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Original Research Paper

COMPARATIVE EVALUATION OF MARGINAL LEAKAGE AMONG TOOTH COLORED DIRECT RESTORATIVE MATERIALS (CENTION N, ACTIVA BIOACTIVE RESTORATIVE AND NANOFILL COMPOSITE) IN CLASS II RESTORATIONS USING STEREOMICROSCOPE: AN IN-VITRO STUDY.

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INTRODUCTION

Composite restorations occupied commendable place among direct restorative materials[1] .The esthetic properties and bonding to the tooth structure and command setting are the unique features of composite restorations[2,3].The other advantages of composite's availability of desired consistencies based on shape, size and volume of the filler particles, such as flowable, packable, bulk filled resins also available site specific demand subjected to withstand various levels of occlusal loads. Based on curing type, chemically cured, light cured and dual cured systems which made possible to control setting time as well as minimise shrinkage stresses and also duel and chemical cured resins can be restored where curing light inaccessable[4]. Commercial dentin adhesives are usually provided by the manufacturers for corresponding composite materials because interchanging of adhesives can produce incompatibility, which may impair the marginal seal and the performance of the restoration. This incompatibility may also account for the conflicting results of the in vitro marginal seal obtained with some dentin bonding agents. Consistent, long-lasting, non leaking margins have not yet been achieved in composite resin restorations that are finished in dentin. There is a need for an effective, durable dentin adhesive agent. Even though the composite restorations having a wide range of merits, equally demerits also evident, such as least wear resistance, polymerization shrinkage and higher thermal expansion ultimately responsible for marginal leakage, postoperative discomfort due to sensitivity, secondary caries and finally clinical failure of the restoration[5,6] . Larry Hench in 1969 was the first to use the term bioactive materials in describing a new material for bone reconstruction that could be able to form a bond to body tissues. The early concept of bioactivity was limited to a biomaterial that elicits a specific biological response at the material tissue interface which results in the formation of a bond between them. Till now, the concept of bioactive materials had extremely expanded . Bioactivity arises when a material could be elicits combination of an intracellular and extracellular response through its interface. These materials are used mainly for repair, reconstruction and regeneration of dental insults. For example, glass ionomer has been described as bioactive material due to their ability to remineralize of tooth structure, in addition to continuous dynamic release of fluoride which delay the secondary caries around the restoration margins[7]. Recently introduced bioactive restorative materials with aim of enabling antibacterial activity and remineralization of hard tissues of the tooth, had successful outcome. Bioactive material is defined as a material that has the effect on or eliciting a response from living tissue, organisms or cell such as inducing the formation of hydroxyapatite[4]. Bioactive Materials are dynamic, not passive, and in the presence of saliva they elicit a biological response that forms a layer of apatite and a natural bond between the material and the tooth. Bio active materials moisture friendly and imitate nature and participate in dynamic ionic exchange. When the pH is low, the demineralization process releases calcium and phosphate ions from tooth surface. As pH raises, these ions available to interact with fluoride ions in our saliva. They are water based or have the capacity for significant water transport or storage and continuously release and recharge their ionic components[8].They react to the changes in the oral environment to bring about advantageous changes in the properties of saliva, teeth, and the materials themselves. This is often referred to as "smart" behaviour. However, the size of the marginal gap as small as 10 µm is sufficient to penetration of the bacteria. The immediate defence mechanisms such as pulpal hydrostatic pressure and plasma proteins present in the dentinal fluid prevents ingression of bacteria through host innate immune mechanisms[9]. But the rate of sclerosis of dentinal tubules and reparative dentin is very slower, indeed the invasion of bacterial toxins and bacteria causes faster dissolution and destruction of the dentin. If the restoration is hermetically sealed, bacteria may not be able to survive[2]. Another bioactive restorative material Cention N is alkasite restorative material like ormocer categorised as subgroup of composite[10].It is a dual cure material capable of releasing fluoride, calcium and hydroxide ions, available powder, and liquid in A2 teeth coloured shade. the powder consists of various glass fillers like barium aluminium silicate, ytterbium trifluoride, calcium barium aluminium fluorosilicate, calcium fluorosilicate, initiators and pigments, these patented isofillers acts as shrinkage stress relievers, liquid consists of dimethacrylates like Bis-GMA, Bis-EMS, UDMA and initiators[11],provides low volumetric shrinkage. This study designed to test marginal leakage among bioactive materials with conventional composite restorations. The three materials chosen are Activa bioactive restorative, Cention N, and Filtek TM Z250 universal restorative composite. The Activa Bioactive restorative is composite resin modified glass-ionomer cement (RMGIC) contains a rubberised bioactive resin matrix in the form of methcrylate resin with polyacrylic acid copolymers[12] and bioactive glass fillers that imparts toughness and more resistance to fracture and chipping. It is a duel cured bulk fill restorative material, chemically bonds, recharges calcium, phosphate and fluoride elicit natural remineralization of tooth structure. Further claims that it doesn't contain Bisphenol A, Bis-GMA and BPA derivatives. The setting mechanism through acid base neutralization reaction, self-cure, and light curing forms ionic resin, contains phosphate acid groups interacts with resin, interactive glass fillers and minerals in tooth, as result formation of resin-hydroxyapatite complex[13]. Therefore, the aim of the study is to compare marginal leakage among tooth coloured direct restorative materials (Cention N, Activa bioactive restorative and nanofill composite) in class II restorations using dye penetration method.

MATERIALS AND METHOD

The proposed invitro study got the approval from institutional ethical committee, (Reference no. HFW/(GDC)B(12)50/2015-10405) Himachal Pradesh Government Dental College, Shimla. Maxillary first premolars free from any caries, restoration and lesions were included for this study. Teeth with Fractures, wear off, cracks, carious, restored and altered morphology were excluded from this study. Total 90 extracted maxillary premolars were collected on orthodontic reasons, All the tissue tags and blood clots were removed and disinfected by storing in 10% formalin for one week. The teeth were stored in distilled water for 24 hours. Subsequently the teeth were blotted and dried. A standardised Class II cavity with dimensions 4mm x 2mm x 2mm depth of the axial wall 1mm and gingival floor 1mm into the dentin were prepared with no 245 tungsten carbide bur by using a high speed airotor hand piece with water spray. All the prepared samples were randomly divided into 3 experimental groups, Each group consists of 30 teeth according to the restorative material used: Group I-nano hybrid composite NHC; Group II cention-N CN; Group III Activa Bioactive Restorative ABR. subsequently Tetric N-bond universal adhesive applied and cured for 25 seconds.

Study design

Group I: Nano hybrid composite NHC filltek -245 was placed and condensed incrementally into the cavity and cured with light cure gun for 25 sec each increment in prepared cavity with Teflon coated plastic instruments.

Group II: Cention N CN placed and condensed with plastic instruments into the prepared cavity and cured for 25 seconds.

Group III :Activa Bioactive Restorative ABR placed into the prepared cavity with specially designed delivery mechanism given by manufacturer. condensation done with plastic instruments cured for 25 seconds

In order to achieve proper marginal adaptation at proximal boxes, mylar strips were used while curing was performed. The teeth of all the three groups were finished and polished with composite polishing burs.

Method

The restored teeth were stored in distilled water at 37°C for 1 week to allow complete acid-base reaction. The specimens were thermocycled with 500 cycles between 5°C and 55°C & a dwell time of 30 sec in each bath. The teeth were blotted and dried. The apices of the specimens were sealed with sticky wax & all the specimens were coated with two coats of clear nail polish with the exception of 1 mm around the tooth-restoration margins to prevent procedural errors and allowed to air dry. Subsequently the teeth were immersed in 2% methylene blue dye solution for 24 hours. After dye penetration was done, the teeth were cleaned and blotted with tissue paper and sectioned along the mesiodistal direction through centre of the restoration with diamond disk under water spray. The dye penetration of the occlusal and gingival margins of each section was evaluated independently by the observer using stereomicroscope at a magnification 10x and microleakage through occlusal and gingival margins were recorded based on the criteria.

The leakage number was taken from the following ratio: Leakage number = distance evidence for dye/over distance determined for margin (=100%) The leakage distance from the margin to the determined limit was recorded in mm, and the leakage number was a result of the proportion of leakage. The scores thus obtained from the samples were then subjected to statistical analysis.

Statistical Analysis

Statistical analysis was performed using SPSS software (IBM Corp 2013;Version 22.0; Armonk, NY). Anova one-way analysis of variance was applied to compare the mean microleakage among three different groups at gingival, occlusal, and combined levels, followed by post hoc Tukey's test was performed to compare mean microleakage between two groups individually at gingival, occlusal, and combined levels, and $P < 0.05$ was taken to be statistically significant.

Table 1: Criteria for Scoring

score	Tooth restoration interface	Score criteria (proportions)
1	No dye penetration	0.00
2	Dye penetration up to the one-third of the prepared cavity wall	0.25
3	Dye penetration up to the two third of the prepared cavity wall	0.50
4	Dye penetration into the entire prepared cavity wall	0.75
5	Dye penetration into the entire prepared cavity wall and the pulpal wall	1.00

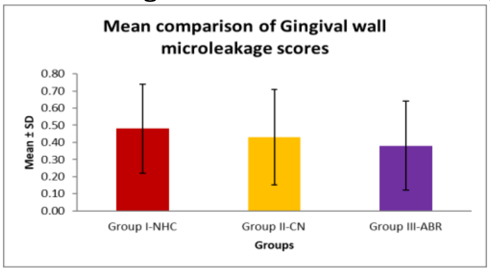
RESULTS

Table 2 shows comparison of mean value of gingival wall microleakage scores among Group I vs Group II vs Group III (0.48 +- 0.26 vs 0.43 +- 0.28 vs 0.38 +- 0.26) which is statistically non-significant; therefore, null hypotheses of no significant difference cannot be rejected. Table 2 shows comparison of mean value of gingival wall microleakage scores between different groups. Mean difference among group I and group II is 0.05 which is non-significant statically. (p value – 0.749) Mean difference among group I and group III is 0.10 which is non-significant statically. (p value – 0.263) Mean difference among group II and group III is 0.05 which is non-significant statically. (p value – 0.675) (graph 1)Table 6 shows comparison of mean value of occlusal wall microleakage scores among Group I vs Group II vs Group III (0.42 +- 0.28 vs 0.51 +- 0.26 vs 0.53 +- 0.27) which is statistically non-significant; therefore, null hypotheses of no significant difference cannot be rejected.

Table 3 shows comparison of mean value of occlusal wall microleakage scores between different groups. Mean difference among group I and group II is 0.09 which is non-significant statically. (p value – 0.387) Mean difference among group I and group III is 0.11 which is non-significant statically. (p value – 0.267) Mean difference among group II and group III is 0.02 which is non-significant statically. (p value – 0.969) (graph 2)Table 4 shows comparison of mean value of occlusal as well as gingival wall microleakage scores among Group I vs Group II vs Group III (0.45 +- 0.27 vs 0.47 +- 0.27 vs 0.45 +- 0.27) which is statistically non-significant; therefore, null hypotheses of no significant difference cannot be rejected. Table 9 shows comparison of mean value of occlusal as well as gingival wall microleakage scores between different groups. Mean difference among group I and group II are 0.02 which is non-significant statically. (p value – 0.907) Mean difference among group I and group III are 0.00 which is non-significant statically. (p value – 1.000) Mean difference among group II and group III is 0.02 which is non-significant statically . (p value – 0.907) (graph 3)

Table 2: Mean comparison of Gingival wall microleakage scores between different groups.

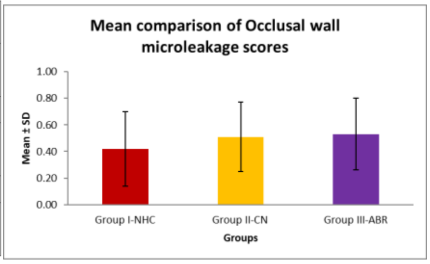
GINGIVAL WALL	Mean	SD	Mean difference	P value
Group I-NHC	0.48	0.26	0.05	0.749 NS
Group II-CN	0.43	0.28		
Group I-NHC	0.48	0.26	0.10	0.263 NS
Group III-ABR	0.38	0.26		
Group II-CN	0.43	0.28	0.05	0.675 NS
Group III-ABR	0.38	0.26		



Statistical Analysis: Tukey post hoc test. S: Significant at the 0.05 level. NS: Not significant.

Table 3: Mean comparison of Occlusal wall microleakage scores among different groups.

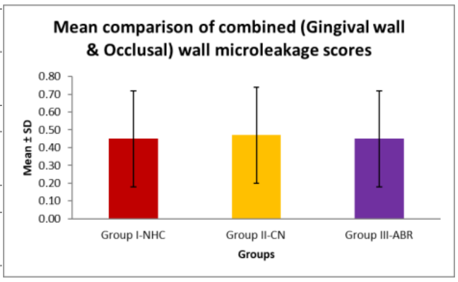
OCCLUSAL WALL	Mean	SD	Mean difference	P value
Group I-NHC	0.42	0.28	0.09	0.387 NS
Group II-CN	0.51	0.26		
Group I-NHC	0.42	0.28	0.11	0.267 NS
Group III-ABR	0.53	0.27		
Group II-CN	0.51	0.26	0.02	0.969 NS
Group III-ABR	0.53	0.27		



Statistical Analysis: Tukey post hoc test. S: Significant at the 0.05 level. NS: Not significant.

Table 4: Mean comparison of Combined (Gingival wall & Occlusal wall) microleakage scores between different groups.

COMBINED	Mean	SD	Mean difference	P value
Group I-NHC	0.45	0.27	0.02	0.907 NS
Group II-CN	0.47	0.27		
Group I-NHC	0.45	0.27	0.00	1.000 NS
Group III-ABR	0.45	0.27		
Group II-CN	0.47	0.27	0.02	0.907 NS
Group III-ABR	0.45	0.27		



Statistical Analysis: Tukey post hoc test. S: Significant at the 0.05 level. NS: Not significant.

DISCUSSION

In this present study, none of the restorative material showed complete resistance to the microleakage. The lower microleakage at the occlusal walls were similar to the findings of previous studies[14]. The mechanism of bonding of adhesive restorative materials with tooth structure usually based on either micromechanical means through hybrid layer formed or ionic bonds due to simple acid base reactions or both with dental hard tissues. The presence of high mineral, less water content and more homogenous chemical nature of dental tissues directly proportional and indirectly corelated to organic content determines the bonding strength and impenetrability of the microbial flora.

In this study, gingival/dentin margins showed slightly higher leakage than occlusal/enamel margins in hybrid composite restorative materials. This was expected as the bond strength to enamel is usually higher than bond strength to dentin, as dentin is a less favourable bonding substrate and the heterogeneous structure of dentin also affects the quality of bonding of the current dentine bonding systems. Also, the orientation of dentinal tubules can affect the formation of the hybrid layer. In areas with perpendicular tubule orientation, the hybrid layer was significantly thicker thanareas with parallel tubule orientation. Therefore, the dentine surface on the gingival floor of class II preparations may be a surface on which good hybrid layer formation is difficult the fact that contributed to the results of the present study in which slightly more leakage occurred[15]. In the present study, the absence of statistically significant differences between occlusal and gingival margins could attributed to the high and reliable dentin bond strength of the used adhesives. The gaps between restorative material and cavity walls generally occur when the bonding capacity of the adhesive systems is insufficient to resist the forces of polymerization shrinkage of the restorative materials.[16].

The comparison of mean microleakage scores among Nanohybrid universal composite, Activa Bioactive restorative, and Cention N in class ll cavities showed comparable results, Cention N at gingival margins and Activa Bioactive restorative at combined gingival and occlusal margins showed slightly better results . The multiple factors such as viscosity, rate of polymerization, monomer conversion and linear expansion of coefficient explains this[14]. The relationship between viscosity and rate of polymerization in resin based material is inverse, this can be explained by the amount of filler and resin matrix ratio.

Higher powder/liquid ratio leads to higher viscosity, in turn viscosity depends upon volume, size, shape, heterogeneity of size of the filler particles and monomer types in the mixture . The recommended powder/liquid ratio of Cention N is 4.6:1.Mobility of free radicals decreases with high viscosity leading to reduced polymerization rate, which impacts shrinkage stress relief and interfacial gap reduction [17]. Further lower powder liquid ratio causes higher volumetric shrinkage and contraction stress, might causes interfacial debonding and higher leakage scores. Another important parameter responsible for volumetric changes among restorative material is linear expansion of coefficient. Incompatibility of linear expansion of coefficient between the tooth and restorative material is responsible for breakdown of marginal seal. Thermal conditions during intraoral function have been reported to occur over a wide range of temperatures, reported from -50C to 76^0C.However, it has been suggested that the mean maximum intraoral temperature is approximately 46^0C with fluids and 41^0C with solid food. As for the minimum range of intraoral functional temperatures, approximately 15^0C was suggested by Youngson and Barclay, and 0^0C was reported by Palmer and others[18].

The linear coefficient of thermal expansion of dentin and enamel is 11 and 17 ppm respectively and for molar teeth at cervical area is 5ppm at 15^0-50^0 C range. The difference of linear coefficient of thermal expansion between the prepared tooth cavity and restorative material causes expansion stresses, responsible for marginal breakdown and microleakage. Pinto-sinaietal explained that the amount of filler content present in the resin based restorative materials influences the linear coefficient of thermal expansion. Cention N has filler content 78.4%, by Wt 61% by volume, Activa Bio-activa restorative has 56% by weight, FiltekTM Z250 has filler content 82% by weight, by volume 60%.Since linear expansion of coefficient is directly proportional to the density of the filler particles, and the density almost similar, this might be one of the possible reason for similar levels of mean microleakage scores among the three groups[18].

In general, the adhesives in resin matrix need to be hydrophobic, that expected to be impermeable to fluids to the intermediate layer, but at the same time adhesives require hydrophilicity to diffuse into hydrophilic dentin[4]. The monomers with lower molecular weight and viscosity and higher mobility might have high degree of monomer conversion[19] however the base monomers such as UDMA are hydrophobic in nature, and presence of considerable amount of hydrophilic monomer HEMA is inevitably responsible for absorption of water, and gradual hydrolyzation is responsible for high degree of conversion, as well as weakening of bond strength between tooth and restoration interface. UDMA is a partially aromatic, highly viscous cross linker which combines the favourable properties of aliphatic and aromatic diisocyanates. UDMA has no hydroxyl side groups, its hydrophobic nature exhibits low water absorption, DCP is a low viscosity, difunctional, methacrylate monomer, enables hand mixing. PEG-400 DMA, enhances the flowability, its hydrophilic nature promotes ability to wet tooth substrate and adapt to smear layer. Its high polymer density and degree of polymerization over the complete depth of the restoration forms the basis for long lasting restorations.

Composite resin, Cention N and Activa Bioactive restorative groups, all with adhesive showed comparable microleakage scores. This finding could be attributed to degree of conversion, polymerization shrinkage and contraction stress of these materials. Degree of polymerization and polymerization stress are related to interfacial gap formation [20]. Degree of conversion is influenced by filler/resin ratio and resin content. The former factor for all the three groups is relatively the same, but their resin content is different. According to manufacturer claim Cention N contain a combination of UDMA, DCP, an aromatic aliphatic - UDMA and PEG-400DMA, crosslinks during polymerization.it doesn't contain Bis-GMA, HEMA or TEGDMA.

Mazumdar et al.proposedCention N as a restorative material with lower microleakage compared to amalgam and glass ionomer cement. The fillers of Cention N include ytterbium trifluoride, barium aluminum silicate glass filler, a calcium barium aluminum fluorosilicate glass filler, an isofiller (Tetric N-Ceram technology), and a calcium fluorosilicate (alkaline) glass filler J. Todd. It seems that the low amount of microleakage in Cention N restorations is due to its specially patented isofiller which is partially functionalized by silanes and leads to a minimum shrinkage stress. This isofiller keeps the shrinkage force at a minimized level since it acts as a shrinkage stress reliever [21].

The results of the present study found that Activa Bioactive restorative exhibited less microleakage in comparison to nano hybrid composite. This could be attributed to the ionic resin component which contains phosphate acid groups with antimicrobial properties that improve the interaction between the resin and the reactive glass fillers and enhance the interaction with tooth structure . The hydrogen ions break off from the phosphate groups through an ionization process that is dependent upon water & are replaced by calcium in the tooth structure. This ionic interaction binds the resin to the minerals in the tooth, forming a strong resin hydroxyapatite complex and a positive seal against microleakage . However, when used in combination with a bonding agent, Tetric N Bond exhibited least microleakage values among all the groups. The results agreed with those reported in previous studies[22]. In addition, due to presence of ionic resin matrix, this material category can achieve polymerization by both light cure and chemical cure. This ionic interaction binds the resin to the minerals in the tooth, forming a strong resin hydroxyapatite complex and a positive seal Kaushik M .Thus, there are three hardening mechanisms involved with the Activa Restorative.

In this study, it was possible to assess the results on enamel and dentine separately. In clinical practice, most cavities show a combination of enamel and dentine margins. This fact in combination with the self-retentive configuration of most cavities after caries excavation and preparation can explain why the loss of restorations is not more frequently encountered. However, in a recent randomized clinical trial of Class I and II restorations using ActivaBioActive Restorative, one of the main reasons for failure was loss of the restoration, followed by post-operative sensitivity and secondary caries, all indicating insufficient adhesion of the material[23]. The clinical behaviour of ActivaBioActive Restorative using only phosphoric acid as pre-treatment was shown to be catastrophic with a very high annual failure rate of 24%. The excessive number of failures occurred in spite of the long familiarization process of the operator with the material before the start of the study, the fact that retentive cavities were prepared, and that the material was used following the manufacturer's recommendations[24].

Our findings corroborate those of Omidi et al[25]. and Kaushik and Yadav, who employed microleakage as a means of assessing marginal integrity and cavity seal. In both these previous studies, significantly higher dye penetration was observed when ActivaBioActive Restorative was used without previous phosphoric acid etching and use of adhesive. In the latter as well as in the present study, only when adhesive was applied was microleakage similar to that of restorations made with a resin composite – though these results depended on the employed adhesive[26]. Their results seem to be contradicted by the >99% intact margins reported by Hughes et al.[27], measured approximately 1 h after placement of restorations Activa BioActive Restorative. Whereas the present study also found a more positive picture for Activa BioActive Restorative immediately after placement of the restorations, these results deteriorated after thermocycling and storage. This deterioration is likely due to the development of contraction stresses resulting from continued polymerization reaction in combination with thermal stresses induced by thermocycling, stresses which could not be compensated for. This in vitro research was performed using standard method of themocycling without cyclic loading to simulate the intraoral environment for checking the microleakage at the tooth- restoration interface. More over the complex nature of the oral environment subjected to various physical and mechanical forces working upon a restoration over a considerably longer period is difficult to replicate in invitro studies. And also lack of availability complete information from manufacturer about Activa Bioactive restorative is another drawback.

CONCLUSION

According to under limitations of current study, NHC group showed slightly higher microleakage at gingival floor than the CN and ABR groups.CN group showed slightly less microleakage than the both NHC and ABR groups. However, ABR group slightly out performed than both CN and NHC groups.

All the 3 materials showed comparable results, and proved to be potential candidates for restoration of class II cavities, however further studies are required to investigate longevity of these restorative materials.

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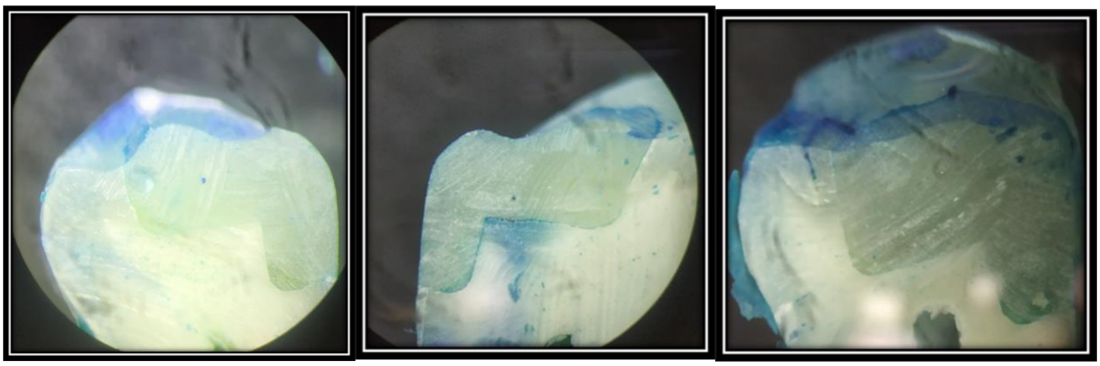
Stereomicroscope



NHC GROUP CN GROUP ABR GROUP