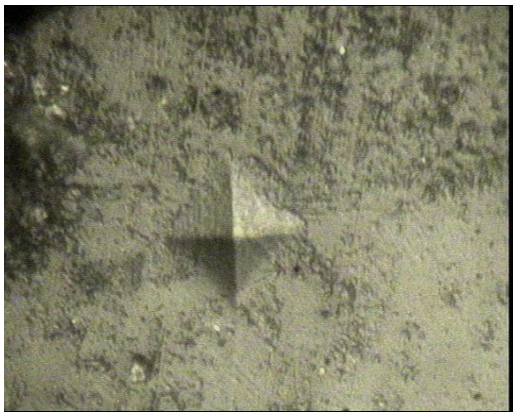


Fig. 2.2- Microstructure of GC ever x under load 500 gm (5000x)

Wear tests : The wear test was carried on ball-on-disc machine. The wear tester was Two Body Wear Tester (Metaserv Grinder/Polisher with wear test set up). Before testing, the specimens were weighed on Precision Digital Balance machine (LWL Germany Make, Model: LB 210S, Least count of 0.0001gm). The balls embedded in acrylic were used for the tests. The values of rpm, load and ball diameter were chosen as per the experimental procedure for the research work.

The results of Vickers micro hardness test are as follows-

TABLE 2.1: Micro hardness of dental composites

Sr. No.	Specimen Identification	Test Load (g)	Micro hardness (in HV)
1	3M-Z350-No.1	25	50.17
2	3M-Z350-No.2	50	55.70
3	3M-Z350-No.3	100	55.90
4	GC Ever X –No.1	25	50.17
5	GC Ever X –No.2	50	55.70
6	GC Ever X –No.3	100	58.72

III. EXPERIMENTATION

TABLE 3.1:

Specimen No.	Test Variables			Initial Weight (g)		Weight after wear (g)		Wear (%)	
				3M-Z350	GC Ever X	3M-Z350	GC Ever X	3M-Z350	GC Ever X
	No. of cycles	Load(gm.)	Ball dia (mm)						
1	5000	1000	6	0.8891	0.8355	0.8827	0.8352	0.71	0.035
2	5000	1000	8	0.8712	0.9567	0.8708	0.9561	0.045	0.062
3	5000	1000	10	0.9459	0.8606	0.9443	0.8602	0.16	0.046

TABLE 3.2

Specimen No.	Test Variables			Initial Weight (g)		Weight after wear (g)		Wear (%)	
				3M-Z350	GC Ever X	3M-Z350	GC Ever X	3M-Z350	GC Ever X
	No. of cycles	Load (gm.)	Ball dia (mm)						
1	4000	750	6	0.9127	0.9328	0.9121	0.9325	0.065	0.032
2	4000	750	8	0.9026	0.9991	0.9019	0.9983	0.077	0.080
3	4000	750	10	0.8812	0.9089	0.8795	0.9083	0.190	0.066

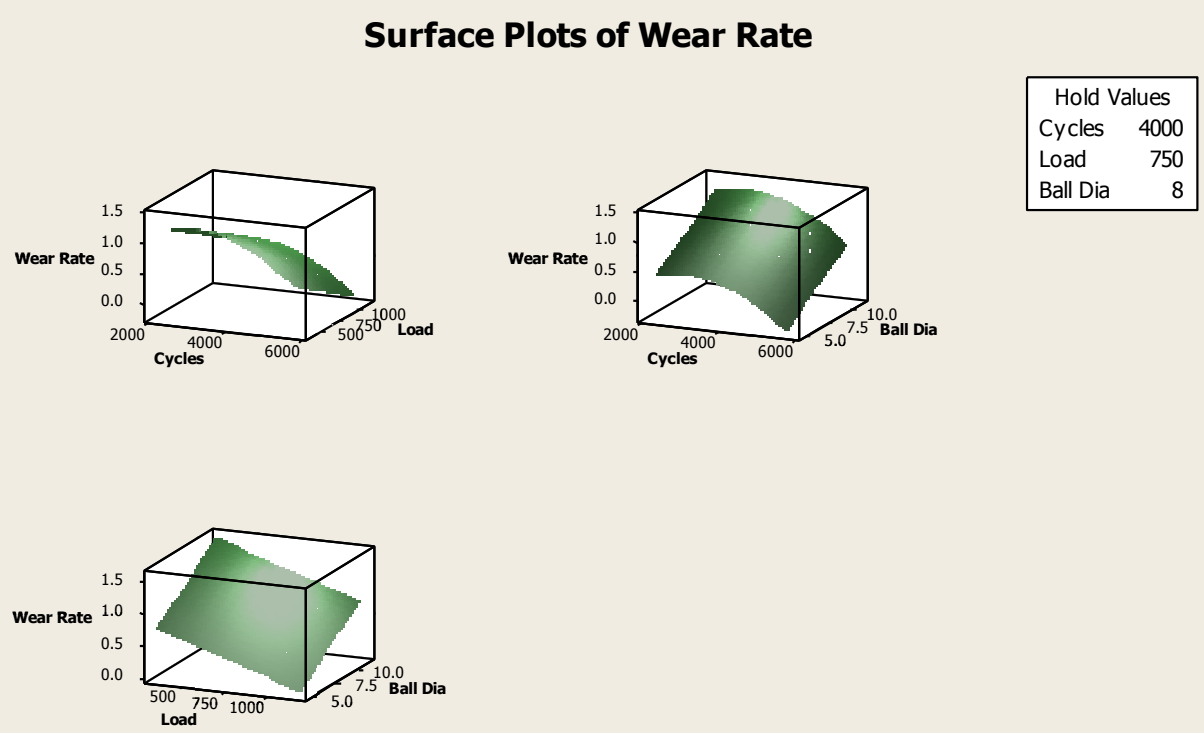
TABLE 3.3

Specimen No.	Test Variables			Initial Weight (g)		Weight after wear (g)		Wear (%)	
				3M-Z350	GC Ever X	3M-Z350	GC Ever X	3M-Z350	GC Ever X
	No. of cycles	Load (gm.)	Ball dia (mm)						
1	3000	500	6	0.9549	0.9444	0.9337	0.9436	0.12	0.084
2	3000	500	8	0.9495	0.9125	0.9487	0.9120	0.084	0.054
3	3000	500	10	0.8706	0.9983	0.8702	0.9978	0.046	0.050

IV. RESULTS AND ANALYSIS

The readings were put in Minitab 14 software for the further analysis. The RSM optimization technique was adopted for the analysis. As seen from the readings tables 3.1 to 3.3, the average percentage wear of fibre reinforced composite GC ever X was 0.04766gm for 5000 cycles and 1000gm of loading whereas the average percentage wear for micro filled composite 3M-Z350 was 0.305gm for the same values of variables.

GRAPH 4.1: 1 Response plot of wear rates for various variables using Minitab 14.



For 4000 cycles and 750gm of loading, the average percentage wear of GC ever X was 0.05933gm and for the same values of variables, it was 0.1106gm for 3M-Z350. For 3000 cycles and 500gm of loading, the average percentage wear of GC ever X was 0.06266gm and for the same values of variables, it was 0.08333gm for 3M-Z350. The average wear, as from table 2.1, for various loads shows that the hardness value of fibre reinforced composite (GC ever X) was superior (average HV 54.86) to that of micro filled composite (3M-Z350) (average HV 53.92).

Response optimization

The graph below shows the optimum values of the factors.

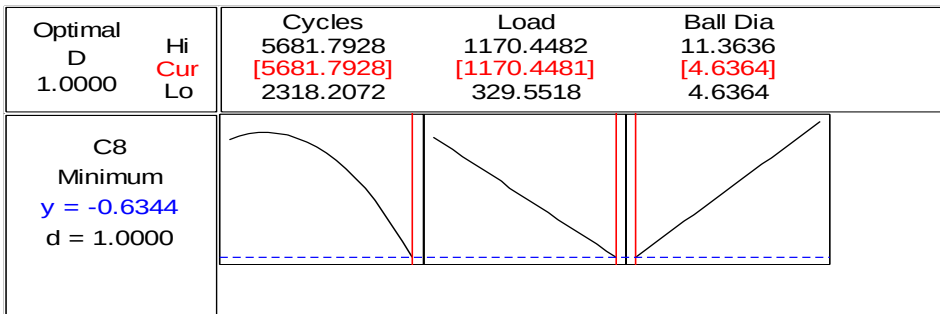


FIG. 4.2: Response optimization of variables using Minitab 14.

Observations : Two composite materialswere tested on ball-on-disc machine for their respective wear rates during this research work. The comparative wear rates within the research work constraints are as follows-

- For 5000 cycles, the GC ever X fibre reinforced composite (avg. wear 0.04766gm) showed better wear resistance over 3M Z-350 micro-filled composite(avg. wear 0.305gm).
- For 4000 cycles, the GC ever X fibre reinforced composite(avg. wear 0.05933gm) showed better wear resistance over 3M Z-350 micro-filled composite(avg. wear 0.1106gm).
- For 3000 cycles, the GC ever Xshowed(avg. wear 0.06266gm) better wear resistance over 3M Z-350 micro-filled composite(avg. wear 0.08333gm).

V. DISCUSSION

- In this research work, the no. of cycles shows the durability of the composites. The no. of cycles is the function of the chewing and biting action by a human. The more are the no. of cycles, the longer a composite work properly.
- The varying load in the research work is the significance of the variable force a human tooth tolerates while chewing and biting. The chewing force is more for the harder food materials and less for the softer food materials. The composite must withstand both kinds of forces. Also the chewing force changes with person to person. It also changes with the age group. The other factors which affect the chewing force are physique of the person the chewing habits, the type of food he chews, environmental conditions where he lives etc.
- The varying ball diameter is a significance of the varying area of the different teeth within a jaw. The molar teeth have larger cutting radius than the canines and incisors. This geometry of teeth will affect the amount of force that is going to be act on a tooth.

VI. CONCLUSION

- In this study, the fibre reinforced composites showed better wear resistance over micro filled composites.
- The optimum values of the no. of cycles, load and ball diameter are 5681.7928, 1170.4481 and 4.6364 respectively.
- The respective average HVs and wear rates of both the materials prove the relation between hardness and wear rate of the material that greater is the HV value, lesser will be the wear rate of the material.

VII. ACKNOWLEDGEMENT

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