RESTORATION SURVIVAL EFFECTS OF TREATMENT ON DENTAL HEALTH IN PATIENTS ATTENDING THREE SELECTED DENTAL PRACTICES

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CHAPTER SEVEN Discussion

APPENDIX

DECLARATION

All results within this report are from original research. Therefore, to the best of the author's knowledge, it contains no material from other sources unless due reference is given.

The contents of this report have not been submitted, in part or whole, for any other degree at this, or any other University.

This report will be made available for photocopying and loan if accepted for the Degree of Master of Dental Surgery.

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SUMMARY

Does dental restorative treatment equate to the re-establishment of the patient's original state of dental health? Are restorative materials an adequate substitute for natural tooth material? Do such materials cure dental caries? For many years the answer to these questions was believed to be yes, but now these traditionally-accepted concepts are being questioned. The challenging of these concepts gathered momentum when the results of a 1978 survey of the General Dental Service (GDS) of the Scottish National Health Service were published. These results indicated that the amount of treatment received and restoration survival varied with the frequency of examinations and how often the patients changed dentists.

The present study was designed to compare the Scottish NHS and other study findings with those obtained from privately-treated adult patients from a different population. The findings were analysed by examining restoration survivals and changes in the dental health status of 100 patients and comparing the results to those reported elsewhere in the literature, primarily Dawson (1989) and Mahmood (1991). This study was a retrospective document survey, with the population group being drawn from the patient lists of three busy Adelaide private dental practices during 1992. The patients all had continuous treatment records ranging between 10 to 46 years.

The survival characteristics of the various restorative materials studied indicated that the mean survival rates of restorations generally reported in the literature may not be representative of many patients who regularly attend private dental practices. For comparison, the results obtained from the present study indicate impressive survival rates of:

Amalgams	22.5 $\pm$ 1.1 years	median survival
Composite Resins	16.7 $\pm$ 1.4 years	median survival
Crowns	15.41 $\pm$ 1.0 year	75% survival
Castings	13.8 $\pm$ 4.7 years	median survival
Glass-Ionomers	11.25 $\pm$ 0.6 years	75% survival

These results are at the higher end of restoration survival when compared to those reported in the literature. As expected, the survivals of replacement restorations were generally inferior to the original restorations, with many such restorations being replaced two or three times over the study period.

Overall, restoration survivals were independent of the dental practice, the dentist and the experience of the practitioner, and regardless of whether or not the restorations were replaced by the same dentist who originally placed them. However, there were some significant differences in restoration survivals by patient age cohorts, material type and distribution by class of cavity preparation, tooth site and arch location.

The general dental health of the patients within this study, using both DMF and T-Health indices, demonstrated a gradual decline over the treatment period. While the age of the patient had some significant effect upon the rate of change of dental health, this effect could be explained by the `saturation' of potential restoration sites in the patient's mouth with time. There was also some significant effect upon the rate of change in dental health related to the practices and the number of changes of dentists. However, the frequency with which the patients attended dentists, or whether or not they changed practitioners, did not have any significant effect upon the rates of changes in their dental health.

INTRODUCTION

The public perception of dentistry as being purely restorative in nature has existed for some time, with dentists being so-called `drill and fill merchants'. Even today the profession has done little to change this situation, for when a dentist examines a new patient, the first instruments usually selected are the mirror and probe. Armed with these instruments the dentist checks the mouth for new cavities or faulty existing restorations. Unfortunately this process is now so well established that changes in philosophy, or even a shift in treatment emphasis, is difficult to achieve.

Still a major influence in modern restorative dentistry is the work pioneered by G.V. Black and subsequently carried on by his son. A pathologist by training, G.V. Black developed cavity designs and classifications for the restoration of carious teeth, and these descriptions are to a large degree still used today, despite changes in the disease process and newer materials.

A tenet of early American dentistry was that any existing restoration which appeared flawed should be replaced. This belief led to detailed assessment criteria being proposed for assessing restoration adequacy. Such assessments subjected all restorations to extremely strict scrutiny. However, the assessments were primarily determined by technological, and not by biological or functional criteria.

Another belief established during this pioneer stage was that a dental restoration was an adequate substitute for natural tooth structure. This belief has been subsequently challenged and disproven, but it still remains a contentious issue.

The aim of the present research project was to determine what effects restorative dentistry had on the dental health of long-term patients attending private practices, and what factors influenced restoration survival. The findings are of significant importance as very few long-term studies have targeted private practice patients; usually the patient pool is taken from the military or another goverment institution of some type, or the treatment is government funded to varying extents.

CHAPTER ONE: FACTORS AFFECTING RESTORATION SURVIVAL

The majority of replacement restorations are believed to be placed for obvious reasons such as secondary caries, bulk fracture or complete restoration loss. In an attempt to confirm this, reviews of the literature on restoration longevity and failure modes were conducted by Mahmood (1991) and Hawthorne (1992). It was found that problems arose when determining why a particular restoration was associated with, for example, caries or fracture and, furthermore, there was no simple formula available to predict future failure modes. The oral environmental factors are multifaceted, and individual restorations react differently to variations in stimuli.

There are a multitude of factors affecting the deterioration and/or failure of restorations, and each can be broadly categorised as either operator, patient, or material related. These categories are briefly discussed below.

1.1 OPERATOR FACTORS

1.1.1 Interoperator Variance

The effect that individual dentist's philosophies have on restoration survival cannot be overstated, as reported by Ngo (1985). He reported that Ludwick et al. (1964) found only 4% unanimous agreement amongst nine dentists who examined 152 patients using set examination criteria. Ngo(1985) also reported that Nakin and Guild (1967) demonstrated the inherent differences in operators' interpretation of criteria, and the degree of importance they placed upon each criterion.

Even though these studies had already been published, the variance between operators' philosophies gained heightened publicity when Elderton and Nuttall (1983) and Nuttall and Elderton (1983) published their results. This work highlighted the lack of diagnostic uniformity between 15 dentists when they examined the same 18 patients. Variations in the dentists' treatment plans were remarkable, ranging from one dentist planning to restore only 20 surfaces while another planned on restoring 153. The majority of dentists were found to agree upon restorative decisions only 40% of the time; some dentists totally overlooked major carious lesions while others planned restorative work where no direct evidence of caries existed.

Marynuik and Kaplan (1986) published the results of a survey on dentists' subjective estimates of restorative needs. The results indicated that materials were thought to be responsible for 23% of restoration failures, dentists 30% and patients 47%; whereas Jacobsen (1984) reported that the operator was responsible for 50% of the restoration failures. In the 30% category of operator failures, Marynuik and Kaplan (1986) found that, `Clinicians estimated that an average of 71% of all restorative treatment they provided was performed on previously restored teeth. Of the defective restorations that were replaced, clinicians estimated that 84% has been done originally by another dentist.' When the clinicians were asked to assess the failed restorations, they attributed 26% of the blame to the operator when they had placed the restorations themselves. However, where the restoration was placed by a colleague, 35% of the blame was attributed to the practitioner.

What these studies show is that there are factors involved in a restoration's failure that are not biological, functional, aesthetic or sometimes even logical in nature; in other words they are operator dependent. Although a restoration may adequately meet all criteria for success, it is still a failure if a dentist replaces it. This is the challenge of the future, to train dentists to be more objective and consistent in their diagnoses of caries activity and restoration adequacy.

1.1.2 Operator Education

The diversity in treatment philosophy has reached the point where only the widespread and uniform education of academics and practitioners is likely to bring about a greater level of treatment homogeneity to the profession. In support of this belief, an international dental symposium was held in Florida in 1987. This symposium attempted to identify criteria which would lead to greater uniformity amongst dentists, especially those of influential teaching status. A summary of these presentations was edited by Anusavice (1989) and, although it included criteria for the placement and replacement of restorations, the overriding theme of the symposium was the conservation of natural tooth structure.

1.1.3 Operator Technique

Not only does the operator's preventive and treatment philosophy have a bearing on the final outcome of a restoration, but the actual manipulation of a material is just as important. The time and care that a practitioner takes in restoring a dentition is reflected in the quality and life expectancy of these restorations, as reported in many studies. Work done by Osborne and Gale (1974), Elderton and Nuttall (1983), Jacobsen (1984) and Marynuik and Kaplan (1986) all show that an operator can largely affect the clinical performance of a restoration, with superior operators producing superior results.

This was demonstrated in carefully controlled clinical studies conducted by Mahler and Marantz (1979), Letzel et al. (1989) and Jokstad and Mjör (1990a). These authors found that certain operators produced consistently superior results to their counterparts, even though all dentists received identical briefs.

The effect of operator technique on the quality of a restoration has been widely examined, with the main findings provided below.

1.1.3.1 Condensation

Condensation, or the physical placement of amalgam alloy into a cavity preparation is a potential source of restoration failure. The general consensus of articles reviewed, state that the process of condensation itself is more important than the method, either mechanical or manual, used to achieve it, Letzel et al. (1978,1989); Vrijhoef et al. (1980) and Leinfelder and Lemons (1988).

1.1.3.2 Trituration

Osborne and Gale (1974) defined trituration as "the abrading of the alloy particle to remove the oxides so that the mercury can wet and more readily react with the alloy particles". There are conflicting reports in the literature regarding the effect of under, over, and correctly triturated amalgams. Osborne and Gale (1974, 1979) claimed there was an effect on restoration longevity, while Mjör and Espevik (1980) claimed no correlation existed. As far as the importance of trituration goes, Leinfelder and Lemons (1988) summarised all the reports well when they said, "It is important to achieve adequate trituration. Improper trituration not only produces an amalgam that is difficult to handle, but also causes a decrease in strength and clinical longevity. Under-triturated amalgams are difficult to insert, condense and carve. They are also more difficult to finish and polish".

1.1.3.3 Isolation

Isolating a restoration from the moisture of the oral environment is conducive to long-term success. However, as with condensation, it appears that the role of isolation (rubber dam, cotton rolls, saliva ejectors etc) is more important than the method used to obtain it, Letzel et al.(1979, 1989) and Smales (1992, 1993). Furthermore, Smales (1992) added that correct rubber dam placement has the additional side benefits of a reduced risk of inhalation and ingestion of materials, as well as acting as a cross-infection barrier.

1.1.3.4 Restoration Finish

The effect that polishing has on restoration longevity depends on which restorative material has been used. With amalgams, Smales and Fenton (1985) found that polishing the restoration had little effect. In fact, after two years they found it difficult to reliably distinguish between the polished and unpolished Tytin restorations. Moffa (1989), in a 19-year-study also found that polishing had no effect on the long-term survival of the restorations. However, if dentists are planning on polishing their restorations, then Leinfelder and Lemons (1988) warned that the polishing process should take place after the amalgam had fully matured, otherwise the physical properties of the material can be affected.

When polishing chemically cured glass-polyalkenoate cements (GIC's), McLean (1990) and Mount (1990) advocated that the process should be delayed by 24 hours, and then be carried out under water spray to avoid desiccation. The newer light cured cements can be polished immediately, although the best finish for all GIC's is obtained with initial matrix placement associated with no post-insertion modification.

The finish immediately following the placement of composite resins, like GIC's, can never be reproduced with polishing. All polishing should be kept to a minimum, as the process produces surface crazing. A layer of unfilled resin or surface penetrating sealant should be applied as a final step, according to Dickinson et al. (1990).

1.2 PATIENT FACTORS

The effect that patients have on restoration longevity is also significant. After all, patients are responsible for every stimulus that the restorations receive throughout their lifespan. The oral environment is a very harsh test for any restorative material and any inadequacies will result in premature failure.

1.2.1 Patient's Age

One of the few studies conducted to detect variations in restoration longevity with respect to the patients age was performed by Hunter (1985). A retrospective study following 1327 restorations in 113 young patients found that the life expectancy of a restoration increased with an increase in patient age. This was partly explained by the difficulty in placing quality restorations in young and sometimes unco-operative patients. Similarly, Jokstad and Mjör (1991b) found that including a group of young caries-susceptible children into their study adversely altered the results of a previous study, Jokstad and Mjör (1990a). Smales (1991b) also established that a patient's age can affect restoration longevity.

Smales (1991b) reported that patients younger than 20 years and older than 60 years were found to have a decreased restoration life expectancy. The author explained that the reduced restoration longevity amongst the elderly patients could be due to them displaying greater oral hygiene and management problems and/or possessing more advanced dental disease states.

1.2.2 Oral Hygiene

The oral hygiene level that a patient displays is related to a restoration's longevity. Patients who have poor oral hygiene and/or extensive caries exhibited more new and recurrent decay around the margins of restorations than patients who displayed good oral hygiene, Smales (1975), Goldberg et al. (1981) and Eriksen et al. (1986). This idea was taken further by Smales and Fenton (1985) and Eriksen et al. (1986) who found a higher correlation between recurrent caries and the periodontal index rather than with the plaque scores. The authors explained that although patients can thoroughly clean their teeth prior to a visit, this cannot alter their periodontal status in such a short time.

Jokstad and Mjör (1991b) stated that the quality of occlusal margins had no effect on recurrent caries. Rather, the strongest relationship was found between secondary caries and their patients' past caries experience.

1.2.3 Tooth Position

This is one of the few variables that attracts almost unanimous agreement between all authors. Although their studies were set up differently, Goldberg et al. (1979), Mahler and Marantz (1980), Lemmens et al. (1987) and Jokstad and Mjör (1990b), all concluded that maxillary restorations deteriorate more rapidly than mandibular, and molar restorations more so than those in premolars.

One of the exceptions was the 29-year study by Drake (1988), where it was found that restoration failures had no predilection for tooth type or position, except for the incisors. It was found that 71% of restorations in the mandibular incisors were still present after 26 years while only 18% of maxillary incisor restorations were still intact.

Elderton (1984) and Jokstad and Mjör (1990a) examined tooth type and restoration failure in another context. These authors studied the slope of the cusps to determine what effect the cavity margin angles had on a restoration's deterioration and failure. They found that the wider a Class I or II restoration was in a tooth, when associated with steep cuspal slopes, then the greater was the chance of early deterioration and failure.

Berry et al. (1981) found that restorations which were less than 1/4 the intercuspal distance in width displayed fewer marginal fractures, but did not relate this to later failures. Smales and Fenton (1985) found more bulk fractures with narrow restorations.

1.2.4 Bruxism

The degree of occlusal forces that a patient applies to a restoration affects it's survival. In the studies of Derand (1983), Lemmens et al.(1987) and Smales (1993) there was a direct relationship between early restoration deterioration or failure and an increase in biting forces. Tyas (1990), when studying Class IV composite resin restorations, stated that his results supported the hypothesis that wear occurs under the stimulation of low stresses, while fracture occurs under high stresses.

1.2.5 Staining

The effect that staining has on a restoration is particularly important with anterior composite resins. The stain can be on or in the restorative material's surface, or at the margins. Smales (1975) and Van Dijken (1986) found marginal staining in 36% and 30% of patients respectively, with the great majority being heavy smokers. Accessible surface stain can be removed by tooth brushing, this may roughen the restoration's surface making it more susceptible to stain absorption via eating, drinking and smoking.

1.2.6 Wear

The definition of wear according to the Mechanical Engineers of the United Kingdom is: "The progressive loss of substance from the surface of a body brought about by mechanical action". The following sub-paragraphs are a summary of the articles by Mohd and Ramlah (1990) and Smith (1989, 1991).

1.2.6.1 Adhesive Wear

This is the most common type of wear, and occurs when two solid materials rub together with a net loss of material. The resultant wear particles then contribute further to the process by acting as an abrasive medium. Adhesive wear results when opposing enamel, composite, gold, porcelain or amalgam surfaces meet.

1.2.6.2 Abrasive Wear

This happens when a solid material meets one of a softer consistency, with the process being exacerbated by food particles and toothpaste. Class V restorations suffer the most from this type of wear. Incidentally this is also the method by which we polish restorations. Abrasive wear is a physical wear caused by non-tooth structures.

1.2.6.3 Impact Wear

Impact or percussive wear results from repetitive impact between two solid surfaces. This kind of wear only occurs during mastication, and can ultimately lead to marginal and bulk fracture of a restorative material.

1.2.6.4 Erosive Wear

Erosive wear is the loss of enamel and dentine through acid of non-bacterial origin. It is either idiopathic or chemicomechanical in origin. Idiopathic wear results in the surface of the teeth having a polished appearance while chemicomechanical wear is the result of impact and sliding forces in the presence of acids or solutions of varying pH values. The three main sources of this acid are;

a. dietary,
b. industrial (not so common today), and
c. regurgitation as a result of many medical disorders such as;
    1. anorexia and bulimia,
    2. peptic and duodenal ulcers,

3. chronic indigestion,
4. morning sickness,
5. hiatus hernia, and
6. chronic alcoholism.

Erosive wear is normally associated with abrasive wear which is a particularly potent combination.

1.2.6.5 Corrosive Wear

This type of wear occurs when the oral environment interacts with a sliding surface, followed by the subsequent rubbing off of the by-product. The process is rapid in the initial stage and then slows to a stop when a protective cohesive film layer forms on the surface. When this protective film layer is removed or rubbed off the process starts over again, all the time causing a physical change to the restorative material.

1.3 RESTORATIVE MATERIAL FACTORS

1.3.1 AMALGAMS

1.3.1.1 Alloy Selection

The debate over the benefits of using the more corrosion resistant high copper content alloys over conventional alloys has raged for some time, Vrijhoef (1980), Doglia et al. (1986), Lemmens et al. (1987), Letzel et al. (1989), Osborne et al. (1989), Moffa (1989), Jokstad and Mjör (1990b) and Smales (1991c). Some of these studies found that the high copper content alloys displayed superior longevity, while other authors found no significant difference. The general consensus is that while different alloys display differing longevity characteristics, the skilled operator can achieve similar clinical performances with both conventional and high copper content alloys. However, it is believed that the high copper alloys are more abuse tolerant and exhibit superior results to the conventional alloys when an imperfect technique has been used.

1.3.1.2 Dimensional Change

The dimensional stability of the amalgam is essential to the marginal adaption of the restoration. Any shrinkage of the alloy will leave a void too large for corrosion products to fill, and thus leave margins susceptible to secondary caries. Conversely, excessive expansion of alloys during maturation can cause stresses within the tooth, potentially sufficient to cause tooth fracture. Rupp et al. (1977) stated that if residual mercury levels exceed 55% then the setting expansion can be dramatically increased, although this problem has been all but solved with the advent of capsulated amalgams.

Care must also be taken with matrix bands when restoring Class II cavities, as Powell et al. (1977) reported. The inwards deflections of cusp tips can, in wide cavities, exceed the setting expansion of the modern high copper alloy, resulting in marginal discrepancies and their associated problems.

1.3.1.3 Strength

Although modern day alloys have twice the final compressive strength of traditional alloys, Leinfelder and Lemons (1988) claim the alloys are still not sufficiently resistant to bulk fracture from tensile stresses. The two important aspects of amalgam strength are the initial and final strengths, with the initial strength being of primary importance, as it is then that the restoration is most susceptible to failure by fracture. Vrijhoef et al. (1980) advised against over-carving restorations, as detailed carving of the occlusal contours increases the tensile stresses found at the surface. The stress concentrations in these deeply carved pits may also act as focal points for future corrosion.

Berry et al. (1981) and Jokstad and Mjör (1991a) reported that if the cavities are prepared to allow sufficient bulk of alloy, then failure by bulk fracture should not occur. However, despite this claim Jokstad and Mjör (1991a) could find no correlation between the numbers of fractures and increases in occlusal depth. It was suggested that antagonistic cusp tips, over-carving and over-thick bases could have biased the results.

1.3.1.4 Creep

Creep is a "time-dependent progressive deformation (strain) of a material under constant stress and is related to dislocation movement and grain boundary sliding", according to Sarkar (1978). There is conflicting opinion on the effect of creep on restoration failures. Mjör and Espevik (1980), McLean (1990) and Mjör et al. (1990) claimed that creep plays a significant role in marginal and restoration fractures, while Smales (1991c) found no correlation between creep and survival with several different types of alloys.

1.3.1.5 Corrosion

Corrosion and it's role in a restoration's failure is centred around the gamma-2 phase (Sn_7Hg) and the reduction in the strength of a corroded alloy. The high copper content alloy was developed to minimise this phase, but a small amount of corrosion appears beneficial as it may seal the interface between the alloy and tooth surface.

1.3.1.6 Amalgam Fracture

The appearance of an amalgam fracture is often the result of continuous deterioration of the restoration. However, according to Lemmens et al.(1987), fractured amalgams can also be caused by: tooth position, faulty cavity preparations, insufficient bulk, improper manipulation of the alloy, occlusal trauma and limitations in the strength of the alloy itself. Basically, amalgam fractures can be divided into two categories, marginal and bulk fracture.

As mentioned previously, one of the more unfortunate influences of early American dentistry was it's penchant for replacing any restoration that was not technically perfect, even if it was still serviceable. Throughout the literature there is constant reference to marginal fracture and the ways it can be measured. However, according to Hamilton et al. (1983) such observations often do not indicate the mode by which the restorations will later fail. This statement was later confirmed by Smales and Webster (1993) whose long-term study actually showed no significant correlation between the reason for a restoration's predicted failure mode and the restorations actual reason for replacement. This study emphasised the lack of any evidence for replacing restorations for `preventive reasons'.

Bulk fracture is a common mode of restoration failure as reported by Smales and Fenton (1985), Lemmens et al. (1987), Letzel et al.(1989), Moffa (1989) and Smales (1992) and generally happens in patients with bruxism.

1.3.1.7 Restoration Size

The relationship between the size of a restoration and its longevity has been investigated by a number of authors. Mahler and Marantz (1980) reported that the class and size of an amalgam restoration did not affect its fracture properties, while Mjör and Espevik (1980), Osborne and Gale (1981) and Berry et al. (1981) reported that larger cavities also displayed a higher incidence of amalgam marginal fracture. Smales (1991a) reported on a large number of cusp covered and non-cusp covered Class II amalgam restorations and found the long-term survival rates of each to be similar.

1.3.2 COMPOSITE RESINS (RESIN COMPOSITES)

1.3.2.1 Acid-Etching

A major breakthrough in the use of composite resins was the enamel acid-etch process pioneered by Dr Michael Buonocore in the mid 1950's. The technique is standard practise now, although Smales (1991b) published results that showed no difference in the longevity of restorations of a composite resin placed by the enamel etch and non-etch methods.

1.3.2.2 Wear

The factors involved in the wear of a composite resin include the abrasiveness and chemical nature of the diet, the presence of occlusal interferences and bruxism, type of surface finish, type of resin (filler content) and the matrix formulation. The wear characteristics of the original posterior composite resins were inadequate, but a number of recent improvements, including the introduction of small particle hybrids, have significantly narrowed the resin/amalgam wear susceptibility gap, as reported by Pallav et al. (1986). With the newer composite resins, general body wear is not a problem, but the occlusal or centric stop wear still causes concern, according to Lutz et al. (1983). Leinfelder (1985) stated that, contrary to popular opinion, 66% of a restoration's wear occurred in the first six months of a restoration's life in the non-contact areas. Moffa et al. (1984) studied 356 resins and 314 amalgams over five years and found that 44% of the resins showed obvious occlusal wear compared to 3% of the amalgams. Furthermore, at the end of the study only 58.1% of the resins remained intact compared to 86.1% of the amalgams. It would be interesting to compare these results if the authors repeated the study with the new small particle hybrid posterior, and microfilled, composite resins.

1.3.2.3 Polymerisation Shrinkage and Defects

An unfortunate characteristic of all resins used in dentistry is their polymerisation shrinkage, which in turn leaves a gap that has the potential for microleakage. The shrinkage is towards the centre of the material, away from the cavity walls and must be compensated for when placing resin restorations. If the gap is at the gingival floor of a Class II restoration then secondary caries is likely to occur. Hansen (1985a,b) noted that gaps appeared at the surface as well as within the material, that water sorption cannot close this gap, and that the degree of polymerisation contraction was independent of the amount of filler.

The presence of voids in resins is instrumental in decreasing wear resistance as it leads to areas of stress concentrations, Leinfelder and Lemons (1988); and the presence of oxygen within these voids further inhibits polymerisation, Ogden and McCabe (1986). Since it is virtually impossible to prevent polymerisation shrinkage with current materials, it is advisable that the restoration be finished by sealing this gap with an unfilled resin or surface penetrating sealant.

1.3.2.4 Water Sorption

Composite resins are also noted for their water sorptive potential, and the degree to which this occurs depends on the resin configuration (filler and matrix). Jensen and Chan (1985) believe that this water sorption and subsequent swelling can close the polymerisation contraction gap found in the restoration. This belief differs from that of Luescher et al. (1977) and Hembree (1980) who claimed that hygroscopic expansion is insufficient to close the contraction gap. Ruyter (1985) claimed that the higher the filler/matrix ratio is then the lower the water sorptive potential. It is generally agreed that the inclusion of water into the resin matrix reduces the physical properties of the resin, so gap closure by this process may be detrimental to the restoration's life expectancy.

1.3.2.5 Depth of Cure

Although the chemically-cured composite resins had many disadvantages, their great advantage over light-cured resins was that self-curing properties achieved a higher, dependable cure throughout the entire depth of the restorative material. Antonucci and Toth (1983) and Walls et al. (1986) stated that the depth of cure of a light-cured resin was determined by the intensity of light and exposure time, and the shade, reflectance, refractive index, filler type and loading of the material. The larger the increment cured, then the more incomplete the polymerisation, with a subsequent decrease in physical properties. A decrease in polymerisation produces a polymer matrix more plastic and susceptible to water sorption, further reducing the physical properties, Fan et al.(1986).

1.3.2.6 Colour Stability

The ability of a resin to maintain it's colour is important, as these restoration are frequently placed and replaced for aesthetic reasons. Boland (1991) reported that self-cured large-particle resins exhibit surface staining as a result of surface roughness, and also suffer internal discolouration due to the inclusion of a chromogenic compound (an aromatic tertiary amine for polymerisation). Incomplete polymerisation and non-conversion of monomer also results in staining due to water sorption. Plaque and other acids, alcohol and poor oral hygiene can soften the resin matrix and therefore increase the chance of surface staining.

Makinson (1989) reported that resin restorations became lighter and their opacity also decreased with light polymerisation. Burrows and Makinson (1991) while studying colour changes in light-cured resins concluded that the main cause of colour change of resins in vivo may be dietary in origin, as the colour changes that occurred in the study were less than expected. Smales and Gerke (1992) have shown improved long-term colour stability with the newer, light-cured materials.

1.3.2.7 Restoration Class

Lundin and Koch (1989) found that the larger and more posterior the resin restoration, then the quicker it deteriorated, while Tyas (1990) and Smales (1991b) found that Class IV restorations displayed a much reduced life expectancy compared to Class III and V restorations.

1.3.2.8 Technique Sensitivity

Composite resin restorations are a technically demanding restorative procedure; the more posterior the tooth, the more demanding the procedure. The main technical problems with the material are, according to Ironside (1986);

a. lack of packing feel,
b. flash of excess resins complicating finishing,
c. slumping of the material, and
d. lack of shade contrast with finishing.

1.3.3 GLASS IONOMER CEMENTS

1.3.3.1 General

The glass-polyalkenoate (ionomer) cements have improved tremendously over the past few years, and are now an extremely useful restorative material. Due to their fluoride content, the reported incidences of recurrent caries have been either zero, Mount (1990) or a fraction of any other restorative material, Levy et al. (1988) and Tyas (1991).

Despite all the advantages of GIC's, the problems of early moisture contamination and subsequent dehydration still continue, Mount (1990) and McLean (1990). Whether the advent of the light-cured GIC's solve these problems, only time will tell.

1.3.3.2 Powder/Liquid Ratio

The advent of capsulation has eliminated the problem of incorrect powder/liquid ratio's, which adversely affected the physical properties of hand-mixed GIC's.

1.3.3.3 Maturation Time

The self-curing restorative GIC's are, unfortunately, slow setting and can have prolonged chemical reactions that last from weeks to months. Both McLean (1990) and Mount (1990) advocate the use of an unfilled resin over the GIC to protect it from moisture gain in the initial setting stages, and moisture loss after the initial set. This protection should last up to six months, but may be academic with the advent of light-cured GIC's.

1.3.3.4 Adhesion to Tooth Structure

While GIC's adhere to natural tooth structure, there is a difference of opinion as to whether the smear layer of the tooth should be removed prior to placement. Mount (1990) advocates smear layer removal while White et al.(1989) and Tyas (1991) questioned the need for the procedure. Peutzfeldt and Asmussen (1990) reported varying adhesive results; they found the smear layer should be left on smooth cut dentine, while the smear layer should be removed if it is thick, as happens when diamonds and stones are used.

1.3.3.5 Physical Properties

The physical properties of GIC's are closely linked with the powder/liquid ratio. Even at their optimum, the GIC's should never be used in load bearing situations as they will wear and fracture.

1.3.4 CAST AND PORCELAIN RESTORATIONS

1.3.4.1 General

While most dentists believe that cast metal and porcelain bonded to metal (PBM) restorations have a greater life expectancy than conventional amalgam and composite resin restorations, they often fail to understand their limitations. Because there must not be any undercuts or mechanical locks in the preparations, the full extent of retention must be supplied by the preparation design and luting agent. Any compromises here will limit the restoration's life and, as the prosthesis is produced in a laboratory, a marginal gap is also guaranteed. Once again the luting medium must make up for this deficiency.

1.3.4.2 Failure Modes

Most of the published literature on crown and bridge failure is retrospective and involves reports on longevity estimates. Schwartz et al. (1970) predicted the life span of crowns and bridges at 11.3 years, with 51% failing due to disease; they also reported no correlation between the number of units in the prosthesis and their survival rates. This finding differed from that of Reuter and Brose (1984), who found that bridges of five units or more were more likely to fail than shorter span bridges. Reuter and Brose also reported that root filled abutments reduced the life expectancy of the prosthesis. Valderhaug (1991) found that bridges which failed because of insufficient retention lasted nine years, while those which failed due to disease lasted 12 years, on average. But, overall after 15 years, 91% of the retainers displayed satisfactory margins.

McLean (1990) stated that porcelain crowns fail due either to fracture of the material or cement failure (because of poor fit), lack of retention or resistance form. Furthermore, all ceramic restorations are more susceptible to failure in short, undercut or over-tapered preparations, by the deepening and propogation of micro-cracks. The lack of a metal substructure to act as a crack propogation barrier is the predominant reason for failure while ceramic bridges usually fail due to static fatigue of the connectors.

Boland (1991) also reported that the appearance of the dentition changes with age, and ceramic restorations that were acceptable in youth may later become aesthetically incompatible with the rest of the dentition, thus prone to replacement for purely appearance reasons.

CHAPTER TWO:
FACTORS AFFECTING THE AMOUNT OF DENTAL TREATMENT

2.1 INTRODUCTION

Some of the more common reasons for variations in the amount of restorative treatment a patient receives may include the patient's attitude, the dentist's preventive and treatment philosophy, how frequently the patient attends a dentist and whether or not the patient is seen by the same dentist at subsequent visits.

2.1.1 Frequency of Attendance

How often a person attends the dentist is determined by factors such as dental awareness, previous dental experiences, anxiety, fear and cost (although in government health schemes the financial situation may not be a dominant factor).

Much of the work done in this field uses the same Scottish National Health Service (NHS) population group of 720 people from a 1978 survey. To determine the frequency of attendance these patients were divided into the following cohorts;

a. Frequent attenders - visit the dentist at least once a year without a break of more than 18 months,
b. Infrequent attenders, and
c. Non-attenders - patients who only visit the dentist for pain relief.

Eddie (1984) compared the study groups' claimed attendances with their actual attendances. As expected, these responses showed little correlation. However, it was found that frequent attenders retained more teeth than infrequent attenders, but with fewer sound teeth, as the teeth tended to be more heavily restored.

Using the same patient group, Nuttall (1984) attempted to find a correlation between the frequency of attendance and the amount of restorative treatment received. He narrowed this group down to 116 frequent attenders and 388 infrequent attenders and then followed these patients for five years. The results indicated that on average;

a. frequent attenders had 1.5 times as many restorations to start with and received more restorations during the study period, and
b. frequent attenders received less extractions during the five years, that is they lost 0.81 fewer teeth.

Unlike the NHS survey and the study of Adelaide Hospital patients by Mahmood (1991), where the frequency of attendance did have a significant effect, Dawson (1989) found no significance between frequency of attendance and the amount of treatment received in a military population.

The background paper number 9 to the National Health Strategy (1992) titled `Improving dental health in Australia' demonstrates graphically (**Fig. 1**), that people of lower income who visit the dentist less frequently also have more decayed and less filled teeth. An interesting note here is that, if you project this particular graph beyond 65 years of age, the cost effectiveness of dentistry in the long term could be questioned. This is an especially important observation if you take into account our aging population.

2.1.2 Frequency of Changing Operators

Reasons for patients changing their dentist are many and varied and include personality clashes, changes in residential location and personal recommendations. Whatever the reasons, a change in dentist is often reported to have a detrimental effect on a patient's dentition. Davies (1984), also followed the 116 frequent attenders mentioned previously, for a five year-period. Her research indicated that;

a. 60 patients changed dentists even though only 15% changed their residential address, and

b. patients who changed their dentist received twice as much restorative work as patients who kept the same dentist.

These results could largely be explained by the form of remuneration in the NHS, as they were not supported by the findings of Dawson (1989) and Mahmood (1991). In both these latter studies, which involved different populations, a change in dentist did not increase the amount of treatment received or have any adverse effect upon the dental health status of an individual. The availability of previous records in the hospital and military could also have had an influence on treatment decisions.

2.1.3 Over-Treatment

The question of whether dentists over-treat patients is a sensitive issue, but one that must be asked. In 1984, in response to media coverage, the UK government set up a Committee of Enquiry into Unnecessary Dental Treatment. The report, published in 1986, found that there was over-treatment taking place, but due more to an outdated treatment philosophy rather than fraud. The report stressed the need for a preventive dentistry philosophy, and contributed to the 1987 Florida Symposium, Anusavice (1989), previously mentioned in section 1.1.2.

2.2 MEASURING DENTAL HEALTH

Dental Health, what is it and how do we measure it? These are some of the questions that dentists have been asking and researching for many years. Most of the indices used to detect dental health actually record disease states, and not health, as disease is easier to detect than health.

Because of the nature of this type of research, which requires large population samples and large numbers of dentists, most of these projects have been carried out in government facilities such as the NHS in the United Kingdom. Similarily, the military provided the patient pool for Dawson's 1989 study. His studies formed the basis of an extensive review of the literature of dental health and the factors which influence it. Dawson's conclusions are summarized in Section 2.2.3.

2.2.1 DMF Indices

As the letters suggest, the DMF Index measures decayed, missing (because of caries) and filled teeth. This index can be used in scoring teeth and their individual surfaces, and is extremely useful in recording present and past dental disease. This index provides a useful guide to dental disease, but cannot be used to accurately assess dental health.

2.2.2 T-Health (Tissue Health) Scores

Investigating ways to improve the DMF Index, Sheiham et al. (1987) proposed two alternatives.

1. Recording the number of functional teeth, both sound and filled. The problems here arose with there being no differentiation between sound teeth and filled, but otherwise sound, teeth.
2. T-Health scores. This index allowed full differentiation between sound, filled but sound, filled and decayed and decayed teeth. The index was then weighted arbitrarily with a sound tooth being weighted the most. Because of the weighting given to sound tooth structure over filled or decayed structures, this index can be used as a measure of dental health.

Part of the present research project's scope was designed to determine whether the effects of the previously-mentioned treatment variables were confined to government or large-scale organizations, or if they extended to patients attending private practices. In order to obtain a valid comparison with the results from previous studies, similar measurement indices and parameters have been adopted in this project.

2.2.3 Dental Health Reviews

The relationship between dental treatment and dental health was extensively reviewed by Dawson (1989) with his findings subsequently summarized by Mahmood (1991). The following four paragraphs are reproduced directly from the latter author.

> `The previous concepts of dental health were equated with the placement of dental restorations, involving cavity preparations based on the principles of `extension for prevention' with considerable tooth tissue removal. Current knowledge suggests that placing restorations leads to further replacements and destruction of dental tissues, as the restorative materials only act as `temporary plugs'.
>
> The major factors on which depends the amount of dental treatment provided are: patients and their frequency of attendance, and the frequency of change of dentists and the effect of variations between dentists. Patient factors like oral hygiene, bruxism and dental awareness have been noted to be important to dental health. Dentally unsuccessful people dislike dental intervention and keep on putting off dental visits as far as possible. Such patients are classified as `high risk' patients.
>
> It has been found that frequent attenders of dentists seem to get more restorations and have fewer carious and missing teeth than infrequent attenders and non-attenders. But, at the same time, the frequent attenders also have fewer sound teeth, which can be interpreted as a negative factor on dental health. Patients who change their dentist have been found to receive many more dental restorations than those who do not change their dentists. This may be due either to different criteria being applied or to the fact that dentists are generally more critical of others' work. Wide variations have been reported among dentists in diagnosis, clinical judgement and treatment planning. As a result, there is a strong likelihood that the patients may be receiving unnecessary dental treatment which, in addition to variation in treatment

criteria, may also be related to financial gains, keeping in view that dentists spend most of their time replacing restorations; reportedly up to two-thirds of all restorations placed.

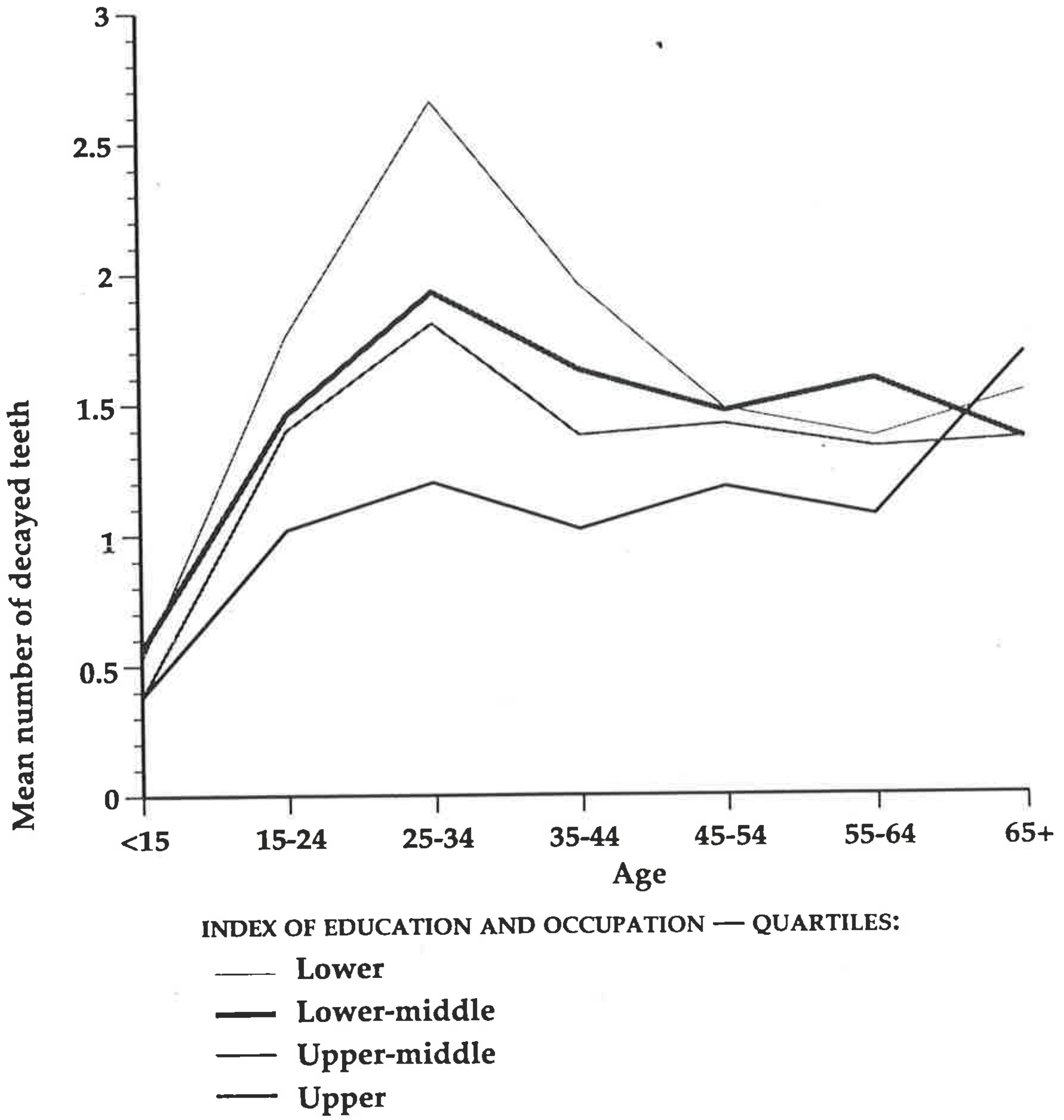
Dental health has been defined in terms of various indices such as DMFT and DMFS scores but, these fall short of adequately describing dental health, as they basically tend to define the disease experience and not the health experience. However, the T-Health (tissue health) score does weight the findings for healthy tooth structure, although the component weighting used are arbitrary and have no scientific basis (Sheiham et al. 1987).'

The first part of the present three-part research project into dental treatment and its relationship to dental health was conducted by Dawson (1989), on a population of military personnel. He concluded that there is a slow but definite reduction in the dental health of individuals who receive regular dental treatment. This decline in dental health slows as the patient ages, and is not significantly affected by the major factors of the NHS study. The amount of dental treatment was also less than the NHS study with the restorations, regardless of material or class, lasting an average of 14.2 years. The different findings were partially explained by the different forms of dentist remuneration, with the RAAF dentist being salaried while their counterparts in the NHS were in a fee-for-service scheme. The author concluded that his results were not affected by examination frequency or a change of dentist, and that they tended to support the philosophies of minimal intervention dentistry.

A follow-up study conducted by Mahmood (1991) compared the long-term effects of restorative treatment on the dental health of selected patients in a developed and a developing country, with the following conclusions. In both population groups there was a gradual deterioration in dental health status. A change in dentist or the number of dentists seen, had no significant effect, while the frequency of attendance directly affected the amount of treatment received by the Adelaide Hospital sample. The number of restorations placed increased significantly with more frequent recalls within the Adelaide sample, especially when the patient did not change dentists, compared to the Pakistan sample where no change was noted. There were significantly more glass-ionomer restorations placed in the Adelaide population sample and significantly more cast restorations in the Pakistan sample.

While the survivals of the conventional restorative materials (amalgam, composite resin etc) were similar for both groups, and compared favourably with other studies, the cast restorations from Pakistan displayed inferior survival characteristics. `Overall, the dental health status findings for both, the Adelaide and the Pakistan samples were comparable, and the reduction in health status was not affected significantly by most of the factors tested'.

Figure 1 : Mean number of decayed teeth by education and occupation for dentate persons, Australia, 1987-88



Source: *AIH Dental Statistics and Research Unit, National Oral Health Survey, 1987-88*

CHAPTER THREE:
MATERIALS AND METHODS

3.1 INTRODUCTION

The present study is a retrospective document survey that continues the work of Dawson (1989) and Mahmood (1991) in investigating restoration survival and the long term effects of dental treatment on dental health. Therefore, the indices measured and the methods used to record these indices, are similar. Accordingly, the following parameters have been analyzed;

a. Restoration failures (true and apparent),
b. DMF indices (Knustan et al. 1940),
c. T-Health scores (Sheiham et al. 1987),
d. Frequency of patient attendance, and
e. Influence of changing dentists and the dentists' experience.

3.2 SAMPLE SELECTION

This research project involved 100 adult patients attending three busy long-established private practices in the Adelaide City Centre, South Australia. The sample of 100 patients was chosen as being representative of the long-term general population attending the practices. To be eligible for selection, each patient had to demonstrate a continuous attendance history, with their initial attendance consultation being prior to 1980. This effectively gave a potential minimum treatment time of 12 years.

Within each of the three practices, a target number of patients was decided upon, with the combined total of all practices providing the 100 patient sample. A list of two to three times the target size of eligible patients for each practice was compiled by haphazardly selecting appropriate case notes from their respective practice filing systems. From these master lists, each patient was assigned a numbered piece of paper. These tags were then placed into a jar, and withdrawn randomly until the target number was achieved. Of the 100 patients selected, 60 were drawn from Practice 1, 25 from Practice 2, and 15 from Practice 3.

Reasons for the decreased numbers of patients in the latter two practices included time constraints and the sheer volume of data collected and processed.

In compiling the master lists, an attempt was made to select patients with a comprehensive charting of all restorations present at their first visit but, unfortunately, these were in the minority. Many patients had posterior bitewing radiographs taken at the initial examination, which established a baseline for the posterior teeth but, unless a full mouth survey was performed, an anterior tooth baseline could not be established. This differed from the study by Dawson (1989) whose research group included members of the Royal Australian Airforce (RAAF). It is policy in the RAAF that all members, upon recruitment, have an initial charting done where all restorations present prior to enlistment are accurately documented.

This limited documentation of pre-existing restorations, and difficulties in establishing an accurate baseline, did not adversely affect the results of the study. The limitations were negated by only analyzing <u>changes</u> in dental health during the study period.

3.3 BASIC PROCEDURES AND ASSUMPTIONS

The treatment records gave an accurate history of the restorations received by the patients but, unfortunately, gave only periodic mention of the reason for the restorative treatment. When this adjunct information was provided, interpretation of the dentist's restorative philosophies was easy to follow. However, since this information was often missing, it was assumed that the treatment received during each visit accurately represented the patient's current dental health status.

Unless obviously different from radiographs, or other documentation, the following procedures and assumptions were made during the data collection and analysis stages:

a. Restorations were placed or replaced because of caries;

b. A restoration failed when it was replaced either partially or wholly, with the criteria used to define restoration failures based on those of Robinson (1975) and Elderton (1983);

i. A true failure was when the restoration was replaced in whole or in part due to caries, fracture or extraction for caries-related reasons, and

ii. An apparent failure was recorded when the restoration was replaced or added to because of unrelated reasons (Thylstrup & Rolling, 1975; Wetherell & Smales 1980). For example, when a Class I occlusal restoration becomes a Class II restoration due to unrelated interproximal caries, or the restoration was removed due to root canal treatment, or the tooth was lost due to trauma or for periodontal reasons. Apparent failures were treated as censored values in the life-table statistical analyses.

c. When it was evident from the treatment records that two independent restorations existed on the same tooth, Robinson's Rule (Robinson, 1971) was observed when assessing restoration failures; and

d. For this study, third molars were excluded from calculations as the reliability of information pertaining to these teeth was dubious.

3.4 DATA COLLECTION

All data collected from the records of the selected patients were transcribed onto three separate proformas, (Forms A, B and C). Examples of completed proformas are shown in Appendix 1.

The Data Collection Form (Form A), provided a concise summary of the patient's treatment records. The information listed on this odontogram included:

a. Baseline data comprising;
   - i. registration number,
   - ii. age,
   - iii. gender, and
   - iv. practice code.

b. Associated risk factors, if clearly identifiable from the records, including;
   - i. poor oral hygiene,

ii. high caries rate,

iii. heavy smoking,

iv. obvious bruxism, and

v. any other factors mentioned in the records.

c. Individual examinations including; examination and treatment dates, procedures carried out and any change in dental operator; and

d. Change in dental health status including; the number of decayed, missing sound and filled teeth (which was measured by both DMFT & S, and T-Health T & S indices).

From these condensed treatment summaries, data from which to analyze changes in dental health status and the associated costs were transcribed onto Form B. The information contained in Form B was separated into two parts. Part I allowed a baseline to be established on the patient's first visit, under the following headings;

a. Registration number,

b. Age,

c. Gender,

d. Practice code,

e. Risk factors, described in 3.4(b), and

f. Restorations present at the initial examination (where identifiable).

All the above information was transcribed onto the initial examination sheet. Subsequent visits only required the registration number in Part I to be completed.

Part II of the form contained data to monitor the changes in dental health status, with this portion of the form being completed for each visit. Information gathered with Part II included:

a. Month and year of examination, treatment performed at this visit and which dentist (coded) performed the task; and

b. Changes in the DMF & T-Health indices as a result of this treatment.

Restoration survival analysis was made possible through information supplied by Form C. Data pertaining to this proforma included:

a. Type of restoration present, with the code listed below, (and coded brands of material were also included, if known).

   1. amalgams,
   2. composite resins,
   3. crowns (gold, porcelain and porcelain bonded to metal),
   4. castings (inlay, onlay, partial veneer),
   5. fissure sealants,
   6. glass ionomer cements, and
   7. dressings.

   Due to the small number of fissure sealants and dressings, these were not included in the results;

b. When the restoration was placed, and the last observation date (if still present at the conclusion of the study) or the date when the restoration was deemed a failure. The observation date could sometimes assist in determining the reason for failure if no adjunct information was supplied. For example, an MODB amalgam restoration that was replaced with a crown one month later was recorded as an apparent failure, and not a true failure;

c. The restoration number. Within the study each restoration was designated an individual number and a prefix number. If a restoration was replaced, the restoration number would stay the same but the prefix number would change by one. For example, if restoration 16 DO was replaced because of caries, the codings would change from 10008 to 20008; where 0008 represented the restoration number, and the underlined prefix numeral represented the number of times the restoration was either placed or replaced; and

d. Class of the restoration, with Class 6 representing full coverage crowns for this study. Also recorded were the surfaces of each tooth restored and whether or not the dentist who replaced the restoration was the same person who originally placed it.

All the information collected and transcribed during this study was performed by the author to minimise transcription and interpretation errors, and the data were also subjected to numerous error checking subroutines before being analyzed on a Sun Sparc Server II microcomputer[1] using BMDP statistical software, Dixon (1990).

As a check on the casenotes and examiner's reliability, five patients were recalled for examination (including the taking of colour photographs) but only four of these patients could attend. These dental chartings were later compared with the original chartings obtained directly from the casenote records.

3.5 OPERATOR EXPERIENCE

In order to establish the experience of the dental practitioner, the graduation year of all dentists within this study were obtained from the Dental Register, South Australia, and then used as a reference as to when each restoration was inserted. To determine whether practitioner experience did have any significant effect on restoration longevity, dentists were placed into cohorts representing, in years since graduation, experience at the time each restoration was placed. The cohorts of 0-5, 6-10, 11-20, 21-30, 31-40 and 41+ were subsequently used for comparisons between restoration survivals for each material.

1. Microsystems Inc.,Mountain View, CA, USA

RESULTS

The results of this study will be reported in the following three chapters:

Chapter 4.	Basic Data, highlighting the restorative treatment performed during the study;
Chapter 5.	Restoration Survivals; and
Chapter 6.	Dental Health Changes.

CHAPTER 4:
BASIC DATA

As this study was a retrospective survey, only information of a definitive nature was used for the analyses. Upon final data compilation, it was found that the risk factors, as described in Chapter 3.4.(b), were so seldomly mentioned that they were subsequently deleted from the analyses.

4.1 DEMOGRAPHICS - POPULATION SURVEY

The patient sample used in this study was drawn entirely from private dental practices. As the ratio of males to females selected was found to be approximately 50:50, the gender sample is representative of the general populace attending the three practices. The demographics were analysed by individual and by combined practices using the following criteria:

a. Gender;

b. Length of Dental Treatment; and

c. Age and Age Distribution, using the following age cohorts:

   i. 0-20 years,

   ii. 21-40 years,

   iii. 41-60 years, and

   iv. 61+ years.

4.1.1 Gender

As previously mentioned, although the patient pool for this study was selected haphazardly, the gender distribution of the study population closely resembled that of the general population. Of the 100 patients chosen, there were 45 males and 55 females, distributed as follows:

Practice	No. Pats.	Male	Female	Age at: 1993	Age at: 1st Visit
1	60	27	33	60.0 ± 12.1	31.7 ± 14.5
2	25	11	14	51.1 ± 14.9	26.2 ± 15.3
3	15	7	8	44.3 ± 15.5	25.9 ± 13.5

The breakdown of patients, into their relative age cohorts, at the primary visit were as follows:

Age	Practice 1	Practice 2	Practice 3
0-20	12	10	4
21-40	32	10	8
41-60	13	5	3
61+	3	-	-
Total:	60	25	15

4.1.2 Length of Dental Treatment

One of the selection criteria of this survey was for patients to have had an initial dental examination prior to 1980; giving an expected minimum continuous treatment time of 12 years. However, treatment finishing prior to 1993 had the potential of altering the length of dental treatment, as reported in this study.

Taking the above statement into account, there was one instance where the minimum length of dental treatment was only 10 years, while the longest period of continuous treatment was 46 years. The mean length of continuous dental treatment was 24.8 years, with a standard deviation of 8.7 years.

4.1.3 Age and Age Distribution

Age is a relative phenomenon and, as such, is only relevant if a static reference is used.

During this study, the age of a patient at restoration placement was classified according to the previously-mentioned cohorts. However, patients with multiple restorations may have these restorations assigned to consecutive cohorts, simply because the patients aged during the study period.

For the purpose of demographics, the age range and mean age for the study population is shown as at 1993. This year was chosen as the reference, as this was when most of the data were collected. The age distribution of patients at 1993 ranged from a minimum of 19 years to a maximum of 88 years; with the mean age being 55.4 years with a standard deviation of 14.5 years. While the 1993 reference year enabled age distribution data to be calculated for demographic purposes, restorations were assigned to age cohorts according to the year in which a restoration was placed relative to the patient's birthyear, with the mean age of the patient at the primary visit being 29.5 $\pm$ 14.6 years.

4.2 DATA VALIDATION

To ensure the validity of any inferences drawn from this study, the accuracy of the collected data had to be verified. Five patients were chosen at random, using the method detailed in Section 3.2. of Chapter 3, and recalled by the principal dentist of one practice. However, as only four of the five patients attended, the validation study represented 4% of the overall patient numbers. The results of the data validation process are provided below.

Case No.	Wrong Charting	Treatment Not Recorded	Mischarted Teeth	Transcription Error
5		1		
15				
26				1
41				2

The one restorative treatment not recorded occurred when two occlusal fillings, placed in the one tooth, were recorded as only one restoration. The three transcription errors all resulted from lingual extensions in maxillary molars. On examination, these DO and MOD restorations had extensions which had not been recorded in the casenotes and, therefore, were not included in the study. Although, in reality, these three restorations had one more surface than their study chartings, the effect on the change of dental health results is negligible, as the information remained constant; that is, the charting errors were carried through. This represented an overall error rate of 3.4% which compares favourably with the overall error rate of 6.3% for Dawson (1989) and 4.9% for Mahmood (1991).

While the validation study showed that the transcription of data was reasonably accurate, most problems arose in the interpretation of the data. Classification of why a restoration failed, i.e., `true' or `apparent' failure, had the greatest potential to skew the results. Although the author believed that his interpretation of the casenote records was reasonably accurate, it was impossible to be absolutely certain as to why a restoration was replaced without positive documentary evidence which, unfortunately, seldom existed. Accordingly, the lack of definitive documentation means that the following results will, in all probability, only be a reasonably accurate representation of trends, and not of definite survival characteristics and changes in dental health.

4.3 TREATMENT PERFORMED DURING THE STUDY

4.3.1 Restorations Placed During the Study

Restorative treatments performed during this study were identified for each practice by dentist, material and restoration class. For all three practices, the data collected on restorative materials were analysed according to the age of the patient, restoration class, and tooth site. For this study, tooth sites were divided into the anterior (incisors and canines), premolar and molar segments.

The number of patients who had restorative materials placed during the study period is shown in Table 1 (a-d). The tables are divided into the three separate practices, each reflecting the age cohorts during which the restorations were placed. For each restorative material, a set of figures is provided. The first figure represents the number of patients in which these restorative materials were placed, while the second (in parenthesis) shows this figure as a percentage of the overall total (by row). This study was limited to 100 patients, but the total number of patients (all three practices combined) with different restorative materials present, as indicated in Table 1(d), is 317. This figure is an artifact and is the result of patients having more than one type of restorative material placed during the study period; it does not indicate that there were 317 patients in the study. Overall, there were relatively few patients with restorations placed in the 0-20 and 61+ age cohorts. More patients had amalgam and fewer had gold castings, than other types of restorative materials. Most of the patients with crowns and castings were from Practice 1.

Represented by Table 2 are the number of restorations placed during the study, by material and age cohort of the patient when first placed. Table 2(a-c) provides this information for each practice separately, while 2(d) gives an overall summary of the three practices combined, a total of 2931 restorations. The distribution of the number of different restorative materials approximately followed the patient and practice distribution from Table 1.

Table 3 (a-g) shows each restoration broken down into restoration class for the three separate practices, while Table 4 (a-x) dissects this data even further to include tooth site. With respect to Table 3, amalgam restorations predominated in Class I, II and V preparations, and composite resins in Class III and IV preparations. Most of the glass-ionomer restorations were placed in Class V preparations, while castings were primarily placed in Class II and IV preparations.

In Table 4, the relationship between the restorative material, restoration class and tooth site for each practice is displayed. As expected, most of the amalgam restorations were placed in molar teeth, composite resins and ionomers in anterior teeth, while castings and crowns were fairly evenly distributed across all tooth sites.

A summary of Tables 3 and 4, with details of the overall restoration distribution, showing percentages by row (in parenthesis), is provided in Table 5 (a-c). Most of the different restorative materials were placed in the maxillary arch, especially the composite resins (90%), ionomers (60%) and crowns (61%). Amalgams were evenly distributed with 50 % placed in either arch.

4.3.2 Treatment Provided

For the purpose of this study, the total restorative treatment received by each patient in the sample has been separated into that received prior to the study's commencement (also referred to as pre-existing restorations), and that treatment received after commencement of the study (also referred to as restorations placed and replaced during the study).

4.3.2.1 Pre-existing Restorations

When attempting to compile complete restoration histories for each patient in the sample, it was found that the amount of data pertaining to the patient's initial visit varied enormously. Only when a full charting, or full mouth survey, had been conducted at the initial visit was reasonably accurate documentation of the existing restorations possible. Although full charting was rarely provided, this was not of major concern, as only those restorations placed during the study were analysed for their later survival.

However, to assure the study's "completeness", pre-existing restoration data have been included in this report, and are presented in Table 9. Again, it must be emphasised that the information provided is a gross underestimation of the actual situation. A perfect example of this, is that although the patients in Practice 3 did have pre-existing restorations, the author was unable to determine what they were, as all radiographs seven years or older were stored off the premises. Furthermore, the problem of identifying these pre-existing restorations was compounded by the fact that chartings of the restorations present at the initial visit were seldom performed.

4.3.2.2 Restorations Placed and Replaced During the Study

The total number of restorations placed during the study period, in all three practices, is shown in Table 6 (a-d). Also represented here is the number of times a material was replaced. It should be noted, however, that where a certain material is indicated in the \`Replacements' columns, it does not necessarily imply that the same material has been used throughout the study for any particular restoration. For example, the two glass-ionomer restorations shown in the seventh \`Replacement' column in Table 6(a) signifies that this was the last material used, and, in all probablility, differs from the original restorative material. Overall, a relatively large number of original restoration placements had been replaced as many as two or three times over the study period. Crowns often replaced other materials, especially with increased frequency of replacement.
It should be noted that the term \`original' refers to the initial placement of a restorative material during the study, and **not** to a pre-existing restoration.

A list of all test variables studied in this research project is set out in Table 7(a-c), along with their respective survivals, broken down into quartiles. These will be discussed further in Chapter Five.

TABLE 1 PATIENTS by RESTORATIVE MATERIAL

a.

PRACTICE 1 : PATIENT and MATERIAL	Material Present (%)				
Material	0 - 20	21 - 40	41 - 60	61 +	TOTAL
Amalgams	6 (10)	40 (64.6)	13 (21.7)	1 (1.7)	60 (100)
Resins	4 (9.4)	29 (67.4)	10 (23.3)	0 (0)	43 (100)
Crowns	4 (7.9)	37 (72.6)	10 (19.6)	0 (0)	51 (100)
Castings	1 (5.3)	15 (79)	3 (15.8)	0 (0)	19 (100)
Ionomers	4 (9.3)	32 (74.5)	7 (16.3)	0 (0)	43 (100)
Total	19 (8.8)	153 (70.8)	43 (19.9)	1 (0.5)	216 (100)

b.

PRACTICE 2 : PATIENT and MATERIAL	Material Present (%)				
Material	0 - 20	21 - 40	41 - 60	61 +	TOTAL
Amalgams	2 (8.4)	7 (29.2)	13 (54.2)	2 (8.3)	24 (100)
Resins	2 (13.4)	6 (40)	6 (40)	1 (6.7)	15 (100)
Crowns	1 (11.1)	4 (44.4)	4 (44.4)	0 (0)	9 (100)
Castings	1 (25)	1 (25)	2 (50)	0 (0)	4 (100)
Ionomers	2 (16.6)	5 (41.7)	5 (41.6)	0 (0)	12 (100)
Total	8 (12.5)	23 (36)	30 (46.9)	3 (4.7)	64 (100)

c.

PRACTICE 3 : PATIENT and MATERIAL	Material Present (%)				
Material	0 - 20	21 - 40	41 - 60	61 +	TOTAL
Amalgams	1 (6.7)	2 (13.4)	10 (66.7)	2 (13.3)	15 (100)
Resins	1 (8.3)	2 (16.6)	9 (75)	0 (0)	12 (100)
Crowns	0 (0)	0 (0)	2 (100)	0 (0)	2 (100)
Castings	0 (0)	0 (0)	1 (100)	0 (0)	1 (100)
Ionomers	1 (14.3)	1 (14.3)	5 (71.4)	0 (0)	7 (100)
Total	3 (8.1)	5 (13.5)	27 (73)	2 (5.4)	37 (100)

d.

OVERALL : PATIENT and MATERIAL	Material Present (%)				
Material	0 - 20	21 - 40	41 - 60	61 +	TOTAL
Amalgams	9 (9.1)	49 (49.5)	36 (36.4)	5 (5)	99 (100)
Resins	7 (10)	37 (52.9)	25 (35.7)	1 (1.4)	70 (100)
Crowns	5 (8.1)	41 (66.1)	16 (25.8)	0 (0)	62 (100)
Castings	2 (8.3)	16 (6.7)	6 (25)	0 (0)	24 (100)
Ionomers	7 (11.3)	38 (61.3)	17 (27.4)	0 (0)	62 (100)
Total	30 (9.5)	181 (57.1)	100 (31.5)	6 (1.9)	317 (100)

TABLE 2 AGE COHORTS by RESTORATIVE MATERIALS

a.

PRACTICE 1 : AGE and MATERIAL

Material	Age Cohorts 0 - 20	21 - 40	41 - 60	61 +	TOTAL
Amalgams	140	517	395	71	1123
Resins	22	121	119	22	284
Crowns	6	62	216	80	364
Castings	6	32	19	2	59
Ionomers	0	10	136	51	197
Total	174	742	885	226	2027

b.

PRACTICE 2 : AGE and MATERIAL

Material	Age Cohorts 0 - 20	21 - 40	41 - 60	61 +	TOTAL
Amalgams	115	154	83	15	367
Resins	23	54	25	12	114
Crowns	0	6	14	9	29
Castings	0	4	7	0	11
Ionomers	0	2	26	14	42
Total	138	220	155	50	563

c.

PRACTICE 3 : AGE and MATERIAL

Material	Age Cohorts 0 - 20	21 - 40	41 - 60	61 +	TOTAL
Amalgams	38	147	44	9	238
Resins	0	32	27	1	60
Crowns	0	4	2	0	6
Castings	0	1	0	0	1
Ionomers	0	18	7	11	36
Total	38	202	80	21	341

d.

OVERALL AGE and MATERIAL

Material	Age Cohorts 0 - 20	21 - 40	41 - 60	61 +	TOTAL
Amalgams	293	818	522	95	1728
Resins	45	207	171	35	458
Crowns	6	72	232	89	399
Castings	6	37	26	2	71
Ionomers	0	30	169	76	275
Total	350	1164	1120	297	2931

TABLE 3 CLASS by RESTORATIVE MATERIALS

a.

CLASS I RESTORATIONS

Material	Practice 1	Practice 2	Practice 3	TOTAL
Amalgams	138	83	48	269
Resins	1	0	0	1
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	12	2	2	16
Total	151	85	50	286

b.

CLASS II RESTORATIONS

Material	Practice 1	Practice 2	Practice 3	TOTAL
Amalgams	723	224	160	1107
Resins	1	0	6	7
Crowns	0	0	0	0
Castings	38	8	1	47
Ionomers	5	11	0	16
Total	767	243	167	1177

c.

CLASS III RESTORATIONS

Material	Practice 1	Practice 2	Practice 3	TOTAL
Amalgams	40	11	2	53
Resins	177	71	36	284
Crowns	0	0	0	0
Castings	2	0	0	2
Ionomers	42	1	7	50
Total	261	83	45	389

d.

CLASS IV RESTORATIONS

Material	Practice 1	Practice 2	Practice 3	TOTAL
Amalgams	3	0	0	3
Resins	35	20	2	57
Crowns	0	0	0	0
Castings	15	3	0	18
Ionomers	2	5	0	7
Total	55	28	2	85

TABLE 3 CLASS by RESTORATIVE MATERIALS

e.

CLASS V RESTORATIONS				
	Practice			
Material	Practice 1	Practice 2	Practice 3	TOTAL
Amalgams	219	49	28	296
Resins	70	23	16	109
Crowns	0	0	0	0
Castings	4	0	0	4
Ionomers	136	23	27	186
Total	429	95	71	595

f.

CLASS VI RESTORATIONS				
	Practice			
Material	Practice 1	Practice 2	Practice 3	TOTAL
Amalgams	0	0	0	0
Resins	0	0	0	0
Crowns	364	29	6	399
Castings	0	0	0	0
Ionomers	0	0	0	0
Total	129	130	140	399

g.

ALL RESTORATIONS				
	Practice			
Material	Practice 1	Practice 2	Practice 3	TOTAL
Amalgams	1123	367	238	1728
Resins	284	114	60	458
Crowns	364	29	6	399
Castings	59	11	1	71
Ionomers	197	42	36	275
Total	2027	563	341	2931

TABLE 4 PRACTICE vs RESTORATION CLASS

a.

CLASS I PRACTICE 1	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	29	109	138
Resins	0	1	0	1
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	0	6	6	12
Total	0	36	115	151

b.

CLASS I PRACTICE 2	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	17	66	83
Resins	0	0	0	0
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	0	2	0	0
Total	0	19	66	85

c.

CLASS I PRACTICE 3	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	12	36	48
Resins	0	0	0	0
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	0	1	1	2
Total	0	13	37	50

d.

ALL CLASS I RESTORATIONS	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	58	211	269
Resins	0	1	0	1
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	0	9	7	16
Total	0	68	218	286

TABLE 4 PRACTICE vs RESTORATION CLASS

e.

CLASS II PRACTICE 1	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	342	381	723
Resins	0	1	0	1
Crowns	0	0	0	0
Castings	0	21	17	38
Ionomers	0	0	5	5
Total	0	364	403	767

f.

CLASS II PRACTICE 2	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	81	143	224
Resins	0	0	0	0
Crowns	0	0	0	0
Castings	0	4	4	8
Ionomers	0	4	7	11
Total	0	89	154	243

g.

CLASS II PRACTICE 3	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	54	106	160
Resins	0	4	2	6
Crowns	0	0	0	0
Castings	0	0	1	1
Ionomers	0	0	0	0
Total	0	58	109	167

h.

ALL CLASS II RESTORATIONS	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	477	630	1107
Resins	0	5	2	7
Crowns	0	0	0	0
Castings	0	25	22	47
Ionomers	0	4	12	16
Total	0	511	666	1177

TABLE 4 PRACTICE vs RESTORATION CLASS

i.

CLASS III PRACTICE 1				
	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	40	0	0	40
Resins	177	0	0	177
Crowns	0	0	0	0
Castings	2	0	0	2
Ionomers	42	0	0	42
Total	261	0	0	261

j.

CLASS III PRACTICE 2				
	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	11	0	0	11
Resins	71	0	0	71
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	1	0	0	1
Total	83	0	0	83

k.

CLASS III PRACTICE 3				
	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	2	0	0	2
Resins	36	0	0	36
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	7	0	0	7
Total	45	0	0	45

l.

ALL CLASS III RESTORATIONS				
	Tooth site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	53	0	0	53
Resins	284	0	0	284
Crowns	0	0	0	0
Castings	2	0	0	2
Ionomers	50	0	0	50
Total	389	0	0	389

TABLE 4 PRACTICE vs RESTORATION CLASS

m.

CLASS IV PRACTICE 1				
	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	3	0	0	3
Resins	35	0	0	35
Crowns	0	0	0	0
Castings	15	0	0	15
Ionomers	2	0	0	2
Total	55	0	0	55

n.

CLASS IV PRACTICE 2				
	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	0	0	0
Resins	20	0	0	20
Crowns	0	0	0	0
Castings	3	0	0	3
Ionomers	5	0	0	5
Total	28	0	0	28

o.

CLASS IV PRACTICE 3				
	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	0	0	0
Resins	2	0	0	2
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	0	0	0	0
Total	2	0	0	2

p.

ALL CLASS IV RESTORATIONS				
	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	3	0	0	3
Resins	57	0	0	57
Crowns	0	0	0	0
Castings	18	0	0	18
Ionomers	7	0	0	7
Total	85	0	0	85

TABLE 4 PRACTICE vs RESTORATION CLASS

q.

CLASS V PRACTICE 1	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	17	62	140	219
Resins	63	6	1	70
Crowns	0	0	0	0
Castings	4	0	0	4
Ionomers	51	52	33	136
Total	135	120	174	429

r.

CLASS V PRACTICE 2	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	6	11	32	49
Resins	19	4	0	23
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	7	13	3	23
Total	32	28	35	95

s.

CLASS V PRACTICE 3	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	3	11	14	28
Resins	14	0	2	16
Crowns	0	0	0	0
Castings	0	0	0	0
Ionomers	11	13	3	27
Total	28	24	19	71

t.

ALL CLASS V RESTORATIONS	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	26	84	186	296
Resins	96	10	3	109
Crowns	0	0	0	0
Castings	4	0	0	4
Ionomers	69	78	39	186
Total	195	172	228	595

TABLE 4 PRACTICE vs RESTORATION CLASS

u.

CLASS VI PRACTICE 1	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	0	0	0
Resins	0	0	0	0
Crowns	110	121	133	364
Castings	0	0	0	0
Ionomers	0	0	0	0
Total	110	121	133	364

v.

CLASS VI PRACTICE 2	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	0	0	0
Resins	0	0	0	0
Crowns	19	7	3	29
Castings	0	0	0	0
Ionomers	0	0	0	0
Total	19	7	3	29

w.

CLASS VI PRACTICE 3	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	0	0	0
Resins	0	0	0	0
Crowns	0	2	4	6
Castings	0	0	0	0
Ionomers	0	0	0	0
Total	0	2	4	6

x.

ALL CLASS VI RESTORATIONS	Tooth Site			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	0	0	0	0
Resins	0	0	0	0
Crowns	129	130	140	399
Castings	0	0	0	0
Ionomers	0	0	0	0
Total	129	130	140	399

TABLE 5 RESTORATION DISTRIBUTION by ARCH and TOOTH POSITION

a.

RESTORATION DISTRIBUTION			
	Arch (%)		
Material	Maxilla	Mandible	Total
Amalgams	864 (50)	864 (50)	1728 (100)
Resins	414 (90.4)	44 (9.6)	458 (100)
Crowns	245 (61.4)	154 (38.6)	399 (100)
Castings	38 (53.5)	33 (46.5)	71 (100)
Ionomers	166 (60.4)	109 (39.6)	275 (100)
Total	1728 (58.7)	1205 (41.3)	2931 (100)

b.

ALL RESTORATIONS				
	Tooth Site (%)			
Material	Anterior	Premolar	Molar	TOTAL
Amalgams	82 (4.7)	619 (35.8)	1027 (59.4)	1728 (100)
Resins	437 (95.4)	16 (3.5)	5 (1.1)	458 (100)
Crowns	129 (32.3)	130 (32.6)	140 (35.1)	399 (100)
Castings	24 (33.8)	25 (35.2)	22 (31.0)	71 (100)
Ionomers	126 (45.8)	91 (33.1)	58 (21.1)	275 (100)
Total	798 (27.3)	881 (30.0)	1252 (42.6)	2931 (100)

c.

ALL RESTORATIONS				
	Restoration Class (%)			
Material	Class I	Class II	Class III	
Amalgams	269 (15.6)	1107 (64.1)	53 (3.1)	
Resins	1 (0.2)	7 (1.5)	284 (62.0)	
Crowns	0 (0.0)	0 (0.0)	0 (0.0)	
Castings	0 (0.0)	47 (5.8)	2 (2.8)	
Ionomers	16 (5.8)	16 (5.8)	50 (18.2)	
Total	286 (10.1)	1177 (40.0)	389 (13.2)	

ALL RESTORATIONS (contd)				
	Restoration Class (%)			
Material	Class IV	Class V	Class VI	TOTAL
Amalgams	3 (0.2)	296 (17.1)	0 (0.0)	1728 (100)
Resins	57 (12.4)	109 (23.8)	0 (0.0)	458 (100)
Crowns	0 (0.0)	0 (0.0)	399 (100)	399 (100)
Castings	18 (25.4)	4 (5.6)	0 (0.0)	71 (100)
Ionomers	7 (2.5)	186 (67.6)	0 (0.0)	275 (100)
Total	85 (3.7)	595 (20.4)	399 (13.5)	2931 (100)

TABLE 6 REPLACEMENT OF RESTORATIVE MATERIALS

a.

PRACTICE 1: MATERIAL vs NUMBER OF RESTORATION REPLACEMENTS

MATERIAL	ORIGINAL	Replacements							TOTAL
		1st	2nd	3rd	4th	5th	6th	7th	
Amalgams	688	284	104	31	12	2	2	0	1123
Resins	173	73	28	7	3	0	0	0	284
Crowns	93	115	83	41	26	4	2	0	364
Castings	27	19	9	3	1	0	0	0	59
Ionomers	122	41	18	10	2	2	0	2	197
TOTAL	1103	532	242	92	44	8	4	2	2027

Notes: Pearson X2 = 252.202 df = 28 p = 0.000

b.

PRACTICE 2: MATERIAL vs NUMBER OF RESTORATION REPLACEMENTS

MATERIAL	ORIGINAL	Replacements							TOTAL
		1st	2nd	3rd	4th	5th	6th	7th	
Amalgams	239	86	26	7	5	3	1	0	367
Resins	66	26	11	7	3	1	0	0	114
Crowns	5	7	8	4	2	3	0	0	29
Castings	3	3	3	2	0	0	0	0	11
Ionomers	22	8	8	3	1	0	0	0	42
TOTAL	335	130	56	23	11	7	1	0	563

Notes: Pearson X2 = 76.738 df = 24 p = 0.000

TABLE 6 REPLACEMENT OF RESTORATIVE MATERIALS

c.

PRACTICE 3 : MATERIAL vs NUMBER OF RESTORATION REPLACEMENTS

MATERIAL	ORIGINAL	Replacements 1st	2nd	3rd	4th	5th	6th	7th	TOTAL
Amalgams	163	51	20	4	0	0	0	0	238
Resins	45	13	2	0	0	0	0	0	60
Crowns	0	2	2	2	0	0	0	0	6
Castings	0	1	0	0	0	0	0	0	1
Ionomers	19	12	3	2	0	0	0	0	36
TOTAL	227	79	27	8	0	0	0	0	341

Notes: Pearson X2 = 45.915 df = 12 p = 0.000

d.

OVERALL : MATERIAL vs NUMBER OF RESTORATION REPLACEMENTS

MATERIAL	ORIGINAL	Replacements 1st	2nd	3rd	4th	5th	6th	7th	TOTAL
Amalgams	1090	421	150	42	17	5	3	0	1728
Resins	284	112	41	14	6	1	0	0	458
Crowns	98	124	93	47	28	7	2	0	399
Castings	30	23	12	5	1	0	0	0	71
Ionomers	163	61	29	15	3	2	0	2	275
TOTAL	1665	741	325	123	55	15	5	2	2931

Notes: Pearson X2 = 340.463 df = 28 p = 0.000

CHAPTER FIVE:
RESTORATION SURVIVALS

5.1 RESTORATION SURVIVALS

This chapter deals predominantly with the survival characteristics of the restorative materials: amalgam, composite resin, crowns (gold and porcelain), castings (gold inlay, onlays and partial veneer crowns) and glass ionomer cements; and how they behaved during the period of the study. During this study, the materials' survivals were analysed, using the life table method, under a variety of categories which included:

a. Practice distribution,
b. Change in operator,
c. Original versus replacement restorations,
d. Restoration class,
e. Arch distribution,
f. Restoration position within the mouth (tooth position or site),
g. Age of the patient when the restoration was initially placed or replaced, and
h. Experience of the operator.

A summary table setting out the survivals, by quartiles, for each restorative material, according to each of the categories listed above, is provided in Table 7(a-c). Where survival quartile figures are not provided in Table 7, insufficient failures had occurred. While these missing quartiles could be calculated using a modified Weibull analysis, Smales et al. (1991d), only absolute figures have been provided here.

5.2 RESTORATIVE MATERIAL COMPARISONS

5.2.1 Practice Distribution

The number of patients selected from each practice was not evenly distributed: 60 from Practice 1, 25 from Practice 2 and 15 from Practice 3. Therefore, when interpreting the following results, care had to be taken to ensure that sufficient restorations were present before realistic trends could be reported, especially in Practices 2 and 3.

a. Amalgam

In the case of amalgams, there were sufficient restorations placed in all three practices for valid inferences to be made.

Practice	Total	Failed	Censored	Proportion Censored
1	1123	411	712	0.6340
2	367	107	260	0.7084
3	238	68	170	0.7143

There was borderline statistical significance between the practices (p=0.0592). The survival characteristics of amalgam restorations for each practice and the overall situation is provided in Chart 1(a). The estimated overall median survival time was 22.52 ± 1.07 (standard error) years.

b. Composite Resins

As with amalgam restorations, there were adequate numbers of resin restorations placed by all three practices to make a valid conclusion.

Practice	Total	Failed	Censored	Proportion Censored
1	284	132	152	0.5352
2	114	43	72	0.6228
3	60	18	42	0.7000

No statistically significant difference was found between the three practices (p=0.5444). Chart 1(b) shows the survival characteristics of composite resin, both by individual practice and a combination of all three. The overall median survival was 16.72 ± 1.37 years.

c. Crowns

When analysing the data for crown survival, it is important to keep in mind that the great majority of crowns placed during the study were in Practice 1. Where very few restorations exist, the loss of even one crown can have a highly significant affect on the survival analysis. This is demonstrated in Practice 3, where the failure of just one restoration meant a reduction in the Practice's cumulative survival rate (for crowns) from 100% to 77 %.

Practice	Total	Failed	Censored	Proportion Censored
1	364	61	303	0.8324
2	29	13	16	0.5517
3	6	1	5	0.8333

There was a statistically significant difference between the three dental practices (p=0.0000). However, the limited number of crowns placed in both Practices 2 and 3 must be considered when assessing these results. Once again, the survival results are shown graphically in Chart 1(c). The overall 75th quartile survival was 15.41 $\pm$ 0.95 years.

d. ***Castings***

Throughout the study, only a limited number of castings were placed when compared to other restorative materials, and most of these were placed during the 1950's, 1960's and 1970's. There was no statistically significant difference (p=0.6650) in the life of a dental casting between the three practices, as shown in Chart 1(d). It should be noted, however, that the survival rate in Practice 3 is based on a single restoration. The overall median survival was 13.75 $\pm$ 4.65 years.

Practice	Total	Failed	Censored	Proportion Censored
1	59	32	27	0.4576
2	11	5	6	0.5455
3	1	0	1	1.0000

e. ***Glass-ionomers***

As glass-ionomers are a comparatively new restorative material, the period during which these restorations have been studied has been correspondingly short, especially when compared to amalgams and dental castings. Despite this, the survival characteristics of this material are impressive, as shown in Chart 1(e).

Practice	Total	Failed	Censored	Proportion Censored
1	197	23	174	0.8832
2	42	10	32	0.7619
3	36	9	27	0.7500

The above data did indicate a statistically significant difference (p=0.0056) between the three practices, with Practice 1 providing the best results. However, the clinical significance of this is questionable, as the survival rates in all three practices were excellent. The overall 75th quartile survival was 11.25 $\pm$ 0.64 years.

5.2.2 Change in Operator

This section investigated the effect that a change in dental operator had on the survival characteristics of replacement restorative materials. The survival rate of each restorative material, by quartiles, is shown in Table 7, while the behaviour of these materials is reported individually in Chart 2(a-e).

a. *Amalgams*

Of the restorations assessed in this study, 1090 amalgam restorations were placed at the `start' of the study and 638 (218 + 420) of these original amalgams required replacement during the study period. It was these 638 replacement restorations that were analysed in this section, to determine whether a change in operator affected the restoration survival rates.

Operator	Total	Failed	Censored	Proportion Censored
Different	218	68	150	0.6881
Same	420	150	270	0.6429

With amalgam, the change in operator did not have a statistically significant effect (p=0.7054) on the restoration survival.

b. *Composite Resins*

There was borderline statistical significance (p=0.0526) between the two groups of operators, with those assessed by a different operator tending to survive longer than those assessed by the same operator. However the disparity in the sample size between the two groups makes an irrefutable conclusion impossible.

Operator	Total	Failed	Censored	Proportion Censored
Different	46	12	34	0.7391
Same	128	56	72	0.5625

The 284 `missing' composite resin restorations were again the originals and, therefore, ineligible for assessment.

c. Crowns

There was no statistically significant difference (p=0.4043) between the two groups. In addition to those crowns listed below, there were 98 original crowns not considered in this assessment.

Operator	Total	Failed	Censored	Proportion Censored
Different	79	11	68	0.8608
Same	222	45	177	0.7973

d. Castings

No statistically significant difference (p=0.3141) existed between the two group for dental castings. The 30 `missing' castings were originals placed that survived the study period.

Operator	Total	Failed	Censored	Proportion Censored
Different	7	2	5	0.7143
Same	34	21	13	0.3824

e. Glass-ionomers

Again, there was no statistically significant difference (p=0.9502) between the two groups. While the total number of glass-ionomers was 275, 163 of these were originals and therefore not considered in this assessment.

Operator	Total	Failed	Censored	Proportion Censored
Different	15	2	13	0.8667
Same	97	22	75	0.7732

When all data were analysed collectively, it was found that there was no statistically significant difference (p=0.1021) between restorations that had been reviewed by the same operator or by a colleague. In fact, the only restorative material to display any real difference between the two operator groups (albeit slight) was composite resin, most likely the result of the same operator condemning his/her own restorations to a shorter lifespan for appearance reasons.

5.2.3 Original Versus Replacement Restorations

How long a restorative material lasts before it needs replacement, is a question often asked by practitioners. However, what is just as important, if not more so, is the lifespan of the replacement restoration when compared to the original. Comparisons of the survival characteristics of original and replacement restorations are provided below, and in Chart 3 (a-e).

a. ***Amalgams***

There was a significant statistical difference (p=0.0000) between the original and replacement restoration, with the original behaving superiorly.

Restoration	Total	Failed	Censored	Proportion Censored
Original	1090	368	722	0.6624
Replacement	638	218	420	0.6583

b. ***Composite Resins***

With resins, there was no significant difference (p=0.4903) between the original and replacement restorations.

Restoration	Total	Failed	Censored	Proportion Censored
Original	284	125	159	0.5599
Replacement	174	68	106	0.6092

c. ***Crowns***

There was no statistically significant difference (p=0.1212) between the original and replacement restorations, despite the originals appearing to fare better, albeit marginally, according to Chart 4(c).

Restoration	Total	Failed	Censored	Proportion Censored
Original	98	19	79	0.8061
Replacement	301	56	245	0.8140

d. ***Castings***

Again, no significant statistical difference (p=0.0971) between the two groups was found, despite the replacement restorations appearing to fail earlier than the originals.

Restoration	Total	Failed	Censored	Proportion Censored
Original	30	14	16	0.5333
Replacement	41	23	18	0.4390

e. ***Glass-ionomers***

A borderline statistical significance (p=0.0204) existed between the two groups; again, with the original restorations displaying superior survival characteristics.

Restoration	Total	Failed	Censored	Proportion Censored
Original	163	18	145	0.8896
Replacement	112	24	88	0.7857

When all of the data was analysed collectively, a statistically significant difference (p=0.0000) existed between the survival characteristics of original and replacement restorations; with the original restorations having superior survival characteristics.

5.2.4 Restoration Class

The survival characteristics of restorative materials, as discussed above, can be influenced by the class of restoration, and by the restoration's position in the dental arch. The following paragraphs report on the relationship between restoration class and restorative material, with survival rates discussed according to:

i. 5.2.4.1. Restorative material versus class distribution, Chart 4(a-e) and

ii. 5.2.4.2. Restoration class versus restorative material, Chart 5(a-e).

Although these sub-groups are essentially the same, the subtle differences in reporting methods combine to give a clear overall perspective.

5.2.4.1 Material Versus Class

a. Amalgams

When the numbers of each restorative material in each class are taken into account, there was a statistically significant difference (p=0.0000) between restoration classes.

Class	Total	Failed	Censored	Proportion Censored
I	269	43	226	0.8401
II	1107	416	691	0.6242
III	53	24	29	0.5472
IV	3	0	3	1.0000
V	296	103	193	0.6520

Although Class IV amalgams show a 100% survival, there were only three restorations placed, an insufficient number to enable any valid conclusion to be drawn. Class I restorations showed the best survivals where numbers were adequate.

b. Composite Resins

Again, there was a statistically significant difference (p=0.0078) between the restorative classes for composite resin.

Class	Total	Failed	Censored	Proportion Censored
I	1	0	1	1.0000
II	7	1	6	0.8571
III	284	129	155	0.5458
IV	57	20	37	0.6491
V	109	43	66	0.6055

With only one Class I and seven Class II composite resins placed, care must be employed when making judgements. The Class III and V resins, as expected, showed superior survival characteristics compared to Class IV resins.

c. Crowns

There is only one class for crowns, namely Class VI, and as such there can be no comparison between classes for this material.

Class	Total	Failed	Censored	Proportion Censored
VI	399	75	324	0.8120

d. Castings

A statistically significant difference (p=0.0000) was demonstrated between the restorative classes for castings.

Class	Total	Failed	Censored	Proportion Censored
II	47	24	23	0.4894
III	2	0	2	1.0000
IV	18	9	9	0.5000
V	4	4	0	0.0000

No Class I castings were placed during the study; and again, with only two Class III and four Class V restorations, caution must be employed when viewing the results. The potentially misleading nature of the results, where limited restorations have been placed, is especially apparent when considering the 100% survival rate of the two Class III restorations and the 100% failure rate of the four Class V's.

e. Glass-ionomers

As with all the other materials, there was a statistically significant difference (p=0.0000) between the classes of restorations. Restorations subjected to direct loading did not fare as well as the Class III and V restorations.

Class	Total	Failed	Censored	Proportion Censored
I	16	3	13	0.8125
II	16	7	9	0.5625
III	50	5	45	0.9000
IV	7	2	5	0.7143
V	186	25	163	0.8656

5.2.4.2 Class Versus Material

Although demonstrating a 100% survival rate, the results of *Class I* composite resin restorations must be interpreted carefully, as only one of these restorations was actually placed. As far as the other materials are concerned, no real inferences can be made, as the disparity between the sample sizes for *Class I* amalgam restorations and all others is considerable.

Class II restoration survival appears to be bi-polar, with amalgams and castings performing better than the composite resins and glass-ionomers, which can be explained by their respective abilities to resist occlusal loads.

Class III restorations show similar survival characteristics for all materials except castings. Although there were no failures with castings, only two restorations were placed in this class, so the significance of this is debatable. Appearance alone was obviously not a parameter for replacement with castings, and may have been a reason to delay removal.

Class IV restorations again are similar in their survivals, except for one material, amalgam. In this case, of three amalgams placed, no failures were recorded.

Class V restorations for all materials performed well, except for castings. This is in contrast to the other studied restorative materials. The inferior survival characteristics of the castings can attributed to only four restorations failing early.

Class VI restorations were easy to analyse as the only restorations to use this classification were full crowns, and were reported on earlier.

5.2.5 Arch Distribution

The behaviour of the five types of restorative materials in both the maxillae (plural used as the maxillae consists of the right and left maxilla) and mandible are discussed below, and illustrated in Chart 6(a-e).

a. Amalgams

With amalgams, there is a significant difference (p=0.0006) in survival rates between the two arches, with the maxillae demonstrating superior survival characteristics.

Arch	Total	Failed	Censored	Proportion Censored
Maxillae	864	261	603	0.6979
Mandible	864	325	539	0.6238

b. Composite Resins

With composite resins, there is a borderline significant difference (p=0.0252) between the arches. However, while the results show that composite resins placed in the mandibular region fail more in the early stages, the overall failure rate of resins in the mandible is considerably less than that for the maxillae. Again, the relative number of restorations must be considered when viewing the results.

Arch	Total	Failed	Censored	Proportion Censored
Maxillae	414	182	232	0.5604
Mandible	44	11	33	0.7500

c. Crowns

While no statistically significant difference (p=0.1328) exists between crown survivals in the two arches, mandibular crowns appear to fare marginally better.

Arch	Total	Failed	Censored	Proportion Censored
Maxillae	245	53	192	0.7837
Mandible	154	22	132	0.8571

d. ***Castings***

Again, there is no statistically significant difference (p=0.9023) between the casting survival rates in the maxillae and mandible.

Arch	Total	Failed	Censored	Proportion Censored
Maxillae	38	19	19	0.5000
Mandible	33	18	15	0.4545

e. ***Glass-ionomers***

There was no statistically significant difference (p=0.5708) between the maxillae and mandible with respect to glass-ionomer survivals.

Arch	Total	Failed	Censored	Proportion Censored
Maxillae	166	24	142	0.8554
Mandible	109	18	91	0.8349

5.2.6 Tooth Position

How each of these restorative materials survive in different regions of the dental arch is discussed below and illustrated graphically in Chart 7(a-e) and Chart 8(a-c). To highlight the differences in tooth position in relation to the restorative material used, the following topics will be discussed separately, despite the similarities between them:

i. 5.2.6.1. Individual material survival by tooth position (Chart 7), and

ii. 5.2.6.2. Tooth position versus restorative material (Chart 8).

5.2.6.1 Individual Material Survival by Tooth Position

a. ***Amalgams***

Despite the majority of amalgam restorations being placed in the molar region, and thus subjected to maximal stresses, there was no statistically significant difference (p=0.2484) between restoration survivals in the three arch segments.

Region	Total	Failed	Censored	Proportion Censored
Anterior	82	31	51	0.6220
Premolar	619	207	412	0.6656
Molar	1027	348	679	0.6611

b. ***Composite Resins***

There was no statistically significant difference (p=0.2849) between the composite resins for the three regions. However, as only 16 premolar and five molar region composite resins were placed, the significance of the survival data in these two cases are questionable. Interestingly the Class V resin restorations (62% of posterior resins) did not perform any better than the load bearing resins, but the limited numbers prevented any concrete trends from being established.

Region	Total	Failed	Censored	Proportion Censored
Anterior	**437**	**187**	**250**	**0.5721**
Premolar	**16**	**4**	**12**	**0.7500**
Molar	**5**	**2**	**3**	**0.6000**

c. ***Crowns***

With crowns, there was a statistically significant difference (p=0.0034) between the three regions, with anterior crowns displaying a shorter lifespan. The reasons for this are not obvious from the data, but crowns with unappealing margins or shades are more likely to be replaced in the anterior region, than in the posterior region of the mouth.

Region	Total	Failed	Censored	Proportion Censored
Anterior	**129**	**38**	**91**	**0.7054**
Premolar	**130**	**18**	**112**	**0.8615**
Molar	**140**	**19**	**121**	**0.8643**

d. ***Castings***

No statistically significant difference (p=0.7208) existed between the three regions for dental castings.

Region	Total	Failed	Censored	Proportion Censored
Anterior	**24**	**13**	**11**	**0.4583**
Premolar	**25**	**14**	**11**	**0.4400**
Molar	**22**	**10**	**12**	**0.5455**

e. ***Glass-ionomers***

Again, there was no statistically significance difference (p=0.0861) between the groups for glass-ionomer restorations.

Region	Total	Failed	Censored	Proportion Censored
Anterior	126	15	111	0.8810
Premolar	91	16	75	0.8242
Molar	58	11	47	0.8103

5.2.6.2 Tooth Position Versus Restorative Material

a. ***Anterior Segment***

There was borderline statistical significance (p=0.0321) between the restorative materials. Although no individual material stood out, amalgams and ionomers performed better than the rest.

Material	Total	Failed	Censored	Proportion Censored
Amalgams	82	31	51	0.6220
Resins	437	187	250	0.5721
Crowns	129	38	91	0.7054
Castings	24	13	11	0.4583
Ionomers	126	15	111	0.8810

b. ***Premolar Segment***

There was a statistically significant difference (p=0.0016) between the restorative materials for the premolar region, with amalgams, crowns and castings displaying superior survival characteristics.

Material	Total	Failed	Censored	Proportion Censored
Amalgams	619	207	412	0.6656
Resins	16	4	12	0.7500
Crowns	130	18	112	0.8615
Castings	25	14	11	0.4400
Ionomers	91	16	75	0.8242

c. ***Molar Segment***

Again, there was a statistically significant difference (p=0.0010) between restorative materials in the molar region, with crowns displaying superior survival trends, while resins and ionomers failed first.

Material	Total	Failed	Censored	Proportion Censored
Amalgams	**1027**	**348**	**679**	**0.6611**
Resins	**5**	**2**	**3**	**0.6000**
Crowns	**140**	**19**	**121**	**0.8643**
Castings	**22**	**10**	**12**	**0.5455**
Ionomers	**58**	**11**	**47**	**0.8103**

5.2.7 Patient Age Distribution

As detailed in section 4.1, when analysing restorative materials in terms of a patient's age, age cohorts have been used. They are as follows: 0-20 years, 21-40 years, 41-60 years and 61+ years. In this section, the survival characteristics of the restorative materials are analysed by age group, using the same format as employed above. However, it should be noted that, in this case, all figures shown are combined totals; that is, representative of all three practices.

a. ***Amalgams***

There was a statistically significant difference (p=0.0000) in the survival of amalgam for each different age cohort, with those placed in young patients (0-20 years) displaying the best survival characteristics. This is demonstrated in Chart 9(a).

Age	Total	Failed	Censored	Proportion Censored
0-20	**293**	**94**	**199**	**0.6792**
21-40	**818**	**342**	**476**	**0.5819**
41-60	**522**	**139**	**383**	**0.7337**
61+	**95**	**11**	**84**	**0.8842**

b. ***Composite Resins***

Once again, there was a statistically significant difference in the survival of composite resin for the various age cohorts (p=0.0000) and this is shown in Chart 9(b). In this case, resins placed in young and old patients displayed inferior survival characteristics.

Age	Total	Failed	Censored	Proportion Censored
0-20	45	35	10	0.2222
21-40	207	96	111	0.5362
41-60	171	49	122	0.7135
61+	35	13	22	0.6286

c. ***Crowns***

There was no significant statistical difference (p=0.1842) in the survival of crowns. At first glance it appears that crowns placed in young mouths are more prone to failure than those placed in older patients. However, the relatively small number of crowns placed in the first age cohort means that a conclusive statement is difficult to make.

Age	Total	Failed	Censored	Proportion Censored
0-20	6	3	3	0.5000
21-40	72	14	58	0.8056
41-60	232	40	192	0.8276
61+	89	18	71	0.7978

d. ***Castings***

While there was borderline statistical significance (p=0.0475) between the different age cohorts, the limited number of castings placed in at least two of the age groups means that care must be taken when interpreting the results. In Chart 9(d) the survival characteristics of castings are shown.

Age	Total	Failed	Censored	Proportion Censored
0-20	6	6	0	0.0000
21-40	37	17	20	0.5405
41-60	26	13	13	0.5000
61+	2	1	1	0.5000

e. ***Glass-ionomers***

A significant statistical difference (p=0.0165) exists with glass-ionomer cements. It is interesting to note that there were no glass-ionomers placed in patients below the age of 20 years. These results are shown in Chart 9(e).

Age	Total	Failed	Censored	Proportion Censored
0-20	0	0	0	0.0000
21-40	30	9	21	0.7000
41-60	169	30	139	0.8225
61+	76	3	73	0.9605

The best results were found amongst patients in the 61+ age cohort, and these would predominantly apply to non-stress bearing Class III and V restorations.

5.2.8 Experience of the Operator

The experience of the dentist and its effect on restoration survivals was investigated in this section. The following table defines the cohorts used in this study and provides comparison between experience levels and the number of restorations placed, for each material. The 30 missing restorations were placed by unknown dentists, and therefore ineligible for analysis.

	Years Experience when Restoration Placed						
Material	**0-5**	**6-10**	**11-20**	**21-30**	**31-40**	**41+**	**TOTAL**
Amalgam	127	184	527	438	332	98	1706
Composite Resins	39	46	131	167	57	15	455
Crowns	7	16	78	112	135	50	398
Castings	1	2	23	34	9	1	70
Ionomers	8	12	46	8	141	57	272
TOTAL	182	260	805	759	674	221	2901

a. Amalgam

With respect to amalgam, the relative experience of a dentist had no statistically significant effect on its survival (p = 0.1529). All restorations exhibited similar survival characteristics.

b. Composite Resins

With the placement of composite resins being a more technique sensitive process, one would expect differences to emerge between operators of varying experience. This was indeed the case, with a statistically significant difference (p = 0.0036). Recently graduated dentists provided restorations with the best results, while those having graduated more than 40 years ago appearing to produce inferior results. However, as only 15 restorations were placed in this category, there are insufficent data on which to base an irrefutable conclusion.

c. Crowns

As with amalgams, there were no statistically significant differences (p = 0.6427) between the survival characteristics of restorations placed by dentists of varying experience.

d. Castings

Again, there was no statistically significant difference present (p = 0.8189) between the experience of the dentist and restoration survival. However, there was only one casting placed in the 0-5 and 41+ year old cohorts respectively, and both castings were replaced (apparent failures) three years later.

e. Ionomers

There was a statistically significant difference (p = 0.0000) between ionomers placed by the different operators. Restorations placed by recent graduates and those in the 21-30 cohort provided inferior results. However, it must be noted that there was only a limited number of ionomers restorations placed in both these cohorts, which could have affected the results.

Overall, the experience of the dentist did not appear to make any statistically significanty difference (p = 0.3810) to the survival of a dental restoration. However, in the case of both composite resins and ionomers, individual results indicated some relationship between experience and restoration survival.

TABLE 7 SURVIVAL QUARTILES FOR EACH RESTORATIVE MATERIAL

a.

RESTORATION SURVIVALS							
		SURVIVAL QUARTILES					
MATERIAL	GROUP	75th	S.E	50th	S.E	25th	S.E
AMALGAMS	**Overall**	**10.52**	**0.41**	**22.52**	**1.07**	**43**	**0.95**
	Practice 1	10.1	0.51	21.41	1.2	40.43	1.17
	Practice 2	11.59	1.19				
	Practice 3	11.03	0.9	18.89	1.5		
	Same Operator	7.1	0.64	15.57	2.21	26.69	2.79
	Different Operator	5.97	1.11	18.04	1.42	30.24	1.29
	Original	12.24	0.66	27.43	1.01	43.63	0.63
	Replacement	6.88	0.68	16.35	1.41	26.92	2.41
COMPOSITE RESINS	**Overall**	**7.91**	**0.63**	**16.72**	**1.37**	**34.41**	**0.55**
	Practice 1	8.44	0.88	16.42	1.41	25.65	1.93
	Practice 2	6.14	1.17	18.18	2.39		
	Practice 3	9.52	1.33	20.22	0.64		
	Same Operator	7.06	0.82	13.23	3.98		
	Different Operator	12.66	1.16	25.13		25.82	
	Original	8.36	1.21	17.63	1.8	34.47	0.59
	Replacement	7.56	0.64	15.91	1.61	25.94	1.23
CROWNS	**Overall**	**15.41**	**0.95**				
	Practice 1	16.42	1.6				
	Practice 2	2.37	0.74	11.89	2.29		
	Practice 3						
	Same Operator	12.8	2.14	24.93	1.58		
	Different Operator	15.39	1.35				
	Original	16.99	2.32				
	Replacement	14.75	1.41				
CASTINGS	**Overall**	**8.33**	**1.33**	**13.75**	**4.65**		
	Practice 1	8.36	1.18	13.53	3.37		
	Practice 2	6.67	1.56	12.73	1.65		
	Practice 3						
	Same Operator	4.26	2.4	11.66	0.74	18.74	1.22
	Different Operator	8.4	0.97				
	Original	9.61	1.16	30.12	1.62		
	Replacement	4.78	2.52	11.78	0.85		
IONOMERS	**Overall**	**11.25**	**0.64**				
	Practice 1	11.63	0.67				
	Practice 2	3.64	1.62				
	Practice 3	5.05	2.86				
	Same Operator	5.82	1.55				
	Different Operator						
	Original						
	Replacement	5.92	1.71				

TABLE 7 SURVIVAL QUARTILES FOR EACH RESTORATIVE MATERIAI

b.

RESTORATION SURVIVALS							
		SURVIVAL QUARTILES					
MATERIAL	**GROUP**	**75th**	**S.E**	**50th**	**S.E**	**25th**	**S.E**
AMALGAMS	Class I	21.54	2.7				
	Class II	10.22	0.48	19.72	0.98	38.78	1.05
	Class III	15.3	1.51	23.33	1.96	29.93	1.46
	Class IV	no failures					
	Class V	8.17	1.38	23.2	2.42		
	Maxillae	12.51	0.96	25.34	1.62	40.25	1.01
	Mandible	9.01	0.73	18.71	1.04	43.22	
COMPOSITE RESINS	Class I	no failures					
	Class II	1.75	1				
	Class III	9.04	1.04	17.68	1.94		
	Class IV	3.46	0.4	12.73	1.59	34.21	1.59
	Class V	8.15	0.81	25.05	0.62		
	Maxillae	7.9	0.63	15.8	1.33	25.94	3.06
	Mandible	10.1	3.67				
CROWNS	Class VI	15.41	0.95				
	Maxillae	13.87	3.08	25.57	0.84		
	Mandible	15.78	1.55				
CASTINGS	Class I	none					
	Class II	10.44	1.36	15.61	2.57		
	Class III	no failures					
	Class IV	8.18	1.24	30.02	1.95		
	Class V	0.5	0.43	1	0.67	2	
	Maxillae	8.14	1.87	15.65	2.42		
	Mandible	8.72	2.97	13.14	2.71		
IONOMERS	Class I	3.41	0.85				
	Class II	1.6	0.46	3.14	1.29	4.89	1.67
	Class III						
	Class IV	4.3	0.84				
	Class V	11.56	0.6				
	Maxillae						
	Mandible	11.12	0.44				

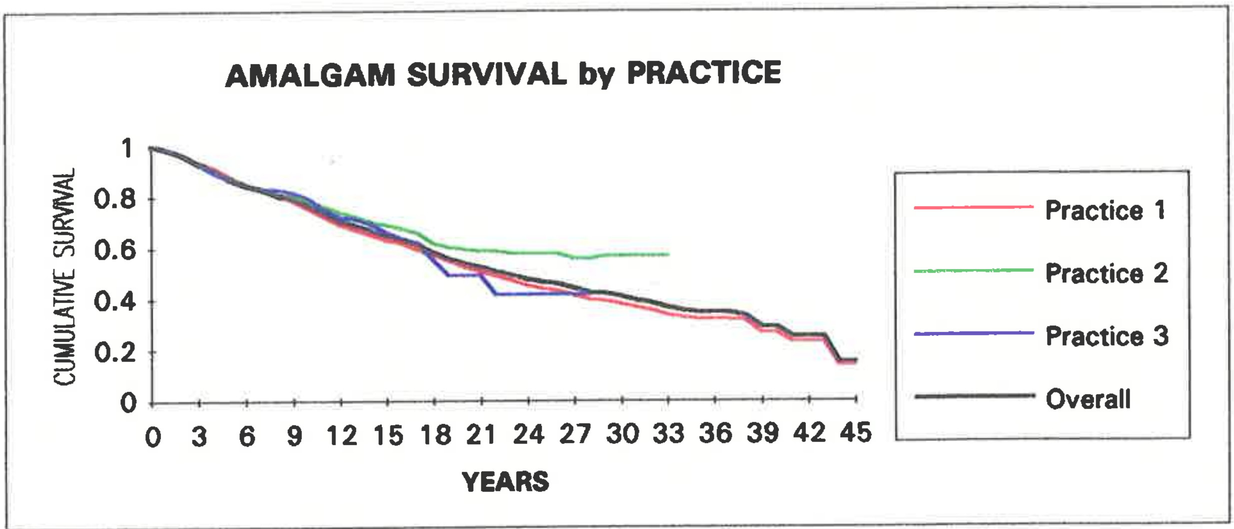
TABLE 7 SURVIVAL QUARTILES FOR EACH RESTORATIVE MATERIAL

c.

RESTORATION SURVIVALS							
		SURVIVAL QUARTILES					
MATERIAL	GROUP	75th	S.E	50th	S.E	25th	S.E
AMALGAMS	Anterior	13.75	4.15	27.18	1.65		
	Premolar	11.48	0.61	24.08	2.05	40.37	0.78
	Molar	9.72	0.48	21.12	1.67		
	0-20	15.55	1.93	33.34	2.38	43.71	0.98
	21-40	10.16	0.5	19.86	0.97	38.8	1.75
	41-60	9.04	0.87	19.86	4.48		
	61+	6.87	1.74				
COMPOSITE RESINS	Anterior	7.96	0.63	16.85	1.48	34.43	0.55
	Premolar	9.13	1.22	10.42	1.06		
	Molar	6	1.15	6.67	0.89		
	0-20	3.54	0.71	9.09	3.3	15.64	1.37
	21-40	8.19	0.84	17.57	1.91	34.12	
	41-60	10.19	0.81				
	61+	3.6	0.96	12.18	1.23		
CROWNS	Anterior	8.13	1.08	25.22	0.82		
	Premolar	18.04	1.33				
	Molar	15.52	1.12				
	0-20	2.5	1.06				
	21-40	18.93	3.02	25.09		25.8	
	41-60	15.95	0.97				
	61+	8.75	1.51				
CASTINGS	Anterior	4	2.09	10.4	1.96		
	Premolar	9.66	1.71	12.97	2.06		
	Molar	11.28	0.57	21.22	0.94		
	0-20	0.75	0.61	2	1.22	15.5	1.06
	21-40	10.04	2.15	21.35	1.24		
	41-60	9.33	1.09	11.82	1.05		
	61+	8.5	0.61				
IONOMERS	Anterior						
	Premolar	11.03	0.81				
	Molar	6.25	0.99	11.4		11.95	
	0-20						
	21-40	1.83	0.77				
	41-60	6.88	1.69				
	61+						

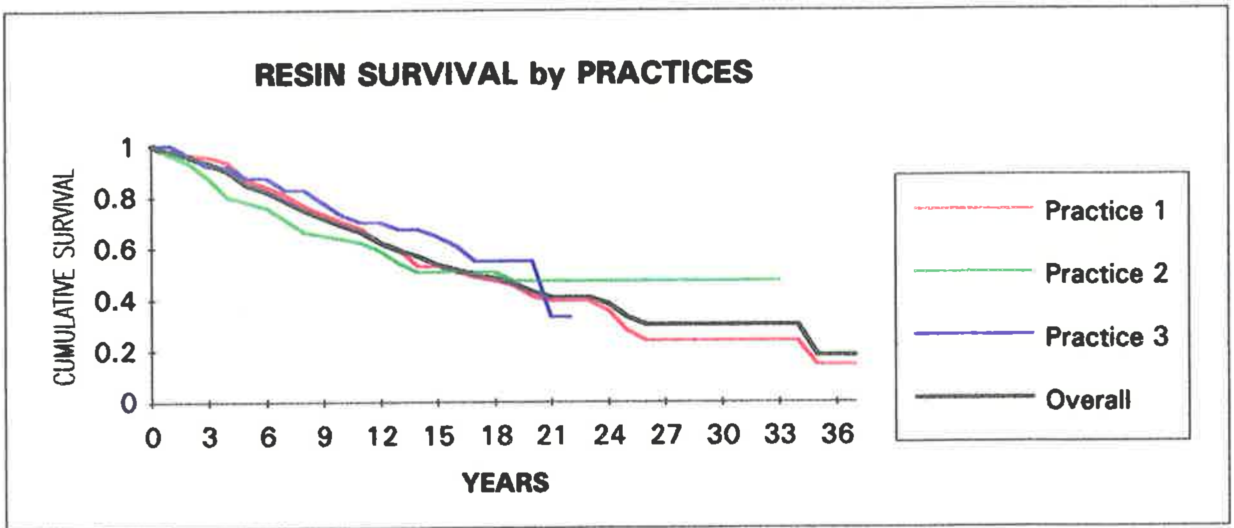
CHART 1 MATERIAL SURVIVAL by PRACTICE

a.



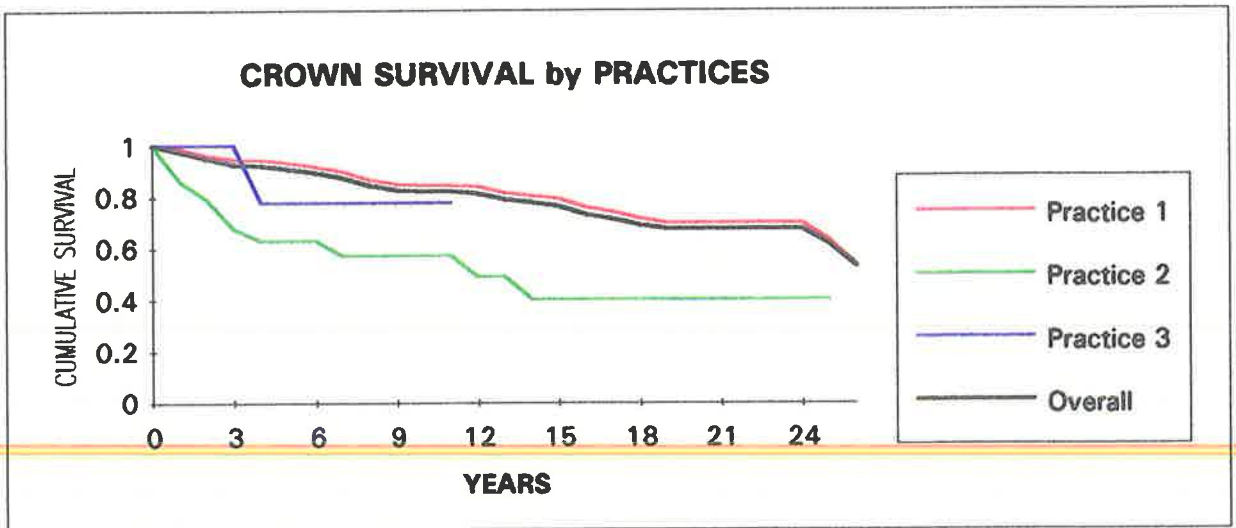
MANTEL-COX = 5.65 df= 2 p= 0.06

b.



MANTEL-COX = 1.22 df= 2 p= 0.54

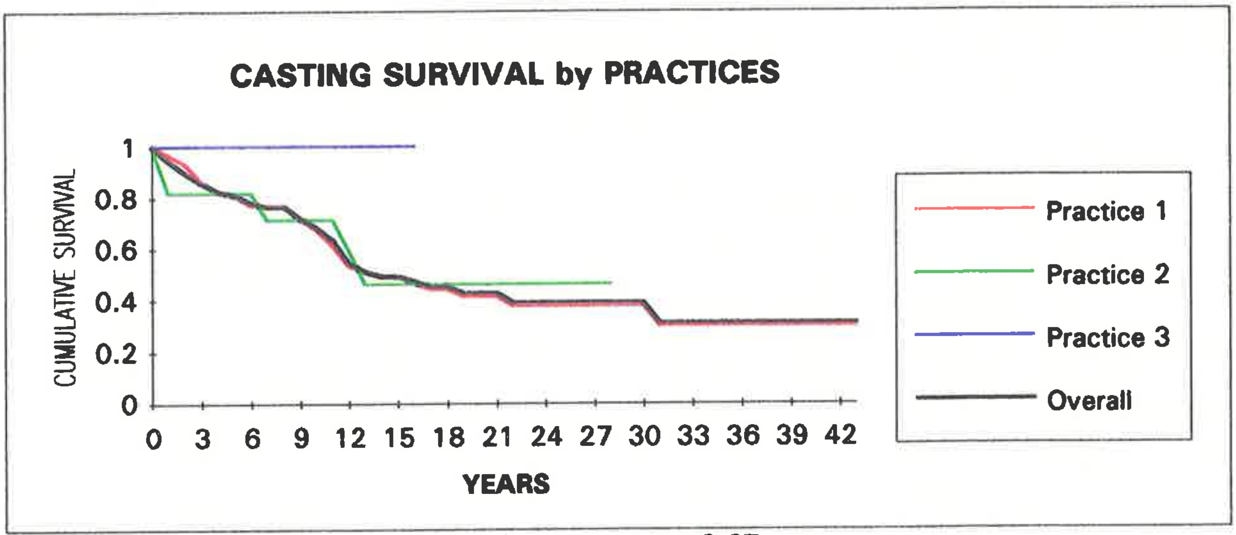
c.



MANTEL-COX= 22.22 df= 2 p= 0.00

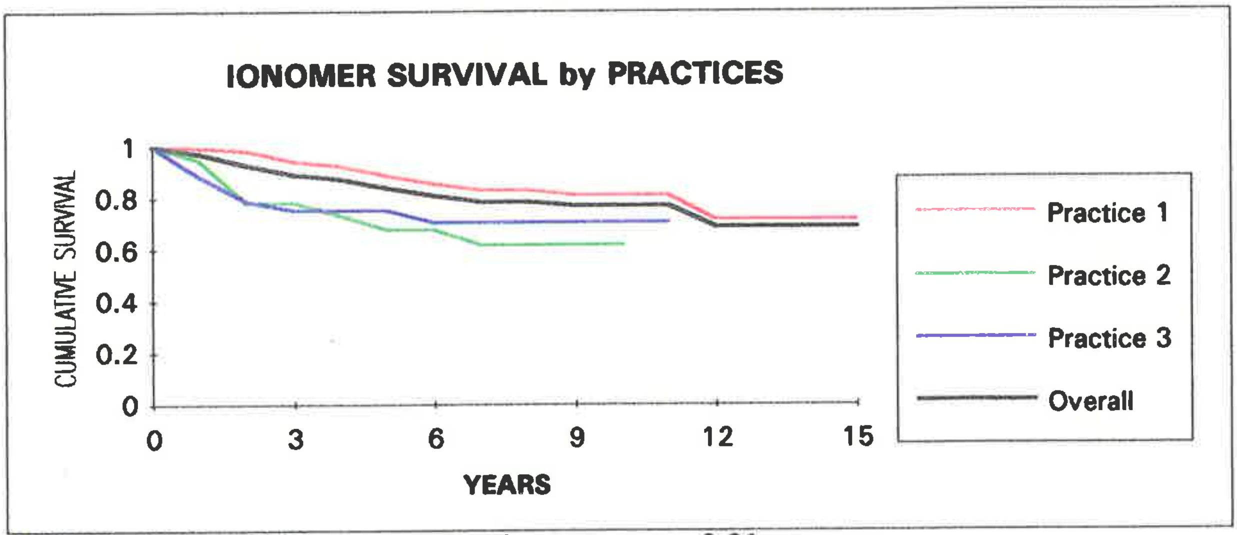
CHART 1 MATERIAL SURVIVAL by PRACTICE

d.



MANTEL-COX = 0.82 df= 2 p= 0.67

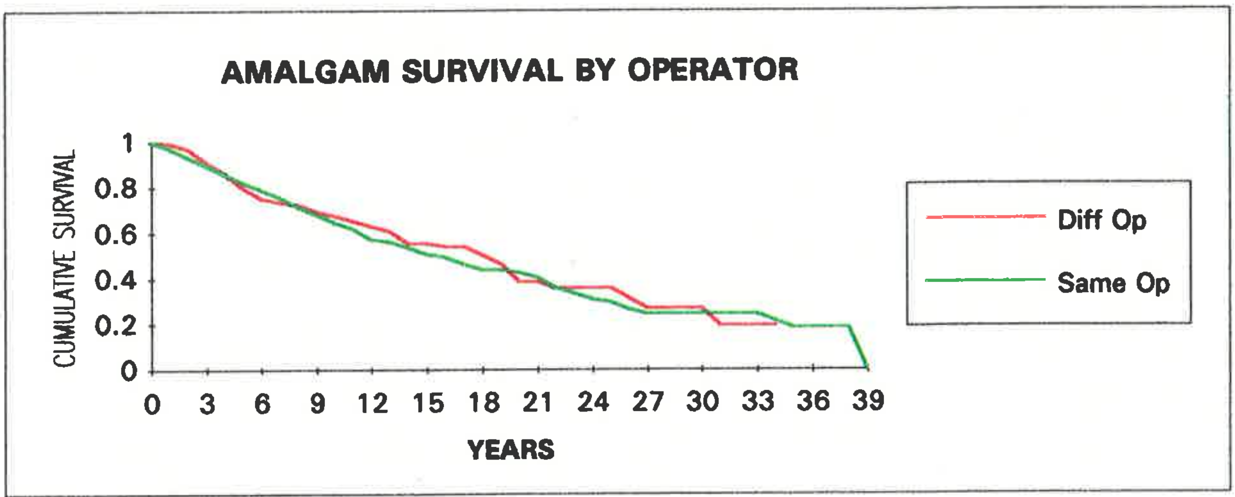
e.



MANTEL-COX = 10.36 df= 2 p= 0.01

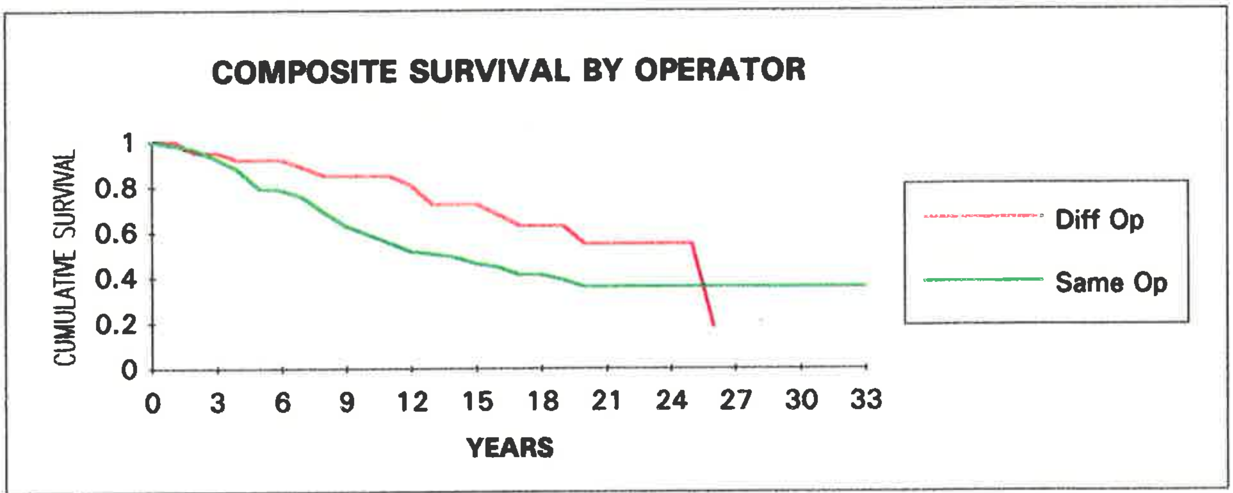
CHART 2 RESTORATION SURVIVAL - DIFFERENT vs SAME OPERATOR

a.



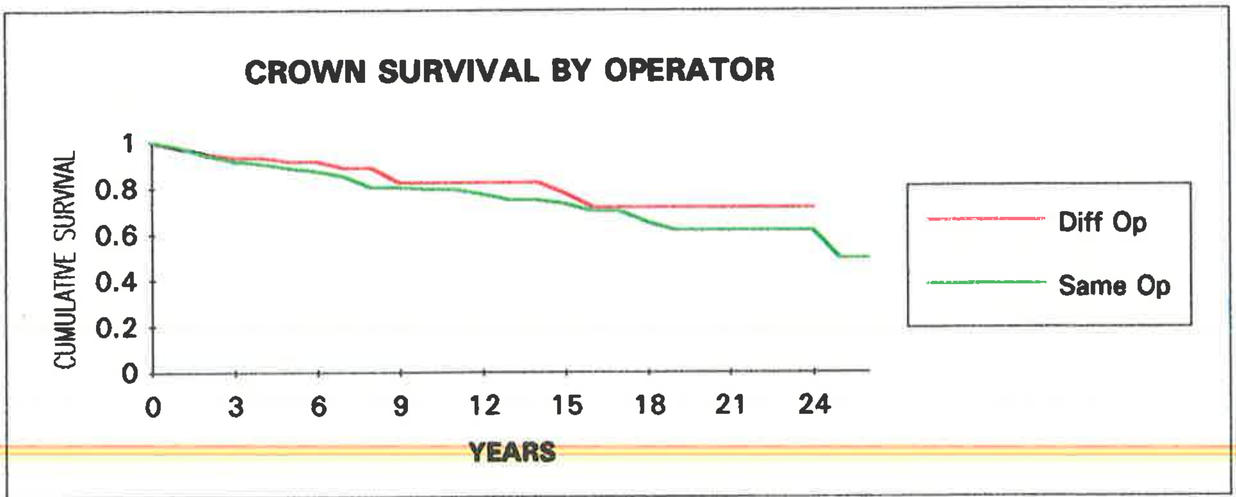
MANTEL-COX= 0.143 df= 1 p=0.71

b.



MANTEL-COX= 3.756 df= 1 p=0.05

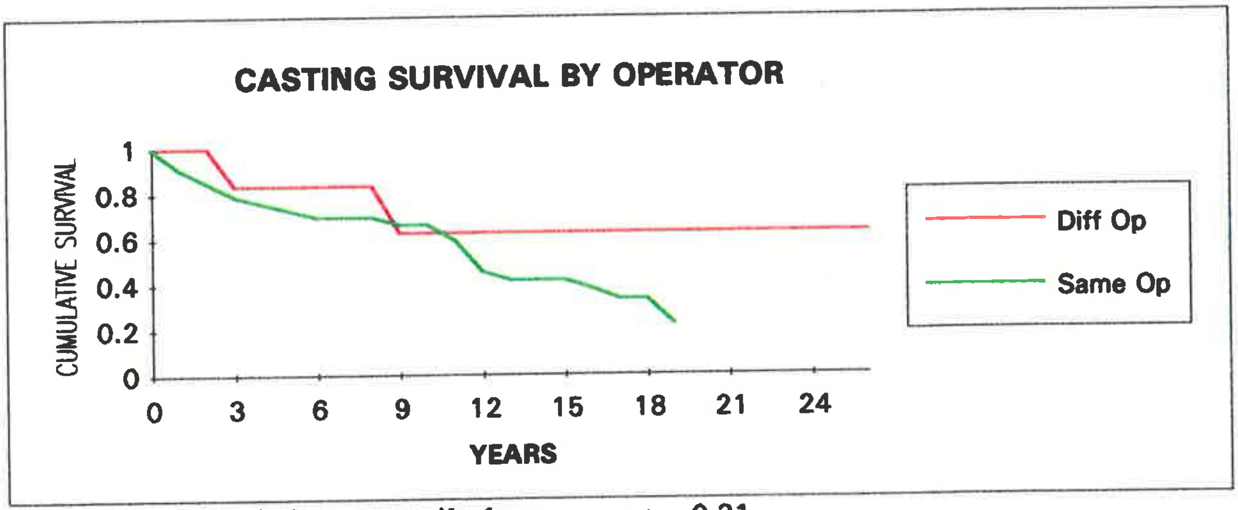
c.



MANTEL-COX= 0.698 df= 1 p= 0.40

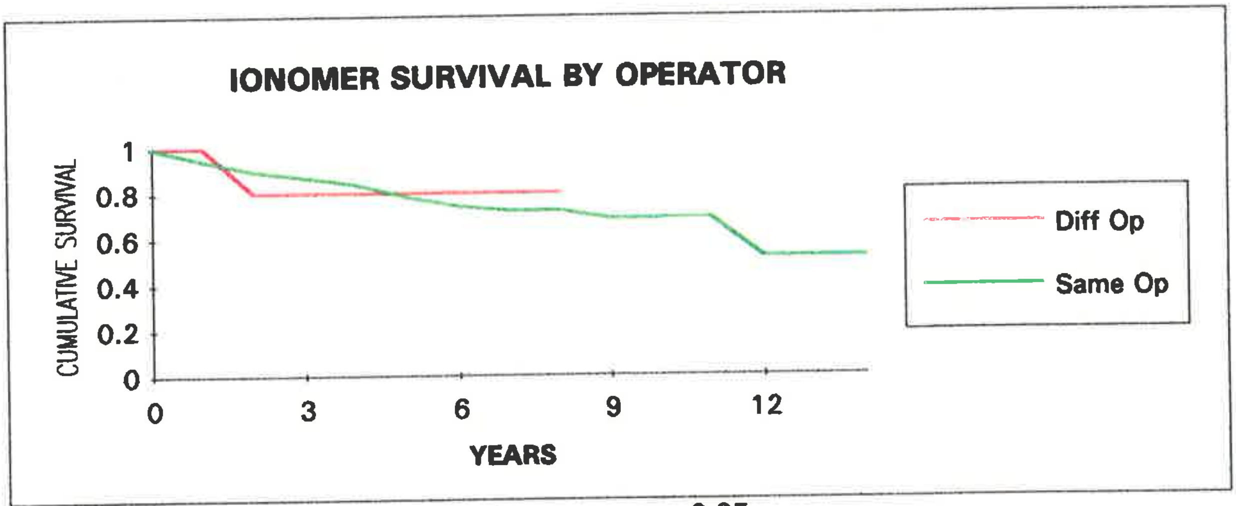
CHART 2 RESTORATION SURVIVAL - DIFFERENT vs SAME OPERATOR

d.



MANTEL-COX= 1.013 df=1 p= 0.31

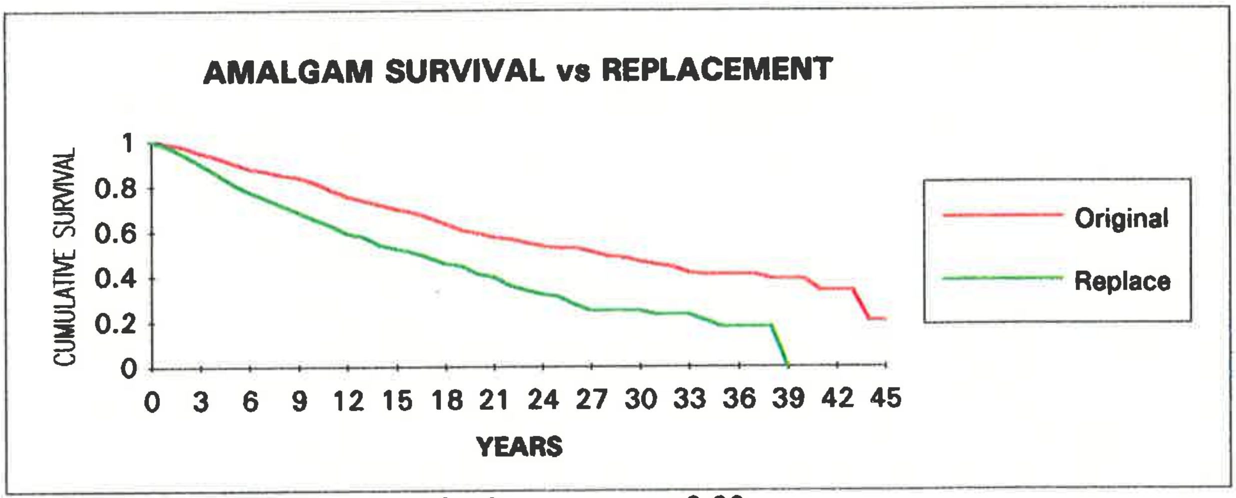
e.



MANTEL-COX= 0.004 df= 1 p= 0.95

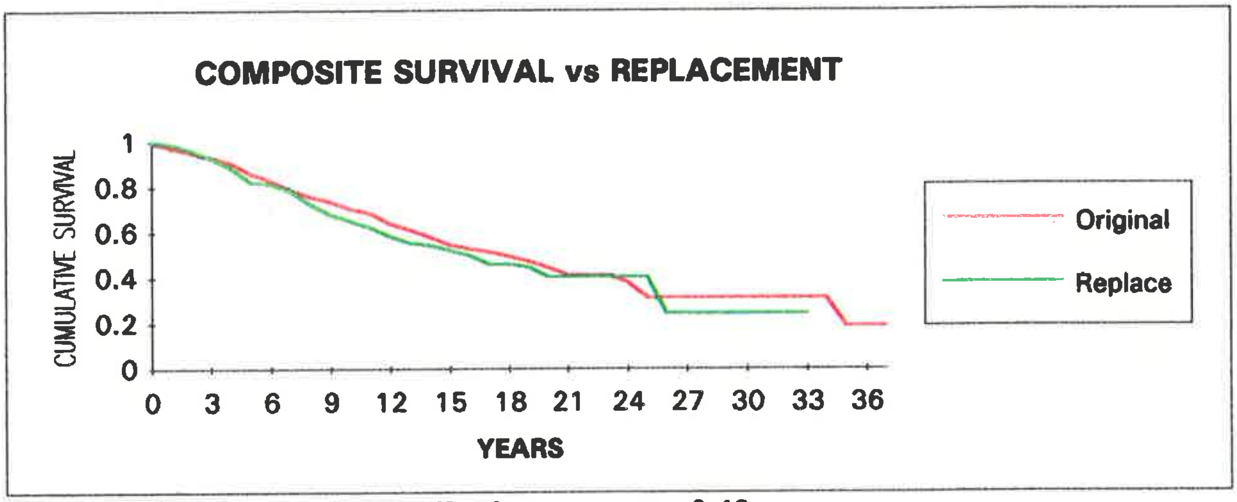
CHART 3 RESTORATION SURVIVAL - ORIGINAL vs REPLACEMENT

a.



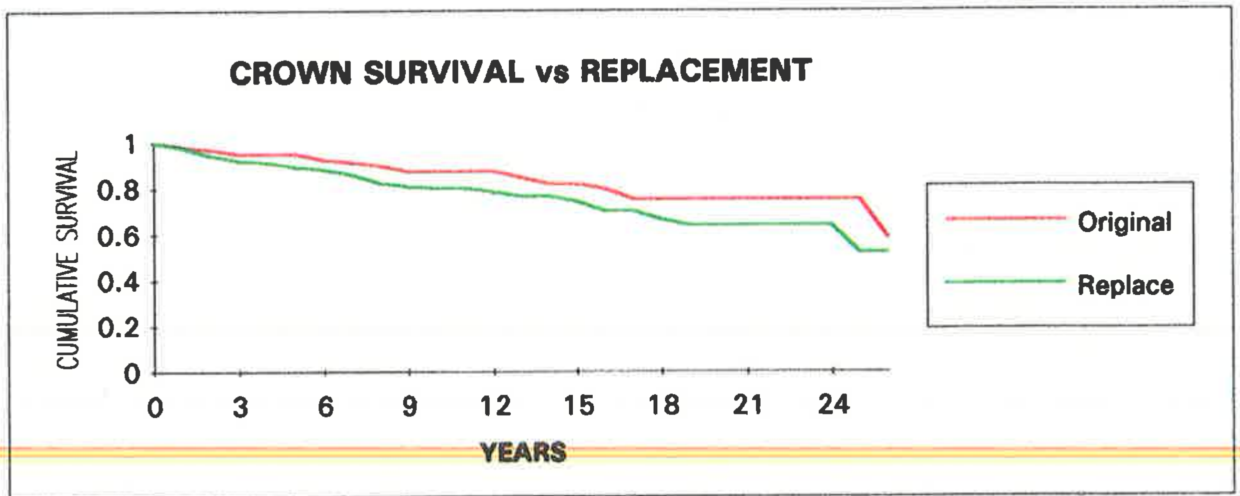
MANTEL-COX= 55.460 df= 1 p= 0.00

b.



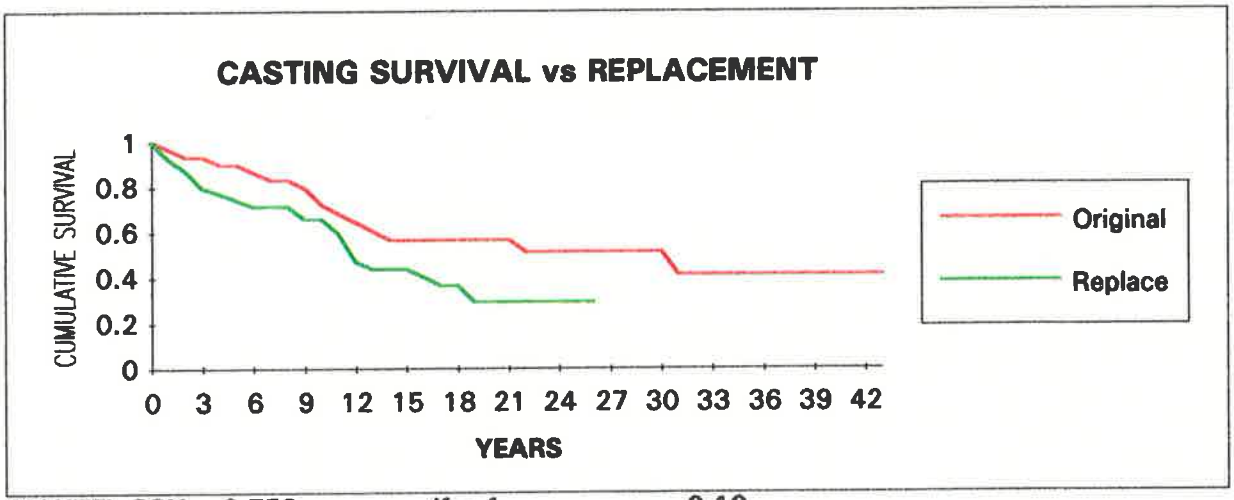
MANTEL-COX= 0.476 df= 1 p= 0.49

c.



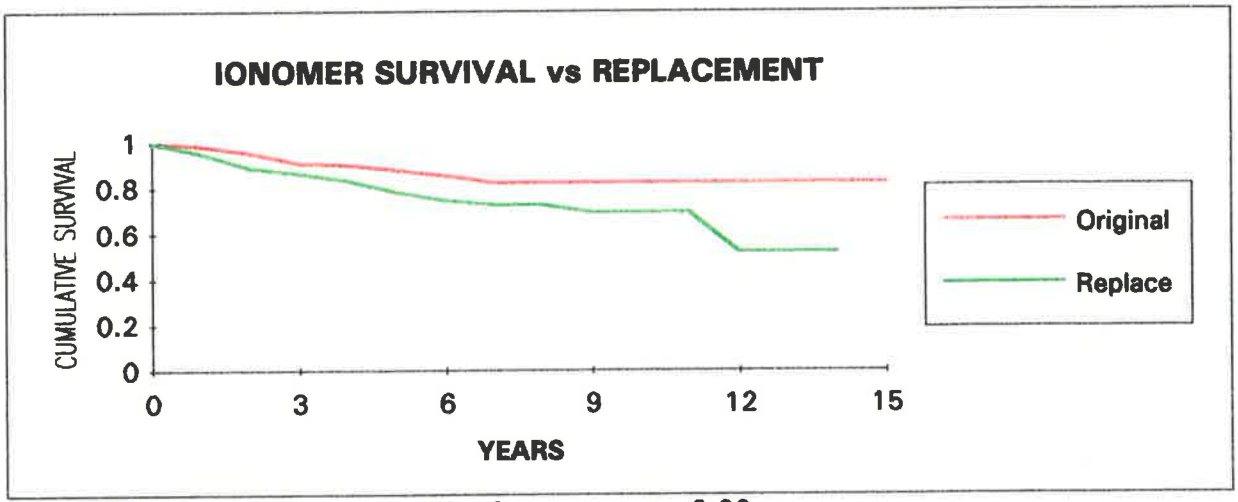
MANTEL-COX= 2.402 df= 1 p= 0.12

d.



MANTEL-COX= 2.753 df= 1 p= 0.10

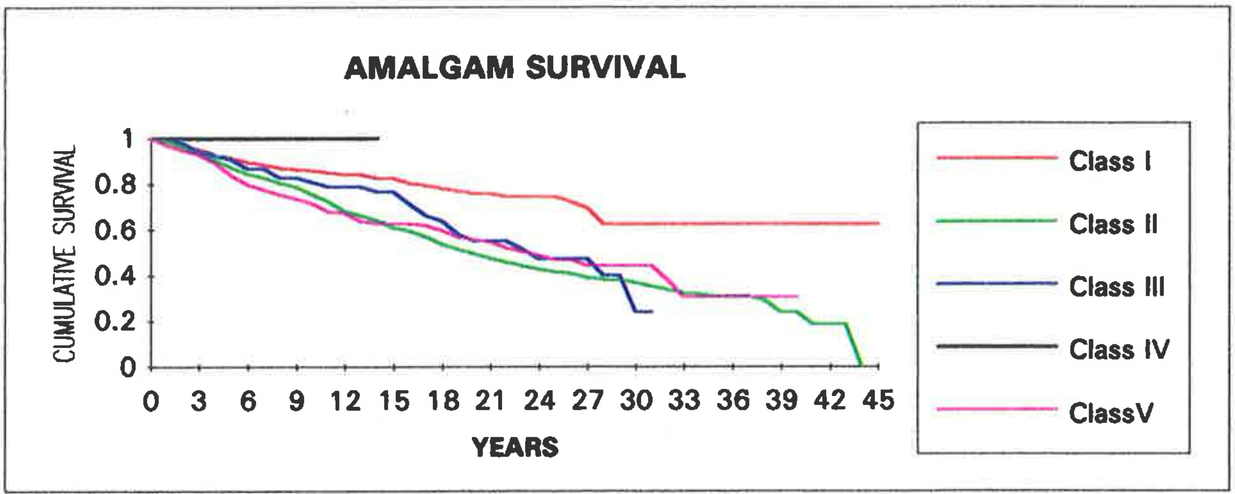
e.



MANTEL-COX= 5.380 df= 1 p= 0.02

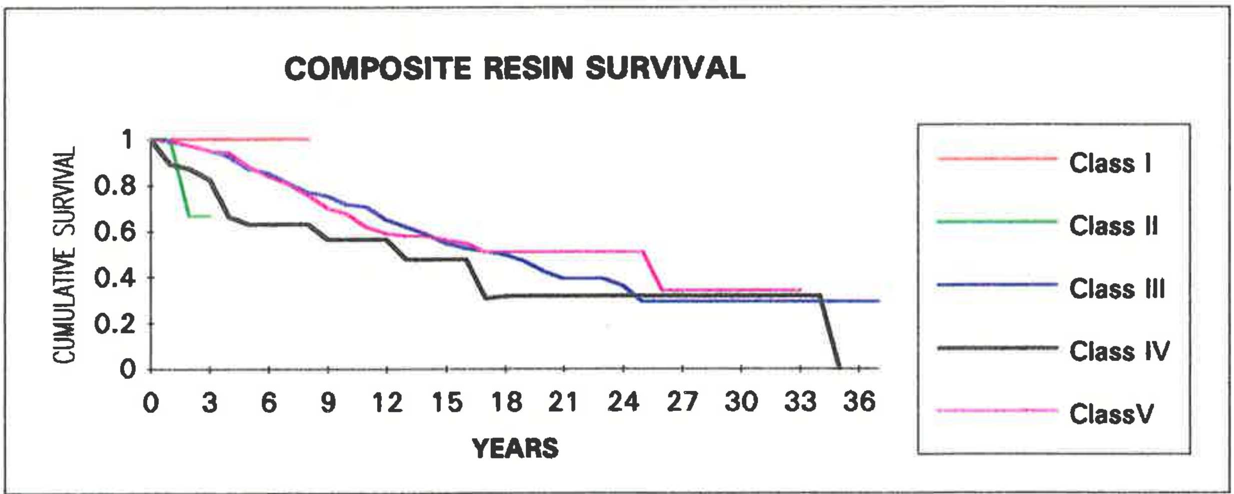
CHART 4 MATERIAL SURVIVAL by RESTORATION CLASS

a.



MANTEL-COX= 30.01 df= 4 p= 0.00

b.



MANTEL-COX= 13.86 df= 4 p= 0.01

c.

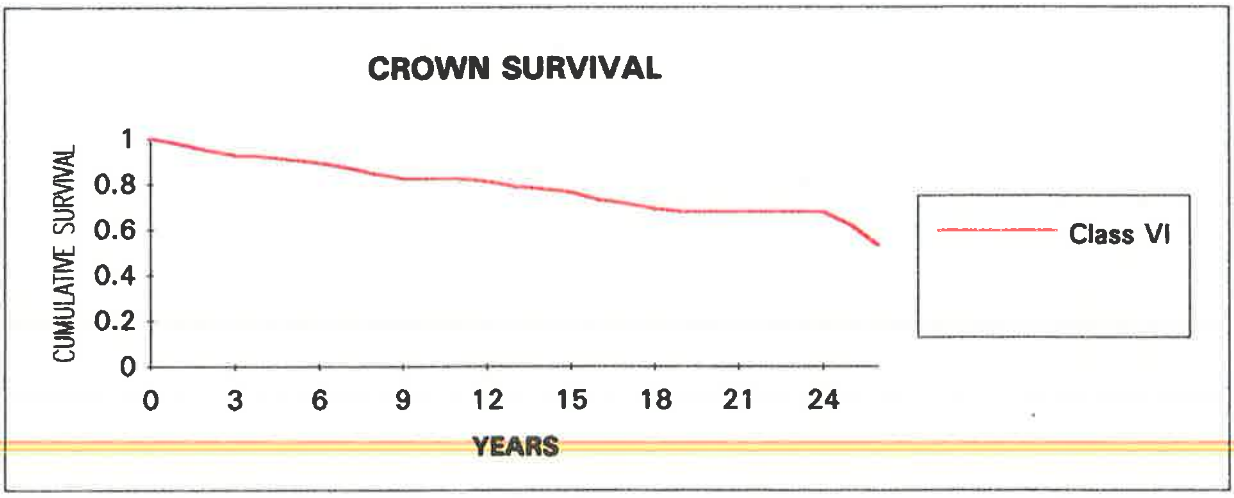
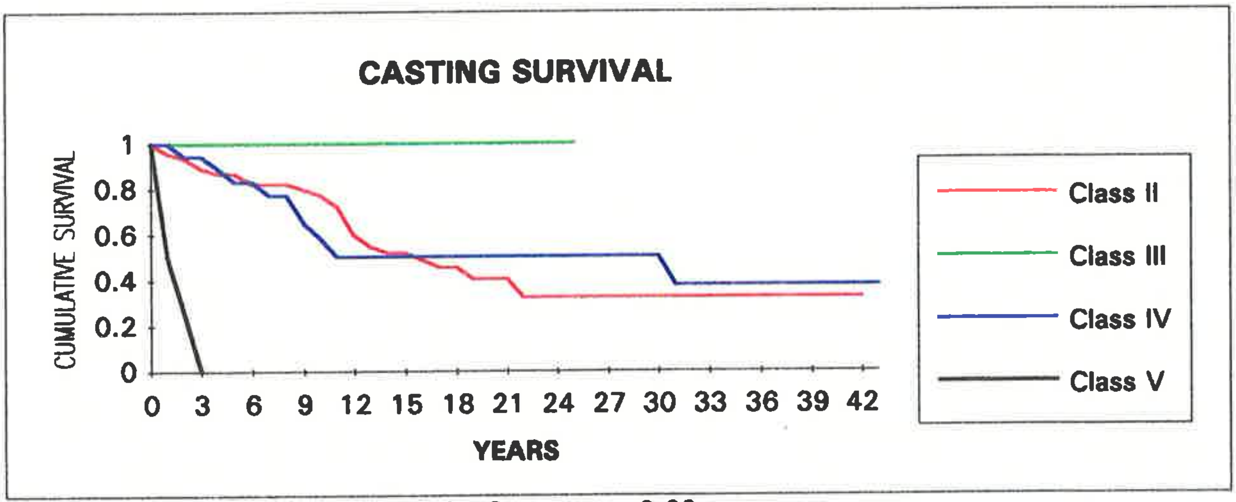


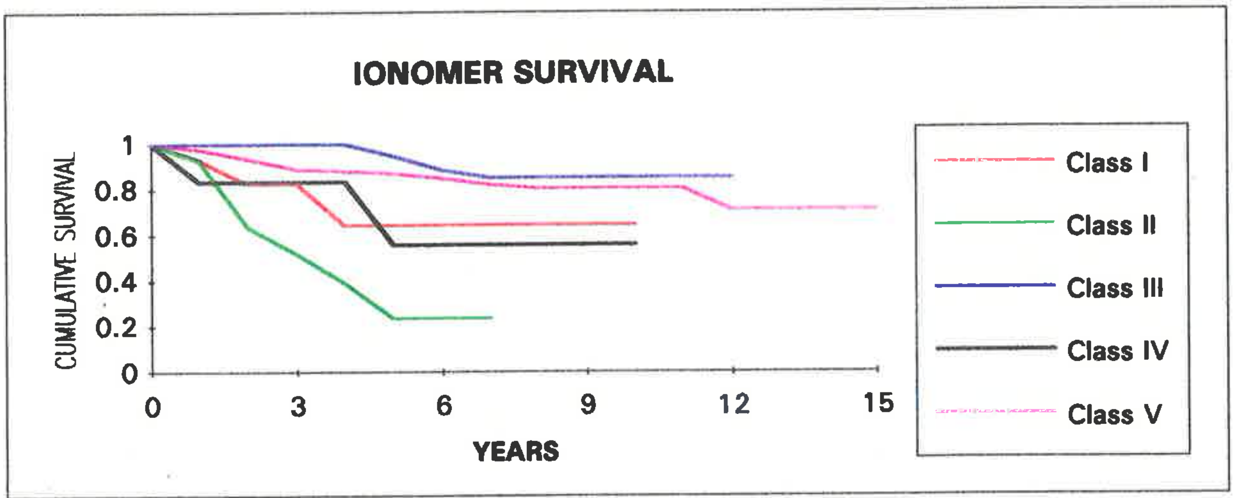
CHART 4 MATERIAL SURVIVAL by RESTORATION CLASS

d.



MANTEL-COX= 49.80 df= 3 p= 0.00

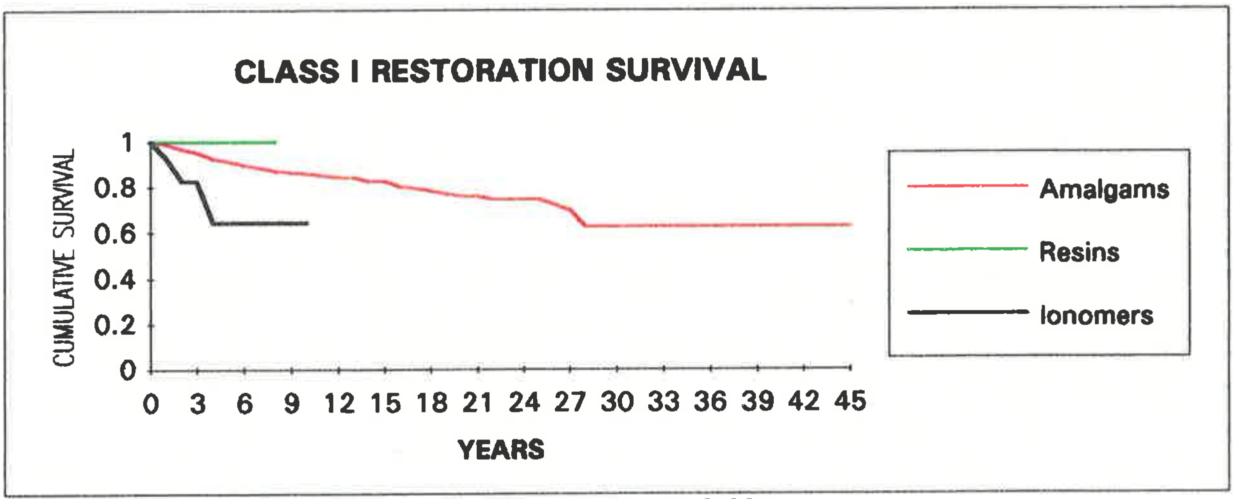
e.



MANTEL-COX= 33.92 df= 4 p= 0.00

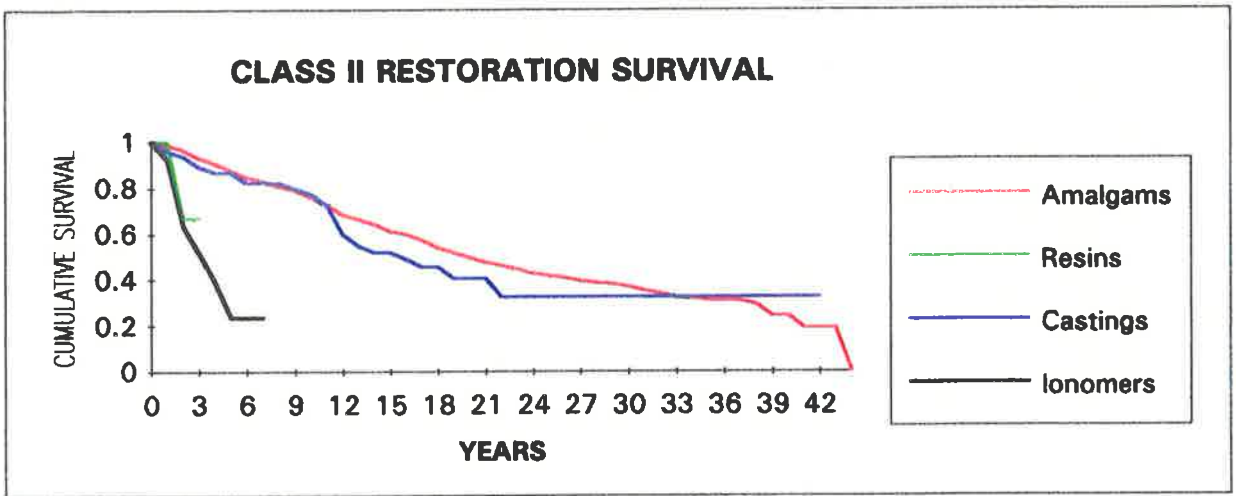
CHART 5 RESTORATION MATERIAL SURVIVAL by RESTORATION CLASS

a.



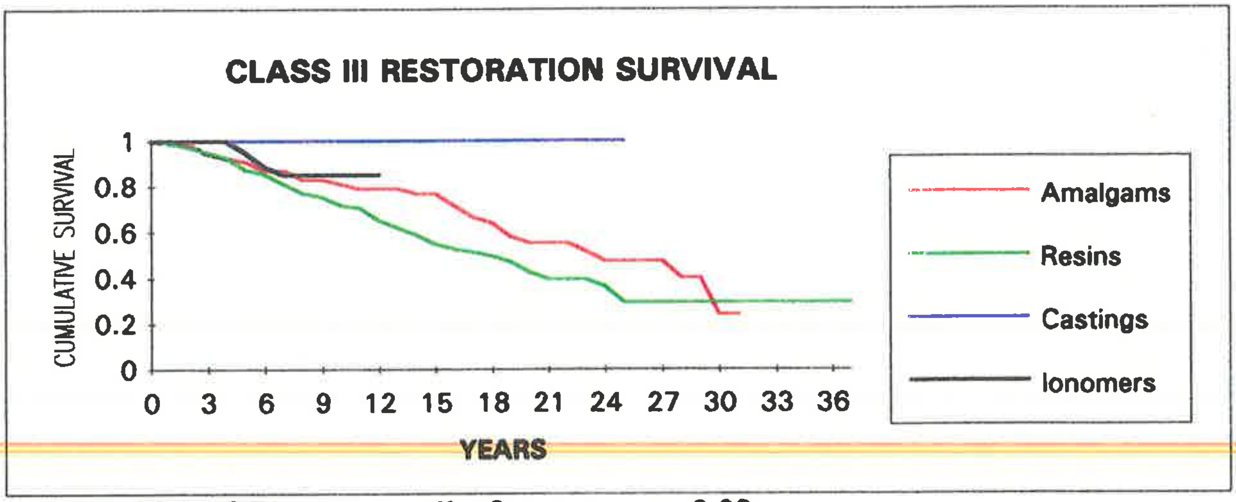
MANTEL-COX= 6.77 df= 2 p= 0.03

b.



MANTEL-COX= 48.82 df= 3 p= 0.00

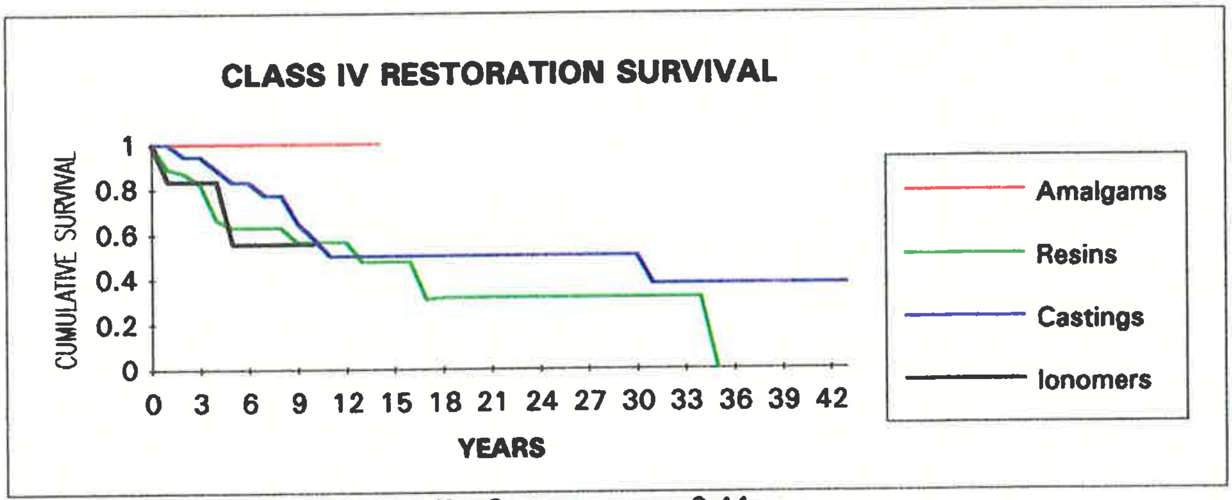
c.



MANTEL-COX= 6.71 df= 3 p= 0.08

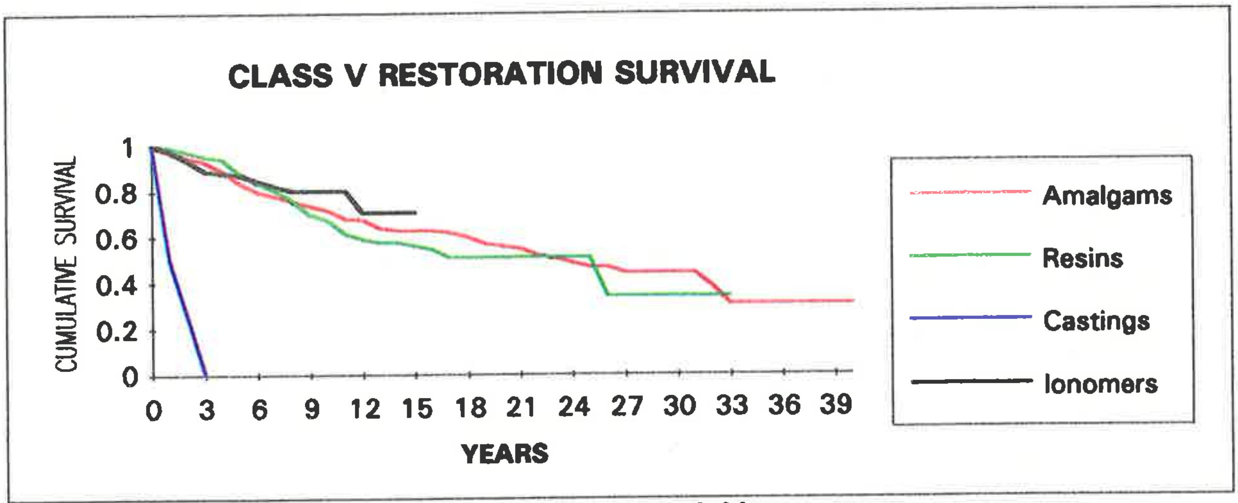
CHART 5 RESTORATION MATERIAL SURVIVAL by RESTORATION CLASS

d.



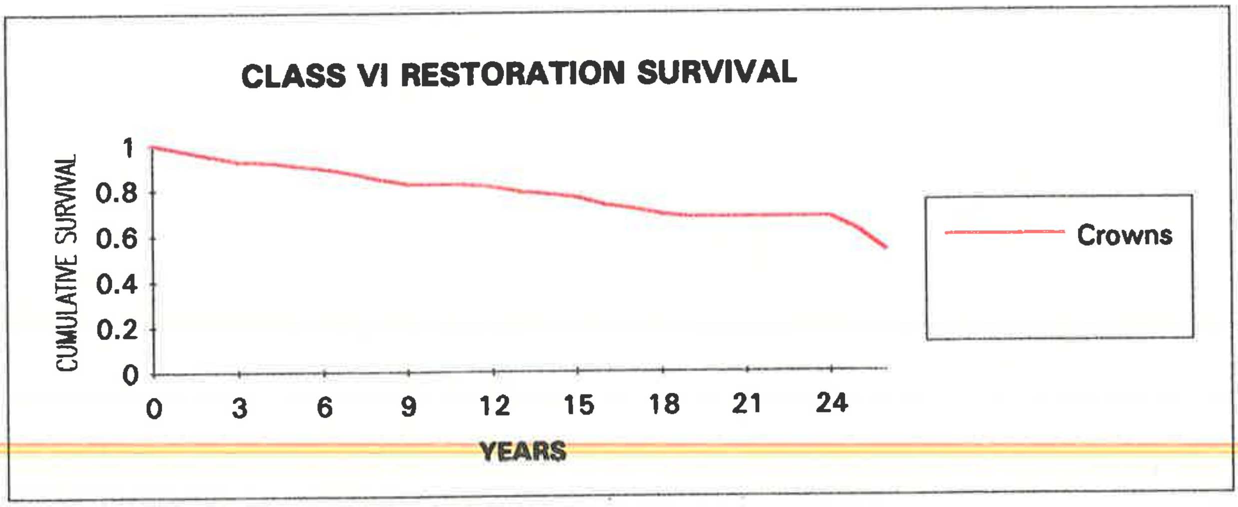
MANTEL-COX= 2.69 df= 3 p= 0.44

e.

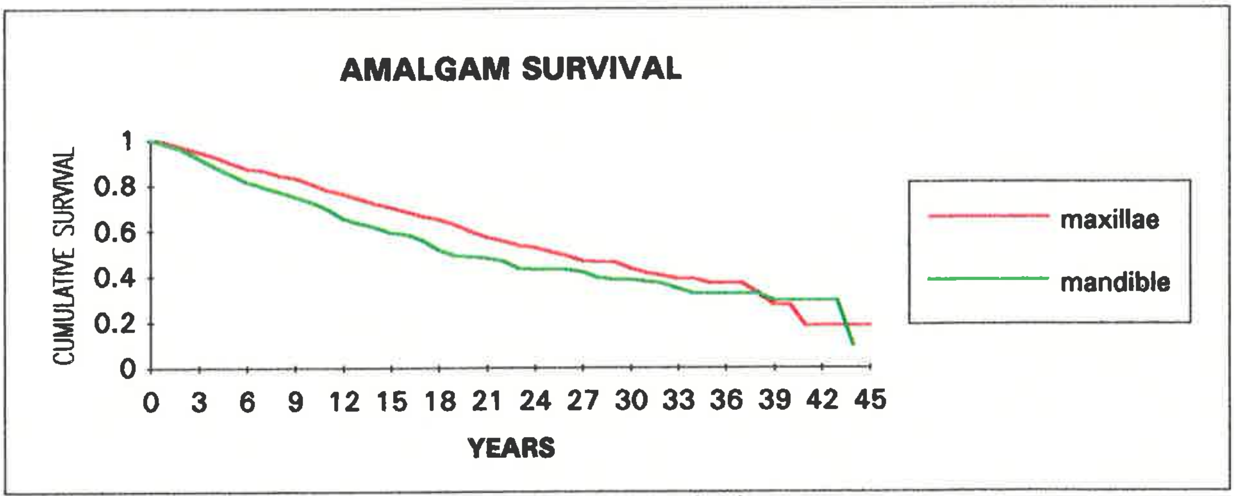


MANTEL-COX= 109.75 df= 3 p= 0.00

f.

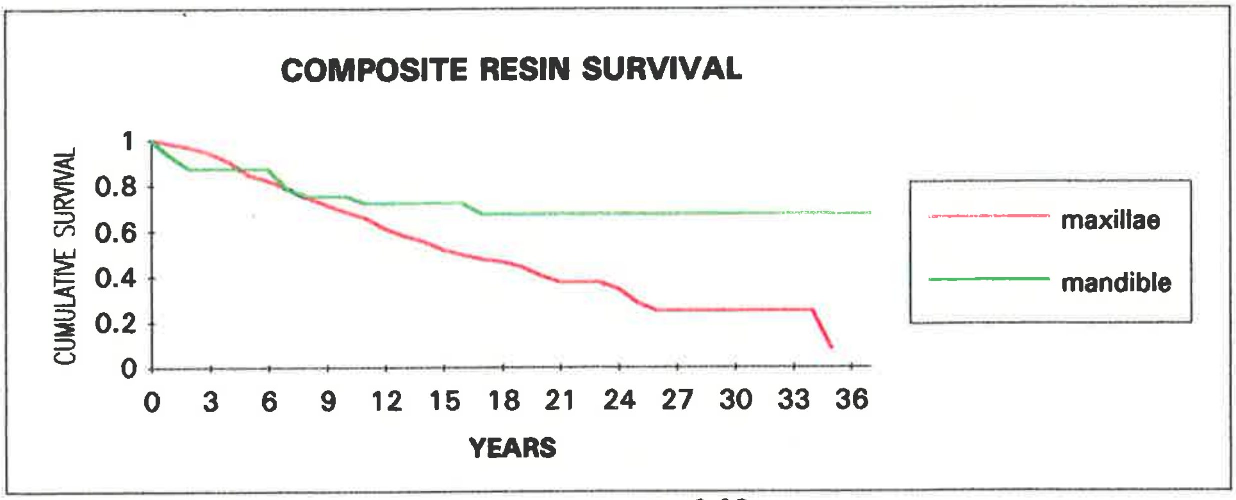


a.



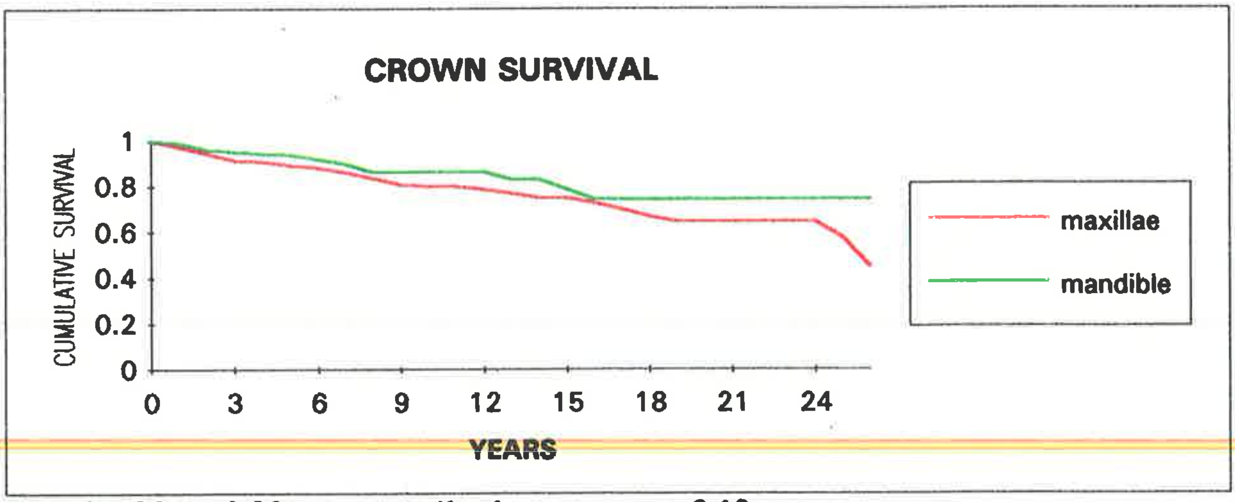
MANTEL-COX = 11.85 df = 1 p = 0.00

b.



MANTEL-COX = 5.01 df = 1 p = 0.03

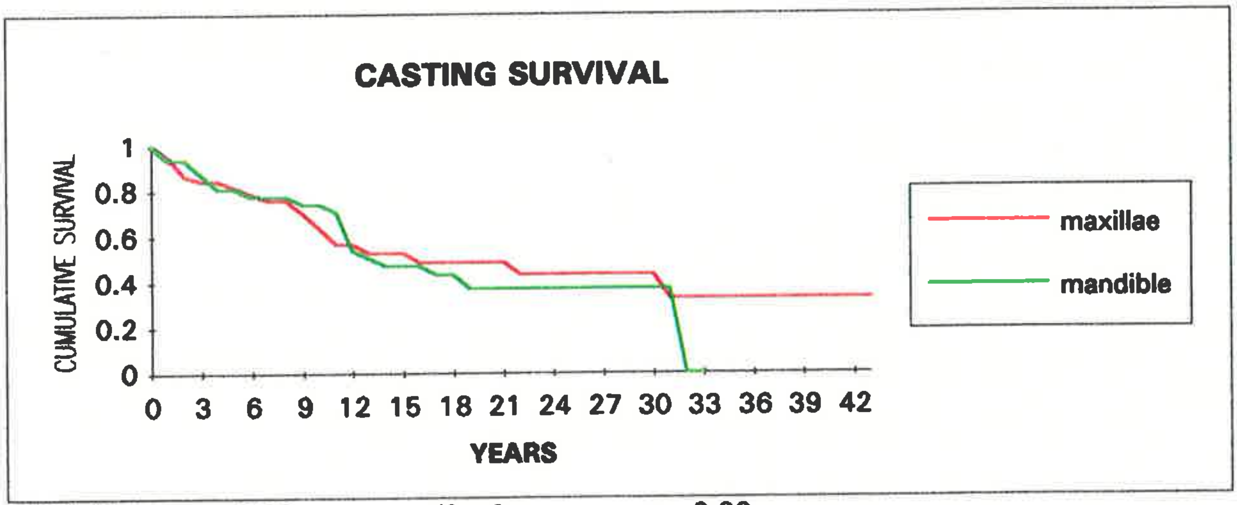
c.



MANTEL-COX = 2.26 df = 1 p = 0.13

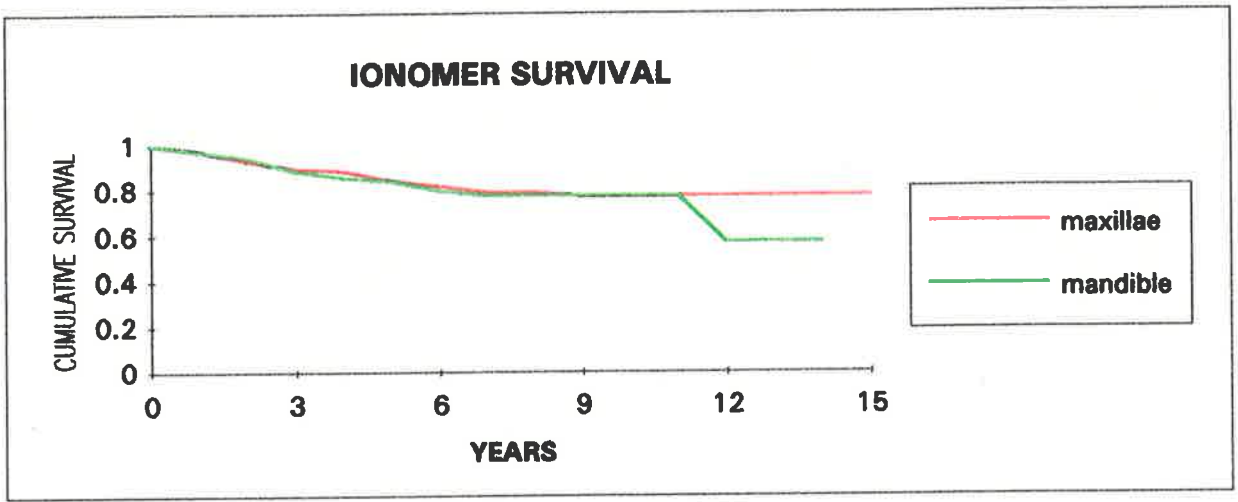
CHART 6 RESTORATION SURVIVAL by ARCH

d.



MANTEL-COX = 0.02 df = 1 p = 0.90

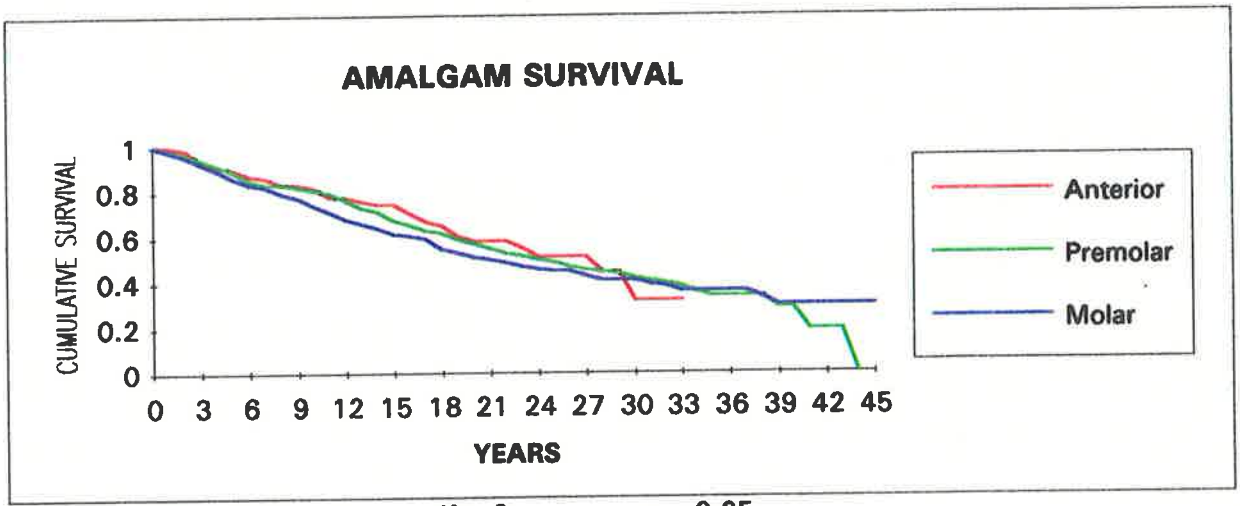
e.



MANTEL-COX = 0.32 df = 1 p = 0.57

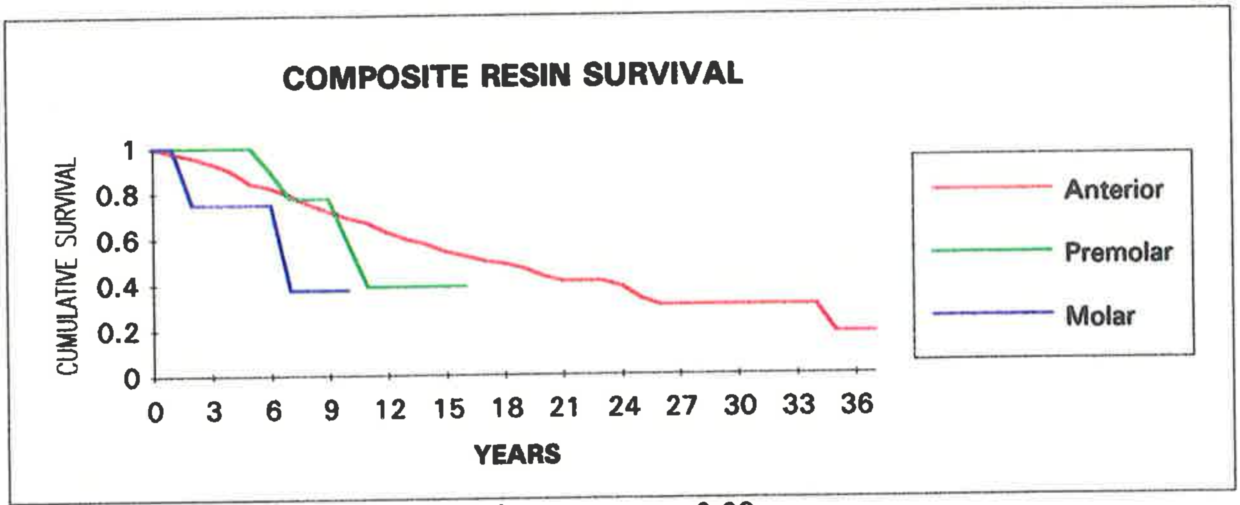
CHART 7 OVERALL RESTORATION SURVIVAL by TOOTH POSITION

a.



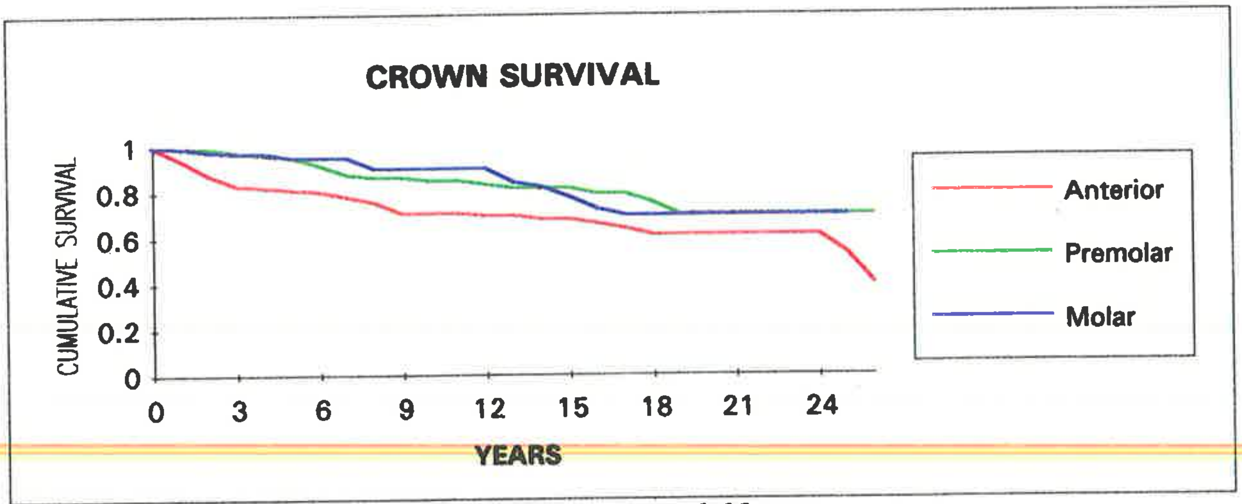
MANTEL-COX= 2.79 df= 2 p= 0.25

b.



MANTEL-COX= 2.51 df= 2 p= 0.28

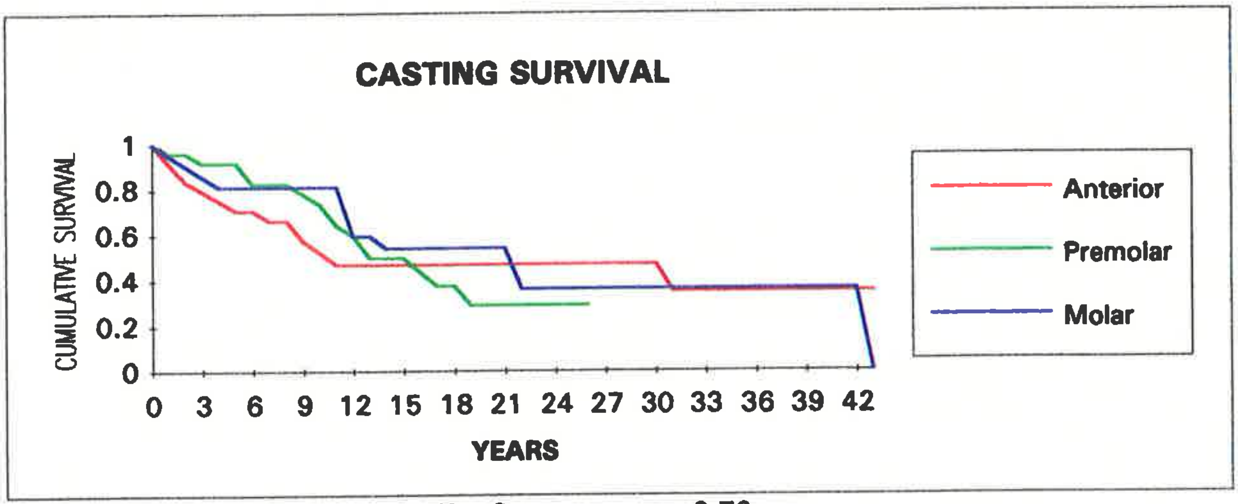
c.



MANTEL-COX= 11.36 df= 2 p= 0.00

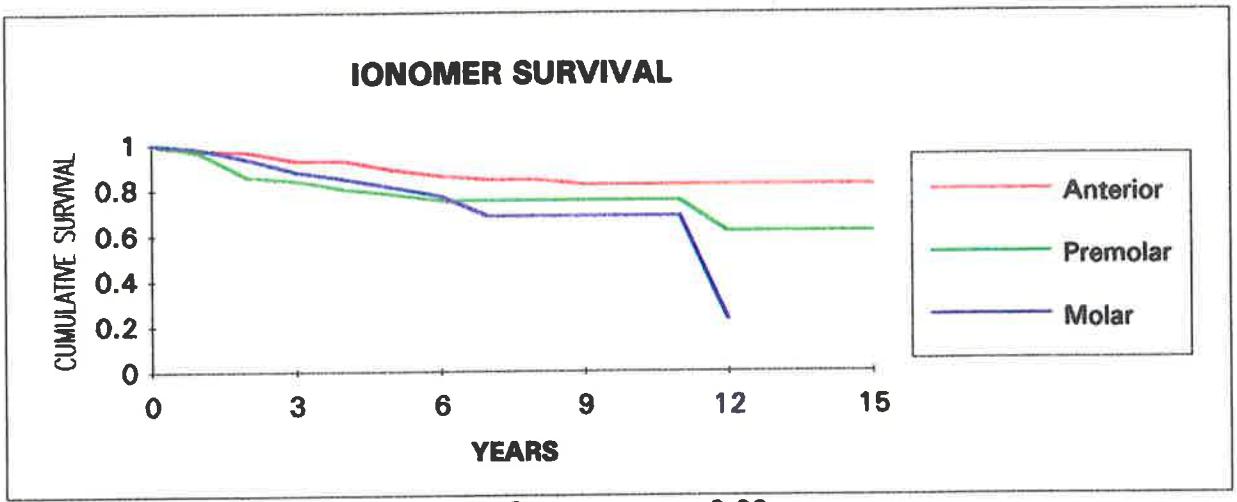
CHART 7 OVERALL RESTORATION SURVIVAL by TOOTH POSITION

d.



MANTEL-COX= 0.66 df= 2 p= 0.72

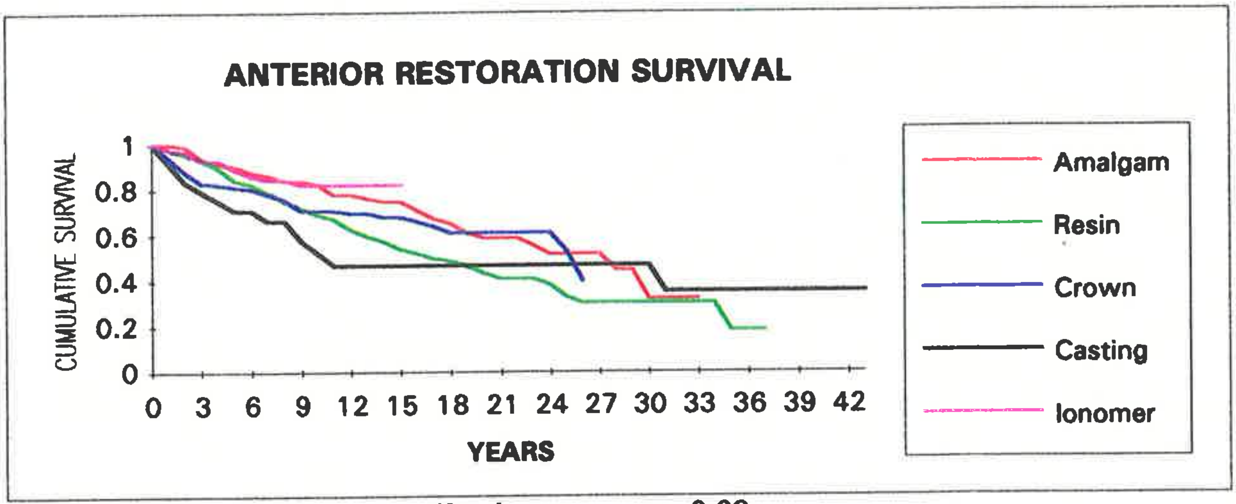
e.



MATEL-COX= 4.91 df= 2 p= 0.09

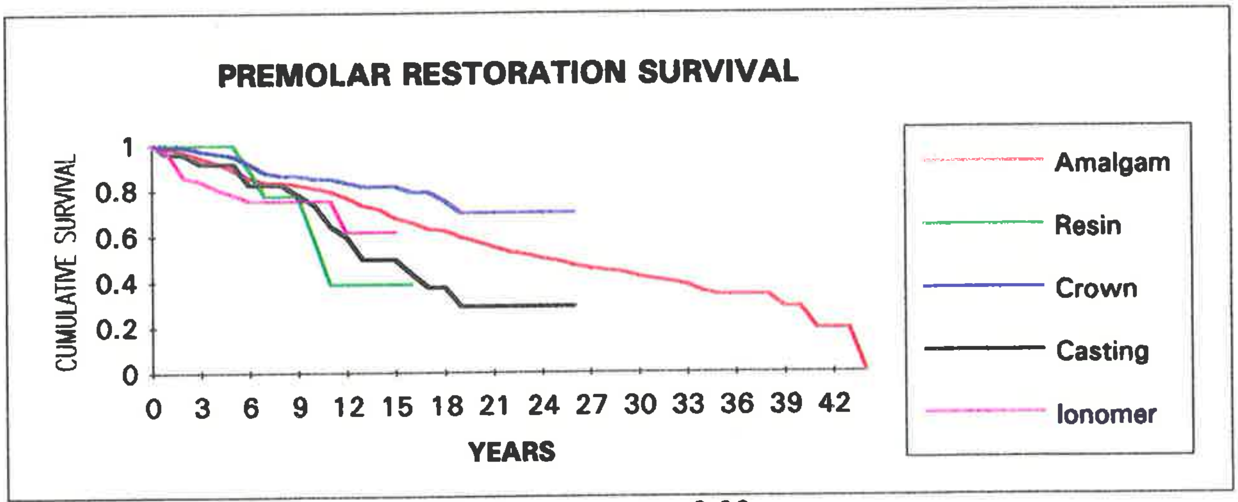
CHART 8 RESTORATIVE MATERIAL SURVIVAL by TOOTH POSITION

a.



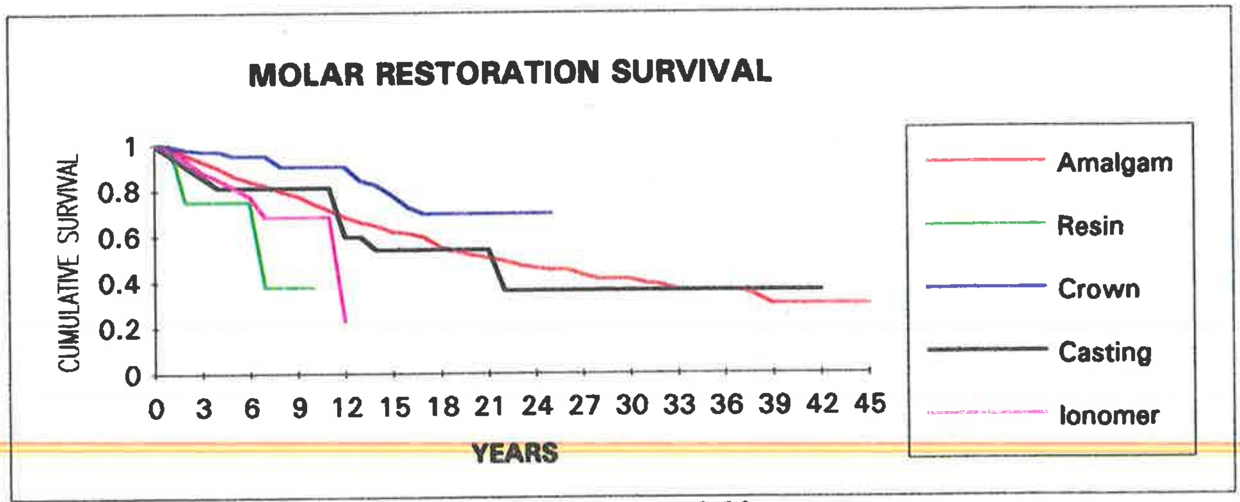
MANTEL-COX = 10.55 df = 4 p = 0.03

b.



MANTEL-COX = 17.43 df = 4 p = 0.00

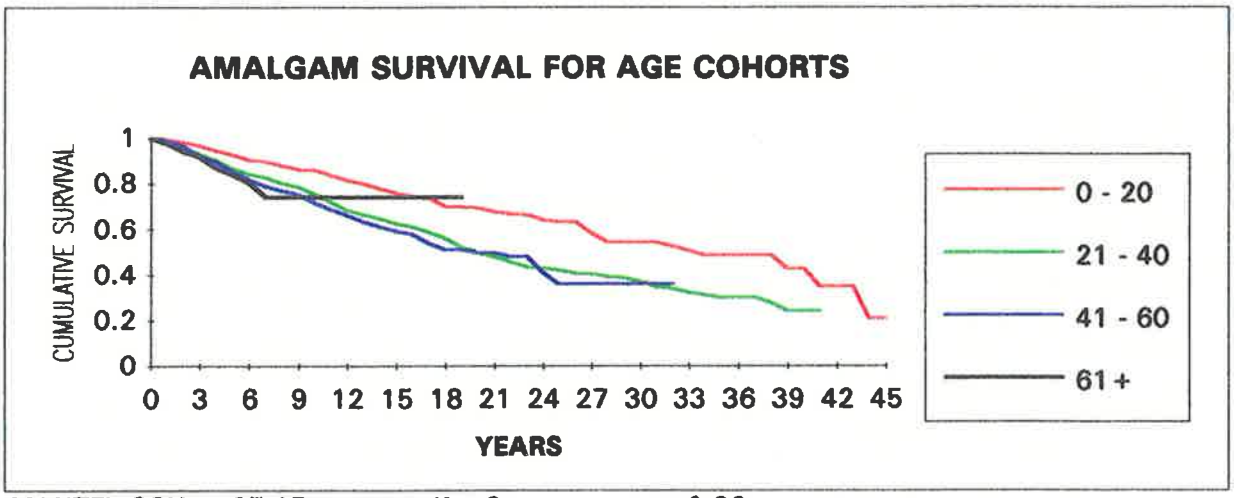
c.



MANTEL-COX = 18.45 df = 4 p = 0.00

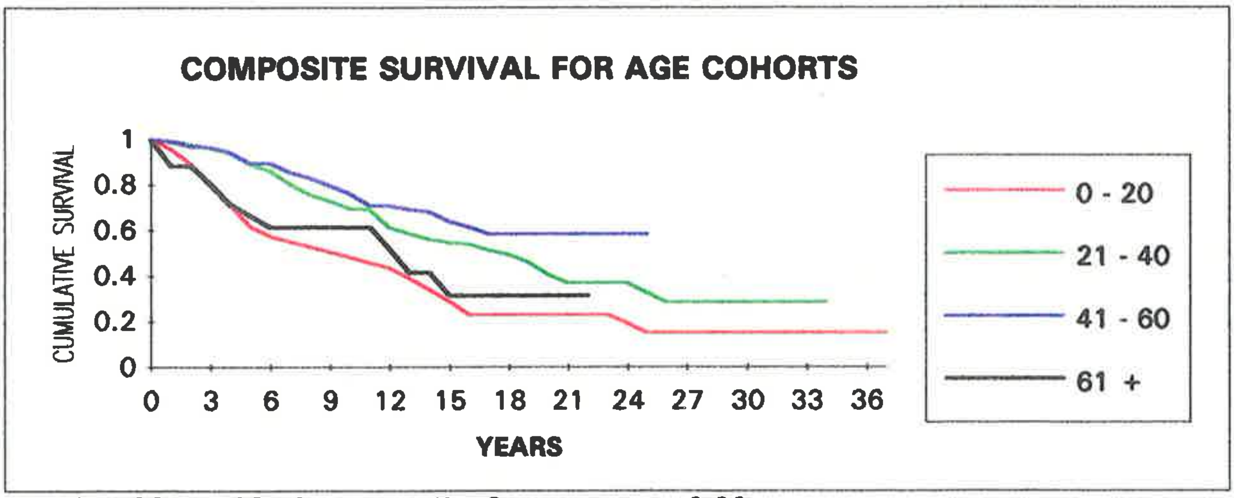
CHART 9 MATERIAL SURVIVAL by AGE COHORTS

a.



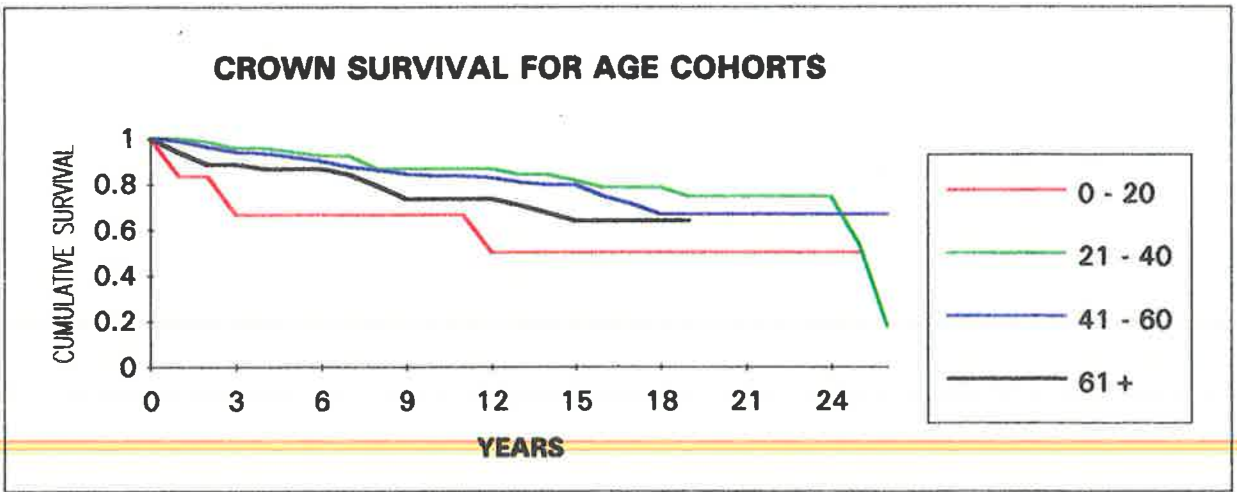
MANTEL-COX = 27.15 df = 3 p = 0.00

b.



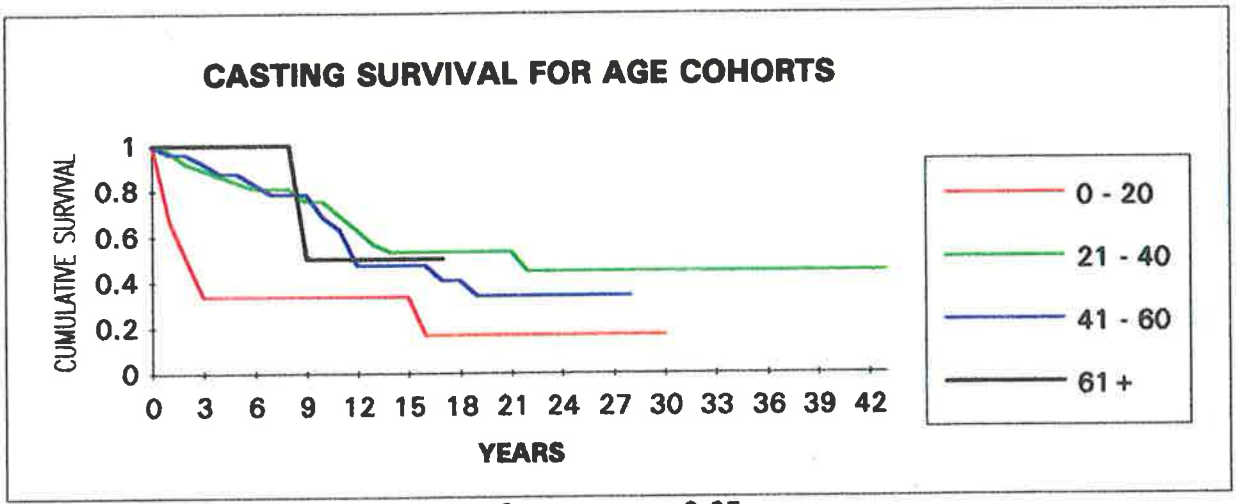
MANTEL-COX = 26.49 df = 3 p = 0.00

c.



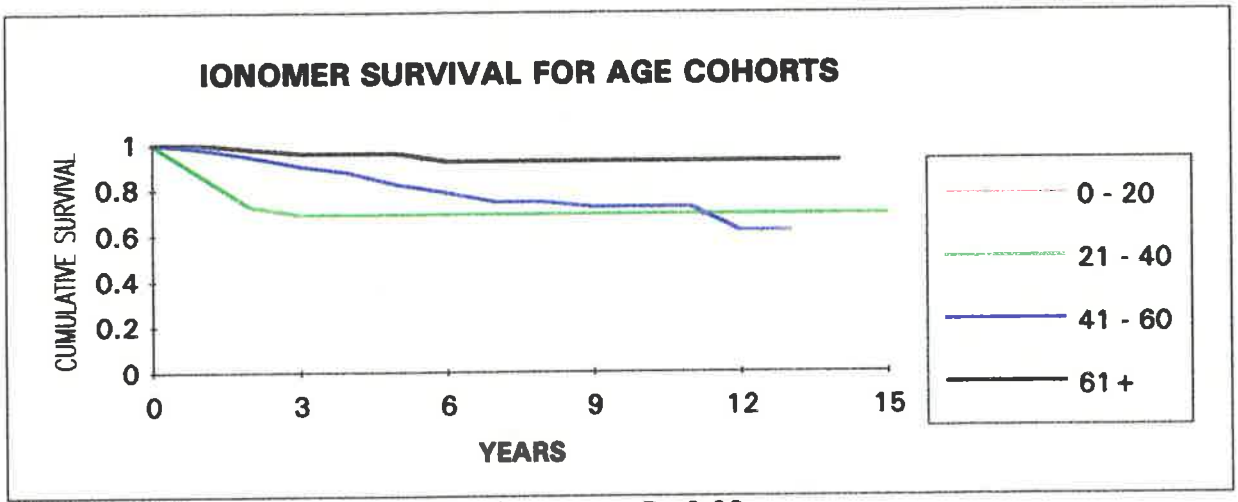
MANTEL-COX = 4.84 df = 3 p = 0.18

d.



MANTEL-COX = 7.93 df = 3 p = 0.05

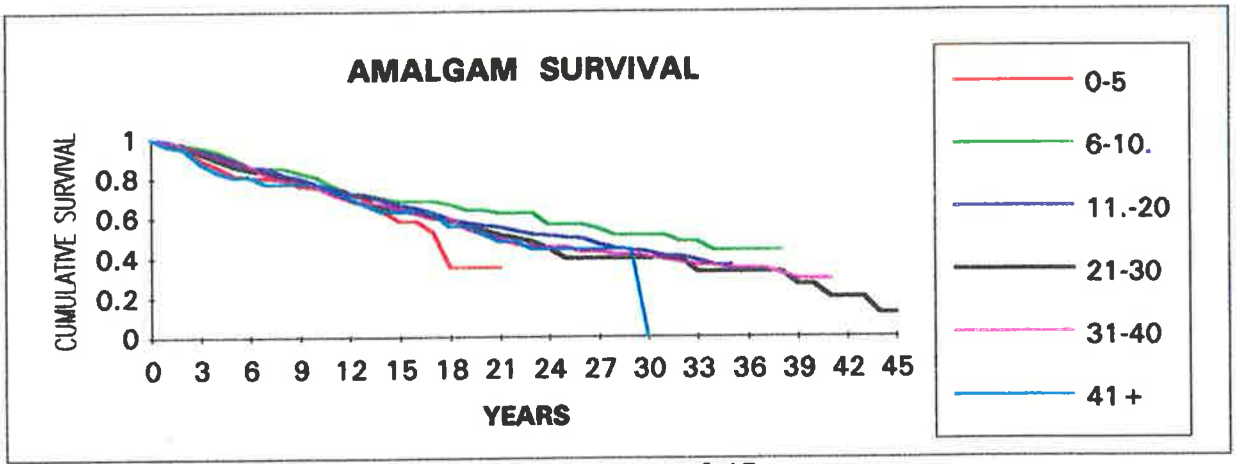
e.



MANTEL-COX = 8.21 df = 2 P = 0.02

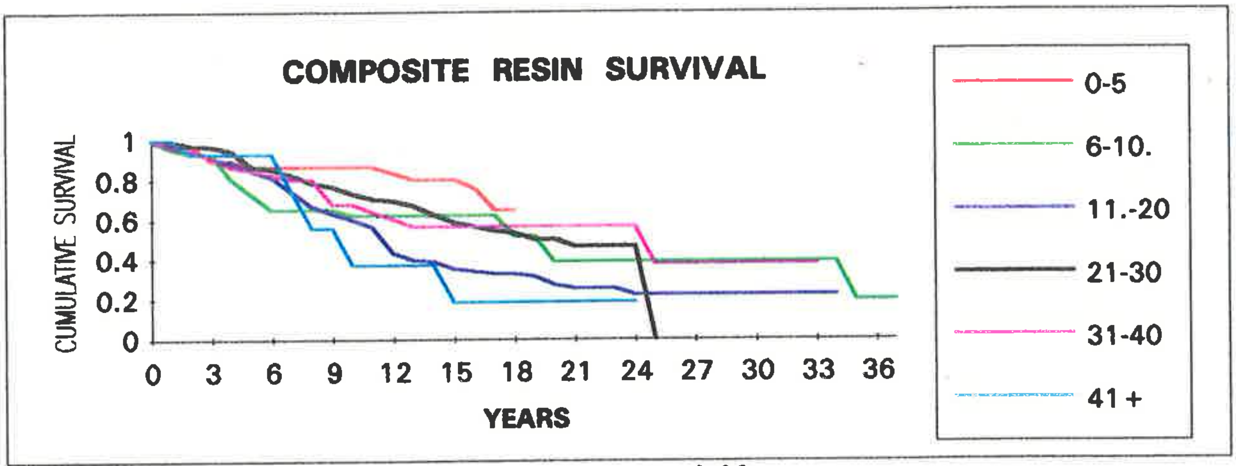
CHART 10 EXPERIENCE OF DENTIST vs RESTORATION SURVIVAL

a.



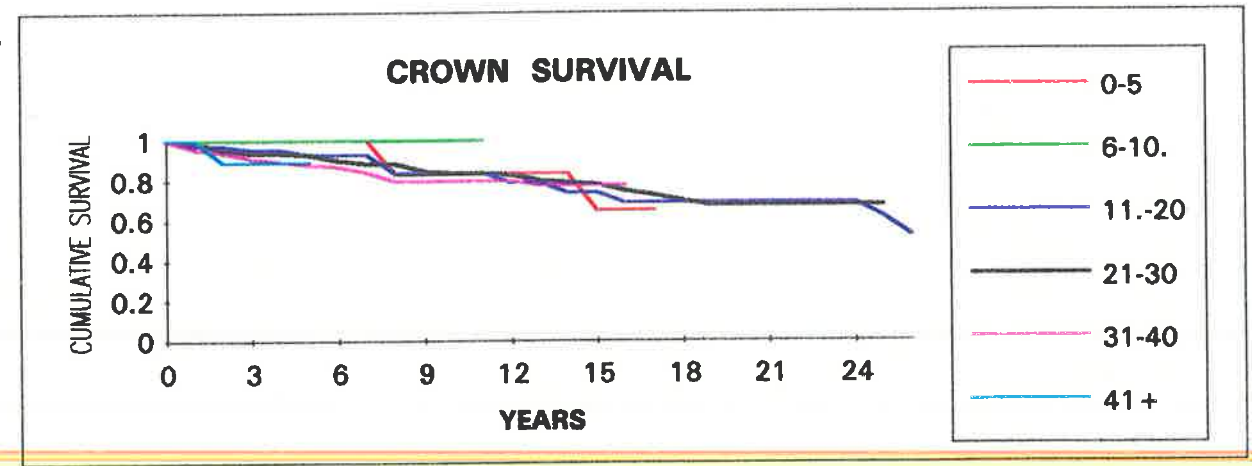
MANTEL-COX= 8.06 df= 5 p= 0.15

b.



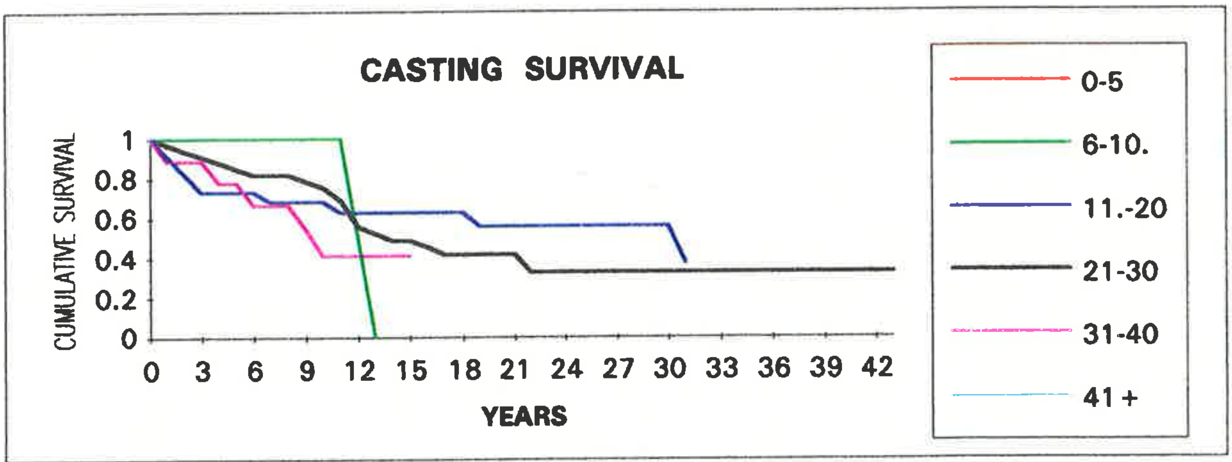
MANTEL-COX= 17.52 df= 5 p= 0.00

c.



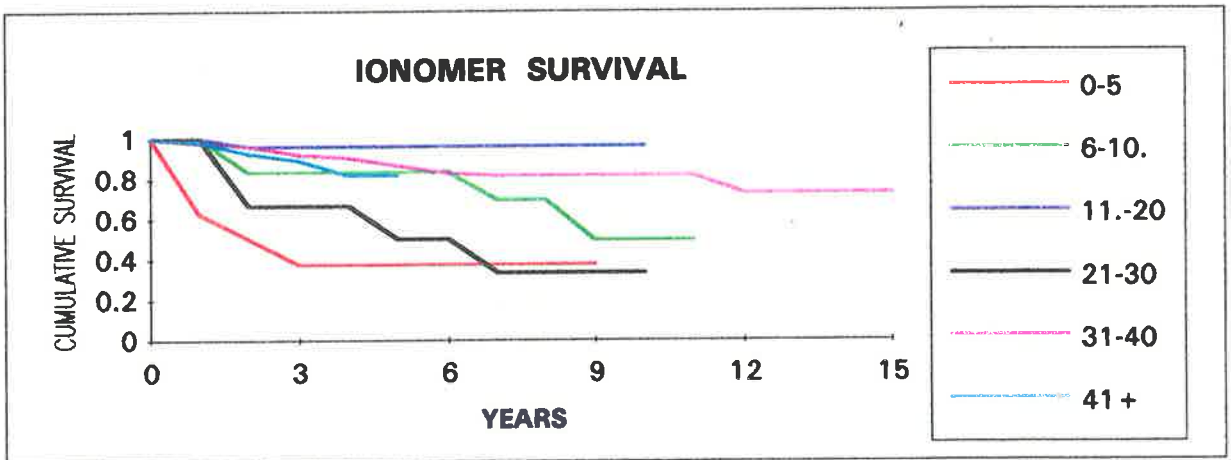
MANTEL-COX= 3.38 df= 5 p= 0.64

d.



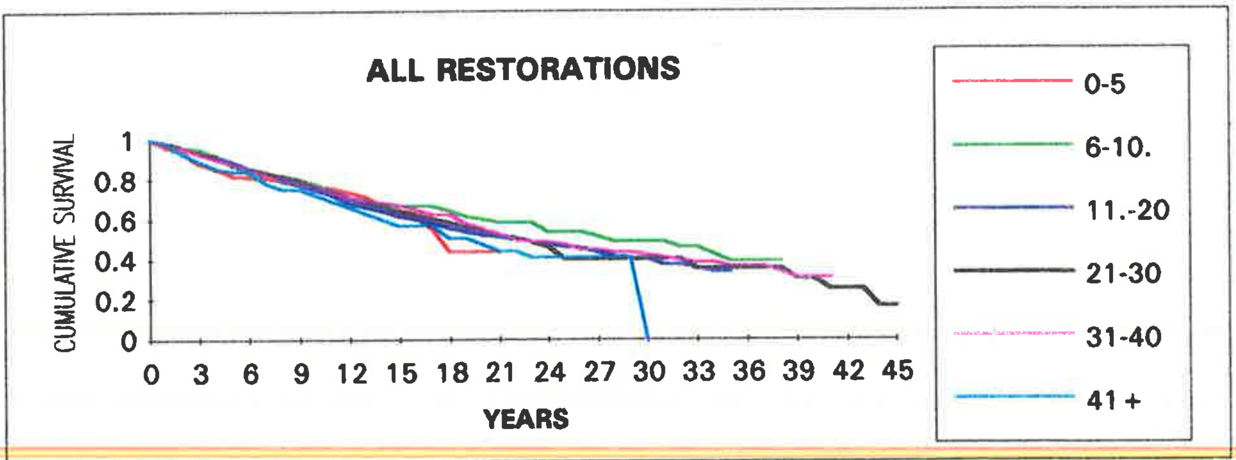
MANTEL-COX = 2.21 df = 5 p = 0.82

e.



MANTEL-COX = 30.81 df = 5 p = 0.00

f.



MANTEL-COX = 5.30 df = 5 p = 0.38

CHAPTER SIX:
CHANGES IN DENTAL HEALTH

6.1 STATISTICAL METHODS

Changes in Dental Health were determined by examining the four indices of DMFT, DMFS and T-Health (for both teeth and surfaces). The weighting used for the T-Health analyses were the same as those used by Sheiham et al.(1987), Dawson (1989) and Mahmood (1991); these being 4 x sound teeth, 2 x filled teeth and 1 x decayed teeth. Although Marcenes and Sheiham (1993) have subsequently modified these weightings to reflect a value of 1 x for filled teeth, this latest weighting was not used in the present research project as it would have prevented direct comparison with the results of Dawson (1989) and Mahmood (1991).

In the analysis, a linear regression routine was used to determine the slope of the line that best depicted the rate of change (ß) in dental health for the study population. This linear regression model determined the beta (ß) co-efficient and the standard error for beta for each of the measured variables. Therefore, using this model, beta (ß) could be used to determine the rate of change in dental health and what effects, if any, the test variables had on an individual's dental health status. Comparisons of the ß-coefficients between the study groups was accomplished by one way analyses of variance (ANOVA) with the reciprocal of the standard error of the test variables being used as the weighting variable.

6.2 DENTAL HEALTH CHANGES

Before any calculations were performed, the baseline dental health values were established, and are shown in Table 8. The baseline dental health values suggested similar DMF indices for males and females, but with increasing values with age. With increasing age, there was a decrease in decayed and sound surfaces, with a concomitant increase in missing and filled surfaces. The T-Health indices also suggested a deterioration in dental health with increasing age.

Table 9 shows the restorations present at the start of the study. Due to incomplete historical data, these figures are likely to be a gross under-estimation of what actually existed. However, as explained in Section 4.3.2.1, little could be done to avoid this, and the effects of the limited baseline data documentation available was circumvented by only analyzing changes in dental health over time. The restorations that were placed during the study period are presented in Table 10.

For the four health variables studied, the mean beta (ß) scores and standard errors for determining ß are represented in Table 11, while the mean ß scores for each of the test variables evaluated are shown in Table 12. This table shows statistically significant relationships (at the 1% level) between:

a. patient age and rate of change in DMFT and T-Health,
b. the three practices and rate of change in DMFT and T-Health, and
c. the number of changes in dentists and rate of change in DMFT and T-Health.

The cohorts involved in determining the effect that the number of changes in operator had on the rate of change in dental health were;

a. zero (0) changes,
b. 1-5 changes,
c. 6-10 changes,
d. 11-15 changes, and
e. 16+ changes.

6.3 CHANGE IN OPERATOR

The effect that change in dentist had on the dental health of a patient was investigated under the test variables outlined in Table 13. Of a total of 3596 examinations, 2828 examinations were performed by the dentist who last saw the patient, while 668 of these were performed by different dentists. This leaves a deficit of 100 visits, which constitutes the initial visit of the 100 study patients. The number of dentist changes for any particular patient ranged between 0 to 21, with a mean of 3.4 changes and a standard deviation of 4.1. The change of dentist had no statistically significant effect on the dental health of a patient at the 1% level; although there was a significant relationship between change of dentist and DMFT at the 5% level, with the patients who changed dentists having lower scores.

6.4 FREQUENCY OF ATTENDANCE

Unlike the research project of Dawson (1989) there were no two groups of patients within the study that displayed any statistically significant difference with regards to examination frequency. Therefore, the present study population was considered as a whole and the intervals between consecutive examinations were categorized as being ≤ 1 year, or > 1 year. Overall, approximately 85% of all the 3496 recall examinations were classified as frequent (≤ 1 year), while around 75% of all examinations were nine months and 50% were only six months apart. The interval between examinations ranged from 0.1 to 7.8 years with a mean of 0.7 years and standard deviation of 0.6 years. The attendance frequency had no statistically significant effect on dental health, as shown in Table 14.

Table 8: Baseline Dental Health Values

Group	Surfaces				DMF		T-Health	
	D	M	F	S	Teeth	Surfaces	Teeth	Surfaces
Overall	1.7 (5.1)	12.2 (16.4)	16.1 (17.4)	110.0 (26.5)	10.0 (7.6)	30.0 (26.5)	86.1 (20.2)	474.0 (81.0)
Gender								
Male	2.2 (7.2)	9.4 (12.1)	16.7 (17.9)	111.7 (24.1)	9.8 (6.9)	28.3 (24.1)	87.4 (17.4)	482.3 (67.9)
Female	1.2 (2.1)	14.5 (18.9)	15.7 (17.2)	108.7 (28.4)	10.1 (8.2)	31.3 (28.4)	85.0 (22.4)	467.3 (90.4)
Age								
0-20	0.9 (2.4)	1.5 (3.9)	1.9 (3.8)	135.7 (6.0)	2.0 (2.8)	4.3 (6.0)	106.7 (7.1)	547.3 (18.5)
21-40	2.4 (6.8)	10.0 (12.8)	18.0 (15.0)	109.6 (18.4)	11.1 (6.2)	30.4 (18.4)	84.3 (15.5)	476.8 (56.7)
41-60	1.0 (1.8)	26.9 (20.0)	24.1 (19.4)	87.9 (24.5)	15.2 (6.6)	52.1 (24.5)	69.9 (18.3)	401.1 (80.9)
61+	0 (0)	38.3 (11.5)	51.3 (18.4)	50.3 (29.7)	22.3 (5.5)	89.7 (29.7)	52.0 (15.6)	304.0 (82.1)
Practice								
Practice 1	2.7 (6.8)	12.0 (16.5)	23.5 (17.5)	101.9 (27.9)	13.4 (7.1)	38.1 (27.9)	78.7 (19.8)	457.1 (85.5)
Practice 2	0.2 (1.2)	12.8 (18.5)	8.1 (11.7)	118.9 (20.8)	6.3 (5.8)	21.1 (20.8)	94.1 (17.1)	491.9 (75.8)
Practice 3	0 (0)	12.0 (12.2)	0 (0)	12.8 (12.2)	2.4 (2.4)	12.0 (12.2)	102.4 (9.8)	512.0 (48.9)

Mean Values (Standard Deviation)

Abbreviations:

D = Decayed
M = Missing
F = Filled
S = Sound

Table 9 : Restorations Present at the Start of the Study

Practice	Amalgams	Composites	Crowns	Castings	Ionomers
Overall	**676**	**40**	**47**	**22**	**0**
Practice 1	587	40	43	16	0
Practice 2	89	0	4	6	0
Practice 3	0	0	0	0	0

Table 10 : Restorative Treatment Provided during the Study

Practice	Amalgams	Composites	Crowns	Castings	Ionomers
Overall	**1728**	**458**	**399**	**71**	**275**
Practice 1	1123	284	364	59	197
Practice 2	367	114	29	11	42
Practice 3	238	60	9	1	36

Table 11 : Dental Health Changes

Test Variable	B		Standard Error#	
	Mean	*S.D*	*Mean*	*S.D*
DMFT	0.208	0.179	0.029	0.027
DMFS	0.863	0.538	0.083	0.066
T-Health	-0.936	0.839	0.166	0.194
T-Health (S)	-3.464	2.101	0.440	0.433

Notes : B represents beta

\# Standard Error for determinimg B

T-Health = 4 x Sound Teeth + 2 x Filled Teeth + 1x Decayed Teeth

T-Health(S) = 1 x Sound Teeth + 0.5 x Filled Teeth + 0.25 x Decayed Teeth

Table 12 : Factors Influencing Changes in Dental Health

Test Variable		B DMFT	B DMFS	B T-Health	B T-Health (S)
Age	F (3,96)	5.74	0.12	8.06	0.01
	P	<0.01*	0.95	<0.01*	0.99
Gender	F (1,98)	0.04	4.99	0.00	4.98
	P	0.84	0.03	1.00	0.03
Practice	F (2,97)	14.53	2.41	9.45	1.84
	P	<0.01*	0.09	<0.01*	0.16
Number of	F (4,95)	4.94	1.44	4.39	1.60
Dentist Changes (0, 1-5, 6-10, 11-15, 16+)	P	<0.01*	0.23	<0.01*	0.18

*Statistically significant at the 1 % level

Notes:
B beta
F F stastic
P probability of null hypothesis being correct

Table 13 : Change of Dentist

Test Variable	No Change		Change		F (1,3494)	P
	Mean	*S.D*	*Mean*	*S.D*		
DMFT	0.227	0.915	0.145	0.628	4.820	0.028
DMFS	0.788	2.307	0.750	2.221	0.150	0.701
T-Health	-0.485	2.040	-0.331	1.510	3.350	0.067
T-Health (S)	-1.770	5.674	-1.530	3.978	1.070	0.301

Table 14 : Frequency of Attendance

Test Variable	≤ 1 Year		> 1 Year		F (1,3494)	P
	Mean	*S.D*	*Mean*	*S.D*		
DMFT	0.208	0.890	0.230	0.725	0.280	0.596
DMFS	0.782	2.374	0.770	1.709	0.010	0.909
T-Health	-0.447	2.007	-0.504	1.588	0.370	0.544
T-Health (S)	-1.711	5.446	-1.801	5.065	0.120	0.729

CHAPTER SEVEN
DISCUSSION

7.1 DENTISTRY IN ADELAIDE

Dental practitioners in Adelaide, as in every other state in Australia, must complete a minimum of five years of undergraduate training before they are legally permitted to practise dentistry. Upon registration, a dentist may then work in a government or private practice. The government practices can include dental hospitals, community and school clinics, and the defence forces. In these government institutions the patients receive treatment either free of charge, or at a heavily subsidized rate, with the dental practitioner being in a salaried position. Alternatively, patients who attend private practices usually pay their own treatment costs, which may be partially compensated later by insurance companies if the patients are covered.

Apart from the remuneration issue, public and private dental practices also differ in terms of the practitioner's conditions of employment, and of patient loyalty. Due to the personal financial commitment involved in setting up, or buying into a private practice, private dentists generally stay longer in one place than their government counterparts. Associated with this, is patient loyalty. When patients find a dentist that they like and trust they are more likely to return on a regular basis to the same practitioner. This is in contrast to the military, Dawson (1989), or to a dental hospital, Mahmood (1991), where it was unusual for patients to see the same dentist for more than one, or a few, consecutive courses of treatment.

It was in this more stable private practice environment that the present study was set, with the results confirming the above statements.

7.2 THE STUDY POPULATION

As previously mentioned, this research project is the third in a series investigating the effect that long-term restorative dentistry has on dental health. Dawson's research report(1989) was the first in the series using members of the Royal Australian Air Force (RAAF) as the study population while Mahmood (1991) used patients from the Adelaide Dental Hospital and from Pakistan.

This study differs from the previous two, and that of Elderton (1983), in that it is concerned with patients attending private dental practices. The three practices studied in this report were all well-established, busy private practices in the Adelaide City Centre. As such, this study should be more representative of the general population, and not limited by the eligibility and financial restrictions of government service.

Comparisons between studies, such as those mentioned above, enable the determination of some factors which may be responsible for the failure of dental restorations, and tooth loss. However, care must be taken with direct comparisons, because factors such as patient age and mode of dental remuneration, can influence the type and amount of restorative dentistry provided, Gordon (1982).

7.3 THE METHOD

As with all retrospective surveys, the accuracy of the information reported is only as precise as the historical documentation available. With no other checks available, this information must be assumed to be correct at the time of examination. While variations in dentists' philosophies have the potential to alter the provision of restorative treatment, Elderton and Nuttall (1983), retrospective studies record only the actual treatment provided.

Comparisons between studies can be difficult, and must be made with caution, as populations and methodologies seldom relate, Elderton (1976), Marynuik (1984) and Ngo (1987). Even with strict restoration evaluation criteria, Mahler and Marantz (1979), Letzel et al. (1989) and Jokstad and Mjör (1990a), to name but a few workers, found obvious differences between operators. Despite these differences, a protocol must be used for uniformity and, for this study, that of Robinson (1971) with the subsequent modifications of Thylstrup and Röllings (1975) and Wetherell and Smales (1980) was used. The modified criteria for restoration failure provided a more realistic picture, as it made an attempt to differentiate between true and apparent failures, as discussed in Section 3.3.

The use of life table analysis allowed survival trends from the entire 2931 restorations placed during the study to be established, rather than only relying upon the smaller subgroup of restoration failures. Despite the potential for life table analysis to skew the results over long periods of time (in this study up to 46 years), the resultant trends are more reliable than simple cumulative survivals, as restorations that survive beyond failure estimates are also taken into account in the estimates. According to Letzel (1989) and Dawson (1989), censoring restoration failures caused by unrelated reasons also creates a more realistic impression of what is actually occurring with a restorative material.

With only one patient out of 100 not being seen by their dental practitioner within one year of the data collection date, virtually no restorations were lost from the study, that is there were no dropouts.

7.4 BASELINE DENTAL HEALTH STATUS

As an accurate baseline dental health could not be accurately established the change in dental health was therefore determined by only analzing those restorations placed during the study period. Establishment of an accurate baseline, reflecting the number of healthy, decayed and restored tooth surfaces was limited by:

a. the limited number of full mouth surveys (FMS) conducted during the inital dental visit,

b. bitewing radiographs which, if taken, only provided information on restorations placed in the molar and premolar regions, not the anterior segments, and

c. difficulties in accessing remotely stored radiographs.

The most accurate baseline dental health status was obtained from Practice 1. Despite not having performed FMS's on all patients selected for this study, those FMS's which were available provided excellent historical data. Similarly, all initial bitewing radiographs were stored on the premises, allowing easy transciption of pre-existing premolar and molar restorative information. Unfortunately, radiographs were not taken for all patients.

Within Practice 2, fewer bitewing radiographs were taken and no FMS's were performed on the study population. This consequently led to a less accurate baseline. In Practice 3, radiographs over seven years old had been transferred to a remote storage facility, making an accurate baseline impossible to determine.

Despite the obvious benefits that a complete initial charting would have had on the establishment of the baseline dental health status, the deficiencies encountered in the initial data were not totally unexpected. For this study, the average length of dental treatment was 24.81 years, with continuous treatments of up to 46 years, and it was not a common practice to perform detailed initial dental charting at that time.

However, the lack of an accurate baseline did not significantly affect the results of this study, as only restorations placed during the study period were followed. As such, accurate restoration survival rates were still able to be obtained, but establishing whether the restoration had been an original or replacement was not always so clear-cut. To overcome this problem, the following convention was adopted. The first restoration placed in each patient was classified as the original and subsequent restorations were, therefore, regarded as replacements. Although not an ideal solution, it was considered the most conservative course of action, tending to underestimate the restoration survivals in the original versus replacement series, as many of the restorations deemed originals were probably replacements. Similarly, overall restoration longevity was underestimated, as there were many pre-existing restorations that survived intact throughout the study, but were not included, as accurate insertion dates were unavailable.

7.5 TREATMENT PROVIDED

While Table 7 provides a summary of the variables tested during this study and their effects on restoration survivals, Table 5 details the restorative treatments undertaken. As expected, amalgam was the most frequently used restorative material during this study. Compared to the other restorative materials, it was used in 59% of cases. Usage figures for the other materials are provided below:

a. **Amalgams** **59.0%**
b. **Composite Resins** **15.6%**
c. **Crowns** **13.6%**
d. **Castings** **2.4%**
e. **Ionomers** **9.4%**

Of the amalgam restorations placed, 79.6% of these were Class I or II restorations. This figure compares closely with those reported by Elderton (1983), 74%, and Mahmood (1991) whose Pakistani and Adelaide samples produces figures of 75% and 80% respectively.

7.5.1 Restorative Materials by Practice

Overall, there were no major differences between the survival characteristics of restorative materials placed in the three dental practices.

Despite results which indicated a statistically significant difference in the survival characteristics of crowns and ionomers between the three practices, this was more likely the result of an uneven restoration distribution between Practice 1, and Practices 2 and 3. With over 91% of crowns and 71% of ionomers placed by Practice 1, any failure of a crown or an ionomer in the latter two practices had the potential to dramatically alter the survival characteristics of these materials. However, when this disproportionate spread of restorations was taken into account, there were no great differences between the practices or restorative materials, with all materials displaying excellent survival characteristics. The excellent survivals displayed by glass-ionomer cements in Practice 1 can be explained by the fact that a majority of them were placed by a dentist internationally reknowned for his work with this material.

7.5.2 Change in Operator

With respect to the restorative materials examined in this study, a change of operator had no effect upon the survival of the restorations. While this finding agrees with the results of Dawson (1989) and Mahmood (1991), it opposes that of Davies (1984). Consequently, this suggests that what happens in the Scottish NHS, is not universally applicable. In the present study, only composite resins showed a finding of borderline statistical significance, with dentists tending to replace their own restorations more often than did a colleague, which agrees with Elderton and Al-Ansary (1991). Again, this differs from Davies (1984) who reported that patients who changed dentists received twice the amount of restorative work compared to those who retained the same dentist. The increased replacement of composite resins in the present study may be the result of a greater critical appraisal on the part of the dentist when reviewing his or her own work, although Elderton and Al-Ansary reasoned, in their study, that it was the result of the infrequent nature of their patients attendances. It could also simply be a case of recurrent caries being a real problem.

The form of dentist remuneration also appeared to have a significant bearing on the number of restorations replaced. The replacement rate of restorations in this private practice study was found to be below those of previous studies, which drew patients from government funded/operated institutions. As this study was set in private dental practices, treatment plans may have been conservatively modified because treatment costs were borne by the patient, not the government.

7.5.3 Original Verses Replacement Restorations

As previously mentioned, to compensate for the lack of accurate baseline data available for this study, certain conventions were adopted. Due to incomplete initial chartings, it was impossible to determine whether restorations were originals or replacements. To overcome this problem, the first restorations placed in each patient were classified as original, or new, or the first restoration the patient received. All subsequent restorations were regarded as replacements. While the convention adopted had the potential to alter restoration survivals, when originals were compared to replacements, such a result was unavoidable. In reality, the difference in survivals between the original and replacement restorations could have been even wider, as most of what were deemed to be original restorations may have been replacements.

Despite these shortcomings, 43% of all restorations were deemed replacements. As expected, this figure is lower that those of previous studies, 66% from Nuttall (1984), 47-68% from Mahmood (1991) and 71% from Marynuik and Kaplan (1986). Regardless of this, the original restorations showed superior longevity when compared to their replacement restorations, as highlighted in Chart 3 (a-e). The one interesting material here was composite resin, which showed no difference in survival rates, despite Robinson and Millar (1989) reporting that the cavity surface area for a posterior composite resin can increase by a mean 36% with each replacement. Although these figures are for Class II posterior composite resins, the same problem of distinguishing resin from tooth structure exists in the incisor region and, therefore, the cavity preparations are also likely to increase in size with replacements.

7.5.4 Materials and Restoration Class

When viewing the relationship between material and restoration class, care must be taken to ensure sufficient numbers of restorations exist to allow valid judgements to be made. In the case of Class IV amalgams, Class I resins and Class III castings, survival rates of 100% were obtained, while all four Class V castings displayed early failure. In each of these cases, the numbers of restorations placed were small and did not provide an adequate basis from which realistic trends could be drawn. For instance, one would expect Class III and V castings to have similar survival characteristics, yet this study's results are diametrically opposed, testament to the misleading nature of results based on small sample sizes. Without care, these results could incorrectly influence a dentist to use certain materials where others would be superior.

The results of the study generally support the literature concerning the poor load bearing capabilities of glass-ionomer cements. The Class II ionomers failed rapidly whereas the Class III and V ionomers had excellent survival characteristics. Similarly, Class IV composite resins did not perform as well as Class III composite resins.

7.5.5 Arch Distribution

In the present study, amalgam restorations placed in the maxillary arch showed superior survival characteristics to those placed in the mandibular region. While this finding disagrees with the general consensus of the literature, as reported by Hawthorne (1992), the difference between the survival rates in the two regions, (as shown in Chart 6a), is so small that the clinical significance is negligible.

Although only a borderline statistically significant difference existed with composite resins, the long-term survival of mandibular composite resins, as shown in Chart 6b, is far superior. While these results can be partly explained by a lower aesthetic demand, Drake (1988) reported that restorations in the mandibular incisor region were less prone to decay than the rest of the mouth. He reported that 71% of restorations were still in the anterior mandible after 26 years, and it was claimed that not even the lesser demands for aesthetics could explain the difference. The results of the present study appear to agree with this statement with 67% of mandibular incisal restorations still present after 26 years. However, it must be pointed out that there were only about 40 composite resins present in the mandibular incisal region.

The remaining restorative materials showed similar survival characteristics in either arch.

7.5.6 Tooth Position

While the position of a restoration within the mouth can affect its longevity, this study found that, with amalgam restorations, it made no difference as to where the restorations were placed. However, with composite resins, the lack of numbers in the posterior regions prevented any credible judgements from being made, as over 95% of resins were in the anterior region.

The results also suggested that crowns in the anterior region of the mouth have a statistically significant chance of being replaced sooner than those placed further back in the mouth. Again this may be partly explained by the aesthetic requirements of this part of the dentition. However, with glass-ionomers, anterior restorations displayed superior survival characteristics. Possible reasons for this include the relative ease of moisture control anteriorly and less occlusal stresses being applied to the restorations (86% in Class III & V restorations).

7.5.7 Patient Age Distribution

A review of the literature by Hawthorne (1992) reported that, in general, restorations in the very young and very old did not fare as well as those placed in mid-life. The results of the present study support this statement as far as composite resins, crowns and dental castings are concerned. However, the best amalgam survivals were found in the 0-20 year age group while glass-ionomers fared best in the 61+ year age group. The amalgam result can be partly explained in that no deciduous teeth were involved and, therefore, the patients could not be classified as very young.

The glass-ionomer result is more difficult to explain, as one would expect more tooth flexure and, therefore, restoration loss with the elderly. The lack of patients receiving glass-ionomers in the 0-20 age group may reflect a decrease in anterior proximal caries, especially in well motivated patients attending the three practices (discussed further in Section 7.6.4), and the lack of abrasion lesions.

The inferior survival of crowns in the youngest patients, apart from unacceptable appearance, could be due to a higher caries experience. Anterior crowns in younger patients are commonly placed as the result of trauma, increasing the risk of early failure compared to the elective crowns often made for the elderly patient. This is a speculation that could not be verified in this research report due to a lack of clinical documentation.

7.5.8 Experience of the Operator

A traditional belief of dentistry is that the newly graduated, or elderly dentists, may produce restorations of an inferior quality compared to experienced middle-aged dentists. One of the major reasons for investigating the effect of practitioner experience on restoration longevity was to determine whether the traditional belief was justified.

Amalgam exhibited similar survival characteristics regardless of the level of dental experience. This was not a totally unexpected result, as amalgam is generally agreed to be the least technique sensitive restorative material. Similarly, the results for composite resins were not unexpected. The best results were provided by the most recent graduates, who should be the most up-to-date with the latest techniques and materials, despite lacking in clinical experience. The poorer survival results among the 41+ cohort may be due to a lack of familiarity with the latest materials and subtleties of new techniques; which the practitioner, apart from attending post-graduate training, would have had to learn by trial and error, or through contact with dental companies or other dentists.

Unfortunately, the same reasoning does not apply to glass-ionomer cements, although it should. As far as restorative materials go, the glass-ionomer cement is a relatively new product and, as such, the most recent dental graduates should have an advantage with greater exposure to the material and the latest placement techniques. This rationale, however, is not supported by the results, but can be partly explained by the limited number (eight) of restorations placed by the 0-5 year dentist cohort. The excellent results of the very experienced dentists (31-40 and 41+ cohorts) are due to the fact that the majority of these restorations were placed by a dentist internationally reknown for his work with glass-ionomers, and skill in placing this restorative material. The results could also be explained by the fact that older dentists may be less likely to replace restorations with defects by monitoring restorations that others might replace.

7.6 CHANGES IN DENTAL HEALTH

7.6.1 Test Variables

As discussed by Dawson (1989), dental health is a very difficult concept to define, which makes any attempt to measure it even more difficult. The DMF indices, Knustan et al.(1940) and T-Health scores, Sheiham et al.(1897) were used in this study in an attempt to monitor changes in the dental health of the sample population. Although the DMF indices actually measure the disease status and not the dental health of patients, these calculations were performed to allow direct comparisons with those in the studies of Dawson (1989) and Mahmood (1991). The T-Health indices measure tissue health by placing arbitary weightings on the value of sound, restored but sound, and decayed teeth (4, 2 and 1, respectively). Missing teeth are not catered for in this process, and although it takes the confusion out of determining why the tooth was extracted (either a true or apparent failure), it does tend to underestimate changes in dental health. If missing teeth were accounted for, a tooth extracted due to decay would obviously have a weighting less than a sound tooth. However, it is often difficult, if not impossible, to determine the causes of extractions.

Recently, Marcenes and Sheiham (1993) reported that the FS-T or filled and sound teeth index, together with the T-Health index, is more sensitive to social and behavioural factors than the DMF index. They went on to suggest a change in the arbitary weighting values to 4, 1 and 1 (for sound, decayed and filled teeth). The rationale behind the modification to this scale was that a decayed tooth had a similar amount of sound tooth structure compared to a restored tooth, if not more. However, while this is true from a cross-sectional perspective, the longitudinal situation is not so clear. There have been many studies, including this one, that have shown very long-term survivals of large restorations. Caries, however, often progresses rapidly and has the potential of leading to the eventual early extraction of the tooth. Therefore, because these new weightings are only a functional and not a biological measure of dental health, whether they are useful in accurately determining the status of dental health over a long period of time is yet to be seen.

7.6.2 Dental Health Changes

Very little research has been conducted into restorative dentistry and its effect on long-term dental health, particularly in private practice. The results of the present research project indicate a slow but definite reduction in the dental health of the study population over time, with more restorations being placed in teeth and surfaces at the expense of sound tooth structure, Table 11. This general decline in the amount of sound tooth substance is reflected in the reduction of the T-Health indices. While the changes in DMFT & S are similar, the changes in both of the T-Health indices are greater than those of Dawson (1989), but closely resemble the Adelaide data of Mahmood (1991). This would suggest that although the numbers of teeth receiving restorations remained similar, the numbers of surfaces that were restored on the teeth have increased to result in larger restorations.

The rates of change in the DMF and T-Health indices were affected by only a few of the test variables. The statistically significant relationship between age and changes in DMFT and T-Health is probably due to the `saturation' from restoration of available tooth sites, as discussed by Dawson (1989). Here, as the patient ages and receives more restorations, the number of potential sites for new restorations decreases, thereby reducing the overall rates of changes in dental health. The changes in DMFT and T-Health for the different practices are more difficult to explain as no statistically significant differences existed between the practices for restoration survival, but again may be related to patient age. As highlighted by section 4.1.1, practice 1 had the oldest patient population, and this was reflected in the rates of change of dental health being the lowest of the three practices. Practice 3 not only had the smallest patient population (15), thus the greatest potential for skewed results, but also the youngest patient population.

The effect of the number of changes in dentists varied between the DMFT and T-Health indices. For DMFT, patients who stayed loyal to the one dentist displayed the largest change in their rates of dental health. This result was opposed to the T-Health index, where patients who changed dentist most frequently (11-15 and 16+ changes) demonstrated the greatest rates of change in dental health. The difference between these results may be explained by the T-Health scores changing more (due to the arbitary rating of sound tooth structure) than the DMFT scores; but other factors not analyzed in the present study, such as patient demographics, could also contribute to the disparity.

7.6.3 Change in Operator

The study by Davies (1984) reported that patients who changed dentists received more dental work than those who remained with the same dentist. Dawson (1989), however, reported that no such association existed despite the fact that his study's population virtually changed dentists with each subsequent visit. Similarly, Mahmood (1991) found no association between a change of dentist and an increase in restorative treatment in a hospital sample, while the results of the present study, as shown in Table 13, also agree with Dawson and Mahmood. A patient attending the three private practices showed a clear loyalty to a dentist, which was not possible in the military population of Dawson (1989) and the hospital situation of Mahmood (1991). Of the 3596 examinations, there were only 668 instances where there was a change in dentist, and often this change was an isolated case, with the patients returning to their regular dentist at the subsequent visit. The isolated nature of these change in dentist may have influenced the extent of restorative treatment performed, especially if the "substitute" practitioner was aware that he or she was only temporary until the patient's regular dentist returned and, therefore, was not keen to perform non-urgent restorations.

7.6.4 Frequency of Attendance

It was noted by Nuttall (1984) that patients who attended the dentist more frequently received more restorative treatment which was also more costly, than infrequent dental attenders. However, Dawson (1989), found that the amount of treatment did not differ between frequent and infrequent attenders, although the cost did. The work of Mahmood

(1991) found that frequent attenders in the Adelaide sample received less comprehensive restorative treatment than infrequent attenders, while there was no difference within the Pakistan sample.

With no clearly-defined groups of patients within the present study for frequency of attendance, the time intervals between individual examinations were used to determine if there were any noticeable effects upon dental health. As shown in Table 14, frequency of attendance was not significant for the amount of restorative treatment received. It must be reported here that the recall frequency of the study patients was short, with 50% of all 3596 examinations being every six months, 75% every nine months and 85% within the year. Whether this is reflective of the general population is doubtful, but it appears that the clientele attending these three private practices are very dentally conscious.

7.7 CONCLUSIONS AND RECOMMENDATIONS

7.7.1 Introduction

As this is the third study in a series investigating the long-term effects of restorative dentistry on the dental health of the population, the inclusion of criteria common to the previous two, Dawson (1989) and Mahmood (1991), was necessary to enable valid comparison to be made between all three. Without these common references, comparisons made between the studies would not be valid, as the population groups varied significantly: from a military sample, from patients drawn from the Adelaide Dental Hospital and three private practices in Pakistan, and from patients attending three Adelaide private practices.

7.7.2 Conclusions

The degree of accuracy of the information analyzed within this research project, as with all retrospective studies, is dependant upon the accuracy of the information detailed by the dentist at the time of examination and restoration insertion/replacement. While adjunct information, including the reasons for restoration failures, made restoration survival analysis more accurate, the limited availability of such information meant that educated guesses often needed to be made. As a result, the information contained within this report can not be regarded as absolute, but more correctly as a trend of what is happening. Restoration survivals for the restorative materials studied were superior to those reported in the Scottish NHS, and by Dawson and Mahmood. Dawson (1989) speculated that the reason behind the greater survivals of restorations in his study, compared to those of the Scottish NHS, may be due to the differing forms of remuneration. To complicate matters further, the present study had superior restoration survivals again, which were associated with another form of dentist remuneration, being a private arrangement between the dentist and the patient.

Overall, although there were no significant differences between the three practices as far as restoration survivals were concerned, the rates of change in the DMFT and T-Health indices differed. A change in dental operator had no effect upon either the rates of change in dental health or the survival of the replacement restorations, while the original restorations had superior survival characteristics compared to their replacements. The frequency of patient attendances was also unrelated to the rate of change in dental health. Age was the other variable that had an effect upon dental health, with younger patients displaying greater rates of changes in DMF and T-Health indices than the older patients who had more `saturated' or heavily-restored dentitions. The survivals of the restorations were independant of who placed them, or the experience of the practitioner.

7.7.3 Recommendations

1. Accurate documentation of the patient's dentition should take place at the first visit. This would not only help with further research but also allow the practitioner to retrospectively refer to the documents to see how the patient's dental health had changed. This could be important in establishing new treatment philosophies, or determining if existing treatment regimes are working satisfactorily.

2. Documentation records should include the reasons for restoration placements or replacement. This, again, would enable the practitioner to look back and determine why the restorations failed. However, accurate documentation is not only important for dentist self-education or for potential research, it is also essential to meet ever-increasing medico-legal obligations.

From the survival data in the present study:

3. Amalgam should continue to be the routine restorative material where appearance is not an important consideration in treatment.

4. Crowns and other restorative materials should be placed in preference to gold castings.

5. Glass polyalkoanate (ionomer) cements show considerable potential.

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APPENDIX

THE UNIVERSITY OF ADELAIDE
DEPARTMENT OF DENTISTRY

Dr W. Hawthorne
Dr R. Smales

FORM A. Name: ______________________

Continued

Data Collection Proforma

Reg. No.		Age (yr birth)	Sex		Practice	Collctn Date	Caries OH Perio	Smoke	Brux

EXAM DATE (Mth + Yr)
CHANGE DENTIST 0–9

8 7 6 5 4 3 2 1 1 2 3 4 5 6 7 8

TREATMENT COST
DMFT
DMFS
T-HEALTH (T)
T-HEALTH (S)

THE UNIVERSITY OF ADELAIDE

Department of Dentistry

DR W. HAWTHORNE
DR R.J. SMALES

FORM B

I. Patient Details: Name ______________________

1 |__|__|__| Reg. No.

4 |__|__|__|__|__|__|

10 |__|__| Age (yr of birth)

12 |__| Sex 1=M 2=F

13 |__| Rank
1=No
2=No
3=No
4=No
5=
6=
7=
8=
9=

Operator
14 (Dental Practice) |__| Groups
1=No
2=No
3=SADS
4=Private(Pakistan)
5=GJM (Adel)
6=
7=
8=
9=

15 |__| Poor

16 |__| Heavy

17 |__| Bruxer

1=Y
2=N

Restorations Present at Start of Study

18 |__|__| Amalgs.

20 |__|__| Resins

22 |__| Crowns

23 |__| Other

II. Examinations/Treatments

24 Date |__|__|__|__| Mth Yr

28 |__| 0-9 Dentist

DMFT 29 D |__|__| 31 M |__|__| 33 F |__|__| 35 Sound |__|__|(28)

DMFS 37 D |__|__| 39 M |__|__| 41 F |__|__| 43 Sound |__|__|__|(140)

Restorations Placed During Course of Treatment

46 |__|__| Amalgs.
48 |__|__| Resins
50 |__| Crowns
51 |__| Other
52 |__|__|__|__| Cost ($)
56 |__| Fis
|__| RCF
58 |__| Xtr
|__| GIC
60 |__| Dsg

61 |__|__|__| Cost ($) RCF

Notes: 1. Baseline: fill out parts I & II
2. Recalls: fill out Reg.No. only in Part 1, & then Part II

(RJS0101/1)

FORM C

DR. W. HAWTHORNE
DR. R.J. SMALES.

'CLINRES' 1984 - THE UNIVERSITY OF ADELAIDE, DEPARTMENT OF DENTISTRY.

FAILURES

1
| 4 | 1 |
FILE

TOOTH SURFACES: ______ HOSP. NO: ______ PATIENT'S NAME: ______

1 = Yes

3 Rest. No. (↑ Times restored)

8 Observation: Day (crossed out), Mth., Yr.

14. Xtrn.: True Fail., Appar. Fail.

16 Rest. Replaced: True Fail., Appar. Fail., Diff. Mat.

Rest. All Lost

20 Rest. Fract. (Part Lost, mobile)

Tooth Fract.

Recurr. Decay

Rest. Repair (Crown recement)

0 = No

24 ~~Pin Expos.~~ Marg. fract. ✓

~~Dentine~~ Stained Marg. ✓

Tooth RCF ✓

27 ~~Tooth~~ Discol. Surf. ✓

~~Partial Abuts~~ Rough Surf. ✓

Gen. Plaque ✓

30 ~~Gen. Gingi- vitis~~ Y.S. Wear ✓

Gen. Staining ✓

Gen. Bruxism ✓

~~Gen. Toothbrush Abrasion~~ Colour Mismatch ✓

ALL BLANKS MUST BE PUNCHED AS ZERO

Comparisons (C) = 0 - 9
Linear Scale = 00 - 99

34 Gingivitis Rest. C

37 Plaque on Rest. C

40 Plaque on Tooth C

43 Over-extended Margins C

46 Under-extended Margins C

49 Poor Anatomic Form C

52 Cervic. Abras. Rest. C

55 Cervic. Abras. Tooth C

58 Occlus. Attrit. Rest. C

61 Occlus. Attrit. Tooth C

64 Surface Roughened C

67 Surface Stain/Tarnish C

70 Margins Stained C

73 Margins Fractured C

76 Colour Mismatch (light/dark) C

79 Opacity Mismatch (less/more) C

VISIT

82 Hosp. No./Reg. No.

88 Surname,

102 Day (crossed out), Mth. (crossed out), Yr. BIRTHDATE

INITIAL

108 FDI Code

110 Surfaces: I/O, M, D, B/L, Li

115 CLAS

116 1 = Y, 0 = No: CLASP/CUSP G (CLASP, CUARG), PIN, POL, NEW, SOAP/AMER (SO AP ME ER)

121 MAT. ↑ Type/Brand

123 OPER. ↑ Practice/Operator 5: GJM (1-9)

125 Day (crossed out), Mth., Yr. Insertion