A Comparative Evaluation of the Stress Distribution under Polymethyl Methacrylate Acrylic Resin & Acetyl Acrylate Resin Dentures During Occlusal Loading : An in Vitro

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ABSTRACT

Aim: To evaluate and compare the stress distribution under **Polymethyl Methacrylate Acrylic Resin** and **Acetyl Acrylate Resin dentures** during simulated occlusal loading.

Objectives: (1)To evaluate the amount of stress distribution on the edentulous ridge under **Polymethyl Methacrylate Acrylic Resin Dentures** subjected to simulated occlusal loading. (2) To evaluate the amount of stress distribution on edentulous ridge under **Acetyl Acrylate Resin Dentures** subjected to simulated occlusal loading. (3) To compare the stress distribution on the edentulous ridge under **Polymethyl Methacrylate Acrylic Resin** and **Acetyl Acrylate Resin Dentures** subjected to simulated occlusal loading.

Materials and Methods: The materials used were Polymethyl Methacrylate Resin (Group I) and Acetyl Acrylate Resin. They were evaluated for stress distribution under occlusal loading.

Results: The observations obtained were statistically analyzed by Student's t- test and Levene's test. Group I showed equal distribution on all the surfaces where as Acetyl Acrylate showed more stress premolar and molar region.

Conclusion: Polymethyl Methacrylate Acrylic Resin Dentures (Group I) showed better stress distribution than Acetyl Acrylate Resin Dentures(Group II).

Key Words: Polymethyl Methacrylate Resin Dentures, Acetyl Acrylate Resin Dentures, Transducers.

Introduction

Complete dentures have been a treatment of choice for many years for completely edentulous patients. The set of dentures dated back from the 15th century they were carved from Bone, Ivory or made up of teeth sourced from graveyards. The first dentures were made around 1770 by Alex Datcheaue. In 1820, Claudius Ash began manufacturing high quality porcelain teeth dentures mounted on 18- carat gold plates. In 1850's dentures were made of Vulcanite material, a form of hardened rubber into which porcelain teeth were set. Thermoplastic Resins were introduced in 1937 in dentistry[1].

Loss of teeth is accompanied by adverse esthetic and biomechanical sequel. This predicament is worst when the entire periodontal ligament support is lost and the patient becomes completely edentulous.

The problem that has to do with the fact that the residual ridge on which the prosthesis is placed, change shape and reduce in size in the same individuals. Many dentist have been tempted to equate the prevalent residual ridge reduction in the edentulous population with increased stresses imposed on these ridges. Pressure exerted by dentures on mucous membrane would interfere with the blood flow, upsetting the metabolism of the tissues involved and lead to the break down of the ridge[2].

Thermoplastic Resins have been used in dentistry for over eighty years. The applications have continued to grow, and the interest in these materials among the professionals and the public has increased. Polymethyl Methacrylate is a thermoplastic and transparent plastic material. Chemically it is the synthetic polymer of Methyl Methacrylate. In 1877 German chemist Fittig and Paul discovered the polymerization process that turned Methyl Methacrylate into Polymethyl Methacrylate. With further evolution of the material in 1937 it was used as a base material for fabrication of the denture. The material is easy to adjust and polish. It is relinable and reparable at the chair side when modified are strong and can resist fracture. It has the property of water sorption, volumetric change and residual monomer irritation and allergy to the monomer. Acetyl Acrylate materials were first introduced in 1954. It was initially developed as fluropolymer (Teflon type plastic) in 1962. The material nowadays is Nylon based plastic-Polyamides. They offer a alternative to Methyl Methacrylate for patients who are allergic to them[3].

The Acetyl Acrylate material has predictable long term performance. It is stable in nature and provides resistance and fatigue endurance. It has excellent wear characteristics and is solvent resistant. It has no porosity, no biologic material build up or odours and stains. The material matches tissues and also requires minimal adjustments. The material is light in weight, flexible[3].

The Denture bases do place stress on the underlying tissues which has been thought to bring about resorption of the residual bone. The material of the denture base does play an important role. The Polymethyl Metacrylate is a rigid material when compared to Acetyl Acrylate which is flexible. It is thought that the flexing nature of the denture base material may reduce the load on the underlying tissues and thereby reducing residual ridge resoption.

This study was planned to evaluate how the rigid Polymethyl Methacrylate and flexible Acetyl Acrylate denture base material would effect stress distribution on the underlying bone when subjected to occlusal loading.

Method

The method of the study was divided into the following steps:-

A. Fabrication of the Edentulous Model

In a edentulous No.3 perforated tray elastomeric impression material- putty consistency was used to make an impression of edentulous cast. The Impression was then poured in Self Cure Acrylic Resin material and allowed to polymerize. The acrylic cast was then retrieved, finished and polished (Fig. 1). This served as the master model. Impression of the master edentulous model was made in elastomeric impression material. From this ten stone casts were poured for fabrication of the test dentures.Ten casts were divided into 2 groups of 5 casts randomely. Group I- Polymethyl Methacrylate Acrylic

Resin Dentures and Group II- Acetyl Acrylate Acrylic Resin. The master model was futher modified for evaluation of stress distribution.

B. Fabrication of the Polymethyl Methacrylate Acrylic Resin Dentures

Shellac base plate was adapted on the stone cast and ideal teeth arrangement was done with proper waxing and carving. An index was prepared to simulate the teeth arrangement for fabrication of other dentures(Fig.2). This waxedup denture w a s then invested in the flask. After the plaster sets, the flask was placed in hot water at 80°C for 10 minutes for dewaxing, and the two halves of the flask were separated and the mould was flushed with hot water to eliminate any traces of wax. Separating medium was applied on the mould and allowed to cool. Polymethyl Methacrylate resin polymer was mixed with monomer (2:1 by weight) in a mixing jar. As soon as the dough stage was reached, the material was packed in the mould. The trial closure was carried out till no flash was seen. The flask was transferred to the clamp. After a wait for 30 to 60 minutes for bench curing, the flask was heated at 65°C and placed in acrylizer following the short curing cycle for 90 min in water bath and then temperature was raised to 100°C for completion of polymerization[2]. The flask was allowed to cool to room temperature before deflasking. The denture was retrieved, finished and polished (Fig.3). Five test dentures were fabricated in similar manner on the respective cast.

C. Fabrication of the Acetyl Acrylate Resin Denture

Shellac base plate was adapted on the stone cast and ideal teeth arrangement was done with the help of an index with proper waxing and carving. After the base flasking was completed the waxed denture was spured on the lingual aspect and attached to the main sprue at the rear of the flask (Fig.4).Vaseline was applied on the exposed plaster surface. Counter flask was invested to complete the flasking and the two halves of the flask were secured with the help of screws. After the plaster was allowed to set and dewaxing was done. The resin cartridge was heated to 305°C for eighteen minutes. It was then pressed by the plunger in to the hot mould. The injected resin was then allowed to cool in open atmosphere and the denture was retrieved from the flask and finished and polished. In the similar manner five test dentures were prepared on respective cast.

D. Preparing The Denture For Occlusal Load Application

Recesses were made on the edentulous master model in four areas in the posterior ridge, one each on crest of the ridge in first Pre-molar and Molar region and one each on Buccal and Lingual flanges to accommodate the transducers[4] (Fig.5). Two holes were made on Buccal and Lingual flanges of all the dentures for the wires of transducers to pass through. For mimicking the overlying soft tissues of the edentulous ridge tissue stops of 2mm thickness were fabricated in self cure acrylic resin and stuck on the master model[5] (Fig.6). Light Body Elastomeric material was manipulated and placed on the fitting surface of the dentures. The dentures was then placed on the master model and pressed till the tissue stops prevented any further downward movement (Fig.7). The material was allowed to set.

The dentures lined with simulated Light body material were placed on the master model and connecting wires of transducers were passed through the holes in the denture flanges. These wires were connected to the Pressure Sensing Circuit.

E. Application of Occlusal Load & Recording of Stress Distribution

On the occlusal surface of the test dentures four Acrylic studs prepared in self cure Acrylic resin were placed and stabilised with glue. A flat wooden plate was placed on the studs and a 3 kg load was placed for subjecting the denture to the required load for evaluating the stress distribution (Fig.8). In similar manner all the dentures were subjected to the load and recordings were recorded and tabulated for evaluation. The pressure readings were recorded on Digital Panel Meter.

Results

The observations were statistically analyzed to comparatively evaluate the stress distribution over four surfaces. The Student's t'test and Levene's test was applied to the data to determine whether the comparisons were statistically significant. Group I showed equal distribution over all the surfaces as compared to Group II. There was a significant difference statistically in the stress distribution over Buccal and Lingual surface of Polymethyl Methacrylate Acrylic Resin Dentures and Acetyl Acrylate Resin Dentures. (Please see the Tables & graphs).

Discussion

Complete and Partial Removable Dentures have been the most acceptable treatment for edentulism. They help in improving the function and esthetics of the patients. Various materials have been used in past for fabrication of dentures like Silver, Gold, Chrome-Cobalt alloy and Porcelain. However one of the most common material in Prosthetic Dentistry is Polymethyl Methacrylate due to its excellent reliability and ease in processing.

M. Vojdani AAR. Khaledi had said that the primary problem of Polymethyl Methacrylate is poor strength characteristics including low flexural strength. This can be improved by modifying and reinforcing the resins. Various combinations of modifications for strengthening of acrylic resin were tried out. One of the most common reinforcement technique is the use of metal wires and wires.[6]

Research lead to the making of Acetyl Acrylate Resins which have better flexing capability than Polymethyl Methacrylate Acrylic Resin. The dentures fabricated were lined with resilient material to simulate the soft tissue over the bone as is present in edentulous ridges. This was similar to the method followed by Charles C. Kelsy M.S ,Fredrick D. Reid , Joel A. Coplwitz to simulate soft tissue .Some amount of stress would have been absorbed by this soft lining material and the pressure under the dentures were recorded an evaluated.

Acetyl Acrylate have been in prosthetic dentistry for making removable prosthesis. These can be used in cases of deep undercuts to have better retention of the prosthesis.

E.Zmyslowska, S.Ledzion, K. Jedrzjewski said that bone is considered to be the base which provides support for denture. In the physiologic sense, it is an area where force is transmitted created while biting and chewing foods. According to Atwood, the degree of mandibular loss of its alveolar portion is three or four times higher than alveolar resorption in maxilla. This is due to smaller denture bearing area in the mandible and thus great load per square cm.[7]

Charles C. Kelsy, M.S Fredrick D.Reid, Joel A. Coplowitz stated that Residual Ridge Resorption is a physiological process through which height and width of the bone changes. There are various factors attributing for bone resorption to take place. One of them is the amount of force applied. In bone Tensile force is better accepted than compressive forces. Also the amount of resorption is directly proportional to the force/unit area. This means that the compressive forces applied by removable dentures should be uniformly distributed so as to avoid stress concentration.[8]

Douglas A Atwood stated that some authors postulate that Residual Ridge Reduction is an inevitable disuse atrophy and other states residual ridge resorption is an abuse bone resorption due to excessive force transmitted through dentures.[9]

Boucher stated that prevalent residual ridge reduction in the edentulous populations are due to increased stresses imposed on these ridges. Pressure exerted by dentures on mucous membrane would interfere with blood flow, upsetting the metabolism of the tissues involved leading to bone resorption.[10]

Acetyl Acrylate and Polymethyl Methacrylate during occlusal loading tends to pass on the stress to the edentulous ridges. What was the pattern of stress distribution under the dentures fabricated with Polymethyl Methacrylate and Acetyl Acrylate were evaluated and compared.

The study showed that under Polymethyl Methacrylate Acrylic Resin dentures, the stresses were uniformly distributed on the buccal, Lingual and Occlusal Surfaces.This may be due to material being more rigid.

Acetyl Acrylate Resin dentures showed less stress concentration on the buccal and lingual surface when compared to Polymethyl Methacrylate of the edentulous ridge. This may attributed to the flexibility of the material.

The results also showed that Acetyl

Acrylate dentures recorded more concentration on the occlusal surface of the residual alveolar ridge but when compared to the Polymethyl Methacrylate Acrylic Resin Dentures are nearly same. More pressure recorded on the crest of the ridge may lead to more resorption of bone on the crest of the ridge. Not much work has been done on the Acetyl Acrylate material for fabrication of the complete denture. Futher studies can be planned for authentication the result got for the present study.

Limitations

The study was preformed by using pressure sensing circuit which included use of pressure transducers which recorded the load and transferred to the Digital Panel Meter. Care has to be taken while loading the transducers which are very sensitive. And unavoidable pressure while placing the load may lead to inaccurate recording of the pressure. The simulation of the soft tissue covering the base may not be even all over the ridge.

Conclusion

This study was conducted to evaluate and compare the stress distribution under Polymethyl Methacrylate Acrylic Resin Dentures and Acetyl Acrylate Resin Dentures during occlusal loading .Within the limitations of this invitro study the following conclusions were drawn:

1. The stress distribution on the Residual Ridge under Polymethyl Methacrylate Acrylic Resin Dentures were equally distributed on Occlusal,Lingual and Buccal Surface.
2. The stress distribution on Residual Ridge under Acetyl Acrylate Resin Dentures were concentrated more on the occlusal surface when compared to Buccal and Lingual Surface .
3. The stress distribution on occlusal surface under Polymethyl Methacrylate Acrylic Resin Dentures and Acetyl Acrylate Resin were nearly equal.
4. Acetyl Acrylate Resin Denture showed less distribution of stress on Buccal and Lingual surface than Polymethyl Methacrylate Acrylic Dentures. This may be attributed to the flexibility of the Acetyl Acrylate Resin material.

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Legends

Fig.1 Master Model
Fig. 2 Index For Mimiking The Teeth Arrangement
Fig. 3 Polymerized Denture
Fig. 4. Sruening of The Waxed Up Denture
Fig. 5 Placement of Transducers
Fig. 6 Placement of Tissue Stops
Fig .7 Placement of Light Body
Fig. 8 Loading of The Denture

Tables

Statistical Analysis By 't'-test For Comparison of Stress Values of Group I And Group II (Group Statistics)

	Type of Denture	N	Mean	Std. Deviation	Std. Error Mean
Premolar Region	Group I	5	558154.54	20881.0530	9338.29
	GROUP II	5	535157.95	79660.6206	35625.3
Molar Region	Group I	5	537886.36	27526.620	12310.2
	GROUP II	5	510602.27	73580.894	32906.3

Statistical Analysis by Levene's Test For Comparison of Stress Values of Group I And Group II (Independent Samples Test)

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		f	Sig.	t	Df	Sig.2-tiled
Premolar Region	Equa variance assumed	3.064	0.118	0.624	8	0.550
Molar Region	Equal variance assumed	2.827	0.131			

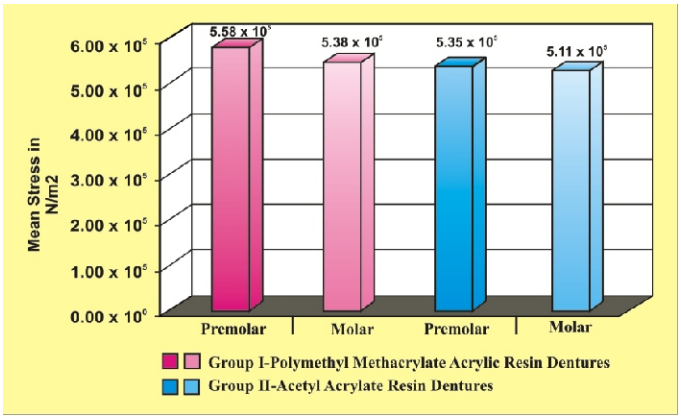
Statistical Analysis By 't'-test For Comparison of Stress Values of Group I And Group II (Group Statistics)

	Type of Denture	N	Mean	Std. Deviation	Std. Error Mean
Buccal Region	Group I	5	235812.500	3645.9900	1630.53
	GROUP II	5	20657.9545	8671.8957	3878.18
Lingual Region	Group I	5	214375.0000	33416.0504	14944.1
	GROUP II	5	28843.1818	3748.71405	1676.47

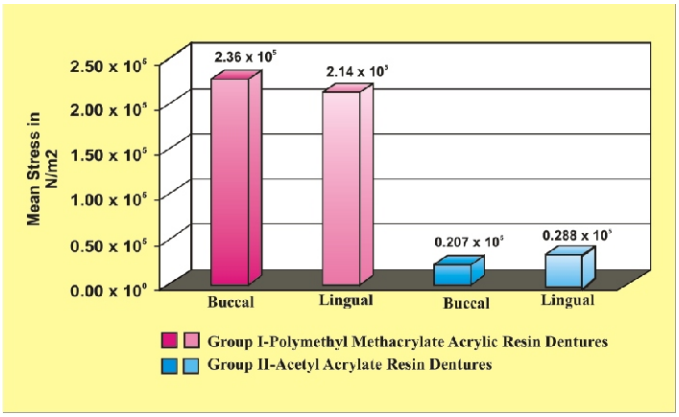
Statistical Analysis by Levene's Test For Comparison of Mean Values Of Group I And Group II (Independent Samples Test)

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		f	Sig.	t	Df	Sig.2-tiled
Buccal Region	Equal variance assumed	6.820	.031	51.142	8	.000
Lingual Region	Equal variance assumed	4.906	.058	12.338	8	.000

Graphs



The comparative values of stress distribution of Group I and Group II



The comparative values of stress distribution of Group I and Group II

Figures