



**Faculty of Dentistry & WHO Collaborating
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For Oral Health
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UNIVERSITY OF THE WESTERN CAPE

**AN ASSESSMENT OF COMPREHENSIVE DENTAL TREATMENT PROVIDED
UNDER GENERAL ANAESTHESIA AT TYGERBERG ORAL HEALTH
CENTRE.**



**A minithesis submitted in partial fulfillment of the requirements for the degree of
Master of Science in Dental Sciences in Paediatric Dentistry at the Faculty of
Dentistry
University of the Western Cape**

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September 2006

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Keywords

General anaesthesia

Children

Comprehensive dental treatment

Oral health

Risk factors

Early childhood caries

Dental rehabilitation

Oral hygiene

Restorations

Clinical performance



SUMMARY

There are several categories of dental problems in children that cannot be treated optimally in the office settings and are best managed in the hospital theatre. The ability to treat children in the hospital environment in order to provide comprehensive dental care using general anaesthesia (GA) is a valuable option to the paediatric dentist, despite some degree of risk to the patient. General anaesthesia provides optimum conditions for restorative treatment such as maximum contamination control, immobilization of the patient, efficiency and effectiveness, and elimination of reflexes. In spite of providing optimum conditions for restorative procedures, high restorative failure rates are reported in the literature for treatments provided under GA (Tate *et al* 2002). **Objectives:** to determine: the profile of the child patients treated; types of dental procedures performed; the oral health status of the patients post-GA; the status of restorative procedures performed. **Methods:** Files were randomly selected from the bank of records of child patients treated under general anaesthesia (GA) At Tygerberg Oral Health Centre in 2004. The caregivers of these patients that met the inclusion criteria were informed and invited to participate in the study. An oral examination of the child was done. Percentile sites were scored to assess Plaque and Gingivitis, and Ryge's Modified Clinical Criteria was used to assess the clinical Performance of the restorative procedures. Data was analyzed using SPSS with appropriate statistical package ($P < 0.05$). **Results:** 60 child patients were examined (25 males and 35 females) with a mean age of 44.78 months at the time of the GA appointment. The average procedures for each patient were 6 restorations, and 4 extractions. The plaque mean percentile score was 37.6% of the sites. Ryge's clinical criteria (Charlie and delta combined) for the restorations that needed replacement were in descending order: Composite **50%**, GIC restorations **39%**, PAMC **33%**, RMGI restorations **31%**, and amalgam **26%**. **Conclusions:** the GA patient is young and had extensive dental procedures done. The post GA oral hygiene is fair to poor, and the failure rate is high for all the materials used especially the Composites. The findings suggest that maybe more aggressive comprehensive treatments including preventive therapies may be needed.

DECLARATION

I hereby declare that *An Assessment of Comprehensive Dental Treatment Provided under General Anaesthesia at Tygerberg Oral Health Centre* is my own work, that it has not been submitted before for any degree or examination in any university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Manhal Ijbara

September 2006

Signed:.....



ACKNOWLEDGEMENTS

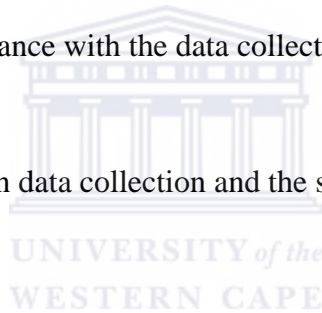
I wish to acknowledge my gratitude to the following people for the assistance given to me in this research project.

Dr S. Y. Harnekar, for her encouragement and guidance in this study and also for sharing with me her knowledge and wisdom whenever I needed it.

Professor Lalloo, for his guidance with the technical aspects of this study and his encouragement during the compilation of this thesis.

Dr N Mohammed, for her assistance with the data collection and the all the support.

Dr M Mustafa Ali for the help in data collection and the support.



DEDICATION

To my mother and father. Despite the distance between us you still the ones in my heart....



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CHAPTER ONE: INTRODUCTION.

Statement of the problem

In many developed countries, the prevalence of caries in the primary dentition has decreased in the last few decades and tends to have stabilized (Holm, 1990; Brown *et al.*, 2000; Almeida *et al.*, 2000). However, even with this decline, it is still one of the most common infectious diseases of childhood. There is a group of children who express high caries susceptibility but are not recognized early. Young children with numerous carious teeth require comprehensive dental rehabilitation and caries preventive regimens.

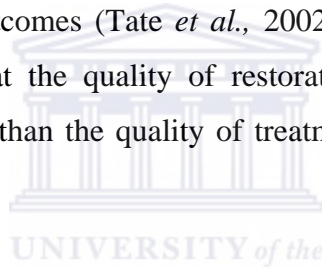
Successful dental treatment to children depends on the cooperation between the child, the parents and the paediatric dentist. The aim of paediatric behaviour management is to effectively and efficiently perform treatment for a child and yet instill a positive dental attitude (Wright 1975). Therefore, a proper mode of pain control is one of the important factors in successful treatment. Local analgesia or local anaesthesia is a common pharmaceutical measure to control pain but the cooperation from the children has to be established before administration. The majority of children can be adequately treated with simple behaviour modification techniques such as Tell, Show and Do (Enger and Mourino, 1985). One of the factors that determine the success of behavioural management is pain control, which can be alleviated by the use of effective local anaesthesia but many young patients can only be managed with either sedation or general anaesthesia.

There are several categories of dental problems in children that cannot be treated optimally in the office settings and are best managed in the hospital theatre. The ability to treat children in the hospital environment in order to provide comprehensive dental care using general anaesthesia (GA) is a valuable option to the paediatric dentist, despite some degree of risk to the patient (McDonald and Avery 2000).

The need for general anaesthesia for the provision of dental treatment is controversial. In England, the 'Poswillo Report (1990) tried to enhance the safety of general anaesthesia for dental treatment and to reduce its unnecessary use. Yet the number of general anaesthetics for tooth extraction by the Community Dental Services showed that the demand was still great among the population (Murray, 1993; Jones *et al.*, 1998).

The clinical guidelines of the American Academy of Paediatric Dentistry for 2005-2006 (AAPD Guidelines 2005-2006) state that the goal of general anaesthesia (GA) in the paediatric dental patient is to eliminate cognitive, sensory, and skeletal motor activity to facilitate the delivery of quality comprehensive diagnostic, restorative, and/or other dental services.

General anaesthesia allows dental treatment to be rendered under optimal conditions, theoretically ensuring ideal outcomes (Tate *et al.*, 2002). A study by Eidelman, Faibis and Peretz (2000) showed that the quality of restorative treatment performed under general anaesthesia was better than the quality of treatment performed under conscious sedation.



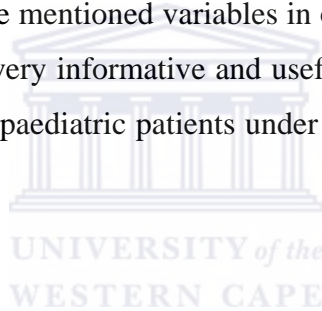
In a study of 300 paediatric patients treated under general anaesthesia, rampant caries was the most common indication for treatment and behavioral management problems were the second (Legault, Diner and Auger, 1972). Similar findings were reported when the clinical features of 933 patients of varying ages who received dental care under GA were reported by Vermeulen, Vinckier and Vandenbroucke (1991). Sheller *at al* (2003) found that patients' mental or physical condition is the third most common reason for dental treatment under GA.

General anaesthesia provides optimum conditions for restorative treatment such as maximum contamination control, immobilization of the patient, efficient and effective working environment, and elimination of unwanted patient reflexes. In spite of providing optimum conditions for restorative procedures, high restorative failure rates are reported in the literature for treatments provided under GA (Tate *et al.*, 2002).

Studies have described the difficulties encountered with providing treatment under general anaesthesia and the outcomes (Almeida *et al.*, 2000). The restorative treatment of rampant caries presents many difficulties. The longevity of different types of materials for restoring the primary teeth has usually been done under normal clinical conditions (Roberts and Sherriff, 1990; Papathanasiou *et al.*, 1994). The relationship between caries activity and the frequency of retreatment of restorative procedures is unclear.

This study will assess the comprehensive dental treatment performed under GA. Many related features will be examined such as the patients' age, weight, feeding habits, and oral hygiene. Other variables are related to the treatment itself such as type and clinical performance of restorative materials used, the number of teeth surfaces involved, pre and post GA preventive treatments, etc.

Although the combination of the mentioned variables in **one** study needs multiple criteria to follow, the findings will be very informative and useful in the future decision making concerning the management of paediatric patients under GA at the **Oral Health Centre, Tygerberg.**



CHAPTER TWO: RESEARCH QUESTION.

Comprehensive dental care under General anaesthesia (GA) is a valuable treatment option to the paediatric dentist. This treatment option is effective, efficient and safe. General anaesthesia allows comprehensive dental treatment to be rendered under optimal conditions, theoretically ensuring ideal outcomes. However high restorative failure rates, low recall rates of the patients, and even repeat of the GA treatments are all reported in the literature.

This study was designed and conducted to assess the outcomes of the comprehensive dental treatment provided under GA at the Tygerberg Oral Health Centre (OHC) theatre. The demand for this type of treatment is high and the waiting period is often up to three months in advance. On weekly basis only about six paediatric patients receive comprehensive dental treatments.

The outcomes of this study will help in the decision-making and the protocol review concerning the treatment provided.

The question will be:

“ Is the comprehensive dental treatment provided under GA at OHC theatre effective and efficient? Should a more aggressive/radical approach (more extractions) be recommended and undertaken to treat paediatric patients with ECC?”

CHAPTER THREE: LITERATURE REVIEW.

Part one: General Anaesthesia (GA) for children.

3.1 Introduction.

Many child patients cannot accept extensive dental treatment because they are unable to withstand the numerous appointments required to complete the necessary dental treatment and/or the discomfort associated with prolonged, repetitive therapy. Even in instances where the initial experience is pleasant and uneventfully, and the children accept the following two or three visits willingly, they can tire of the novelty of '**going to the dentist**' and develop management problems. Consequently, their level of tolerance to the required therapies diminishes, which also spoils the established relationship between the paediatric dentist and the child. Therefore, treatment under general anaesthesia is one of the treatment options for those children requiring extensive and comprehensive dental treatment.

GA is a drug-induced loss of consciousness during which the patient is not arousable, even by painful stimulation. Patients require assistance in maintaining a patent airway, and positive pressure ventilation may be needed because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function. Cardiovascular function may also be impaired. (Clinical Guidelines, American Academy of Paediatric Dentistry AAPD 2005-2006).

Most studies agree that the main reason for providing general anaesthetics in children is the management of caries (Smallridge *et al.*, 1990; Holt *et al.*, 1991; O'Sullivan and Crouzon, 1991; Vermeulen *et al.*, 1991; Holt and Rule, 1992; Mason *et al.*, 1995). In England, more than 230,000 general anaesthetics were given between 1994 and 1995 for the extraction of teeth in patients under the age of 18 years (Bridgman *et al.*, 1999). This seems to support the notion that despite the decline in caries experience in young people over the last 20 years, there remains a group of children and young adults who still required a substantial amount of dental treatment (Nunn *et al.*, 1995).

Dental General Anaesthesia (DGA) will, at least for the foreseeable future, continue to be of particular value for children who are too young to tolerate treatment using local anaesthesia, even with the addition of inhalation sedation, and those with severe and extensive forms of caries, such as rampant caries (Holt *et al.*, 1999).

3.2 Indications for paediatric patients to receive dental treatment under general anaesthesia.

There are several categories of dental problems in children that cannot be treated optimally in the office settings and are best managed in the hospital theatre. The ability to treat children in the hospital environment in order to provide comprehensive dental care using general anaesthesia (GA) is a valuable option to the paediatric dentist, despite some degree of risk to the patient (McDonald and Avery, 2000).

The clinical guidelines of the American Academy of Paediatric Dentistry (2004-2005) state that the goal of general anaesthesia (GA) in the paediatric dental patient is to eliminate cognitive, sensory, and skeletal motor activity to facilitate the delivery of quality comprehensive diagnostic, restorative, and/or other dental services.

Most children can receive routine dental care in a conventional dental environment. However, for those uncooperative children, consideration of alternative methods for treatment is necessary.

There are special indications for the use of general anaesthesia to treat children. (Thomason, 1951; Rule *et al.*, 1967; Hoist, 1967; Legault *et al.*, 1972; Boulanger, 1990; Bohaty and Spencer, 1992). These are as follows:

- Management problems in the dental office: young children, or extremely uncooperative, fearful or anxious, or an adolescent with extensive dental needs and for whom office dentistry has been unsuccessful, or an uncooperative child

who remains uncontrollable after all alternative means of patient management have been unsuccessfully tried.

- Patients with medical disorders requiring close supervision: Such as congenital heart disease, blood dyscrasias, or seizure disorders who are in need of dental treatment and close monitoring after the operation.
- Handicapped or physical disabilities: Patients with sensory, physical, or mental handicapping conditions severe enough to prevent proper oral evaluation and treatment. Common examples are Down's syndrome, autism, mental retardation, cerebral palsy, and seizure disorders (Gordon *et al.*, 1998).
- Local anaesthesia problems: Patients with extensive dental needs on whom local anaesthesia is generally ineffective; or inefficacy due to acute infection and anatomic variations; or because of allergic reactions to certain local anaesthetic agents.
- Patients who have sustained extensive oro-facial and/or dental trauma.
- Patients with extensive dental needs who live in remote areas where dental care is unavailable, or transportation is a problem or for reasons of parental convenience and demands.
- Young patients with craniofacial anomalies and who require extensive dental treatment for which normal treatment would require an unacceptably long period of time.
- Children or adolescents in need of extensive dental care with a high failure rate for dental appointments because of psychological problems or medical neglect and whose health and welfare are the financial responsibilities of a social service agency.
- Patients who are phobic gaggers (Soloman, 1987).
- Patients who need minor oral surgical procedures but cannot withstand the operations in the conventional dental office environment.

The clinical guidelines of The American Academy of Paediatric dentistry (AAPD) for 2004-2005 included the following as indications for both deep sedation and general anaesthesia:

- Patients who are unable to cooperate due to a lack of psychological or emotional maturity and/or mental, physical, or medical disability.
- Patients for whom local anaesthesia is ineffective because of acute infection, anatomic variations, or allergy.
- The extremely uncooperative, fearful, anxious, or uncommunicative child or adolescent.
- Patients requiring significant surgical procedures.
- Patients for whom the use of deep sedation or general anaesthesia may protect the developing psyche and/or reduce medical risks.
- Patients requiring immediate, comprehensive oral/dental care.

Based on information from the literature, the frequencies of various types of paediatric patients who needed dental treatment under general anaesthesia are tabulated in **Table 3.1:**



Table 3.1 Studies reporting on the reasons for dental treatment of child under general anesthesia.

Authors/year	Country	Study period	Sample size	Age range (years)	Reasons for general anaesthetic (%)					
					Medical	Behav	MR	Tx/caries	Surgical	Others
Allen et al 1967	USA	-	-	2-8	38	-	12	50	-	-
Rule et al 1967	UK	1959-1965	225	1.8-15	6	70	16	-	-	8 ^a
Legault et al 1972	Canada	4 years	300	1-15	6.3	31.1	-	52.9	-	9.7 ^b
Keniry 1974	UK	6 months	1307	1-16	-	-	-	93	1	6 ^c
Smith et al 1978	USA	1972-1976	318	mean:6.59	18	50	32	-	-	-
Persliden et al 1980	Sweden	1976-1979	352	0-16	-	-	100	-	-	-
O'Brien et al 1983	Australia	12 years	1316	<3->15	-	-	10	90	-	-
Enger et al 1985	USA	1977-1982	200	1-52 (mean: 7.7)	22	28	-	47	-	3 ^d
Roeters et al 1985	Netherlands	1968-1980	221	-	-	-	100	-	-	-
Mitchell et al 1985	UK	1979-1983	96	6-25+	-	18.8	81.2	-	-	-
Grytten et al 1989	Norway	1975-1983	1067	0-74	14	86	-	-	-	-
Boulanger 1990	Belgium	-	46	1.5-14	92	-	-	4	-	4 ^e
Tarján et al 1990	Hungary	1981-1986	180	2-16	-	49	51	-	-	-

Medical: medical condition

Behav: behavioural and/or management problems

MR: physical and/or mental handicapped

Tx/caries: need extensive treatment and/or caries

Surgical: surgical procedures

a: not recorded

b: young age, single visit comprehensive treatment

c: orthodontic extraction, trauma

d: family lived far from source of care and others

e: local anaesthesia problems

Authors/year	Country	Study period	Sample size	Age range (years)	Reasons for general anaesthetic (%)					
					Medical	Behav	MR	Tx/caries	Surgical	Others
Vermeulen et al 1991	Belgium	1983-1988	933	1-60+	10.5	35.6	23.3	83	4.6	30.1 ^f
O'Sullivan et al 1991	UK	1984-1987	80	2-11	12	76	8	8	1	4 ^g
Holt et al 1991	UK	5 months	103	9.0±4.4	-	21.3	9.7	33.9	44.6	-
Holt et al 1992	UK	1990-1991	2081	0-15+	1.82	-	-	-	8.0	-
Su et al 1992	Taiwan	1989-1991	57	2-14.4	13.5	29.8	25.4	28.4	2.9	-
Sheehy et al 1994	USA	-	44	mean: 4.5	18	27	-	18	-	-
Nunn et al 1995	UK	1979-1983	96	6-26+	-	37.5	62.5	-	-	-
Nunn et al 1995	UK	1983-1993	358	0-26+	8.0	21.4	60.3	10.3	-	-
Harrison et al 1998	UK	1991-1995	1000	1.75-24.2 (mean: 8)	77.7	22.3	-	-	-	-
Gizani 1998	Belgium	1995-1996	98	2.6-6.5	-	100	-	-	-	-

Medical: medical condition

Behav: behavioural and/or management problems

MR: physical and/or mental handicapped

Tx/caries: need extensive treatment and/or caries

Surgical: surgical procedures

f: infection, patient's demand, young, pain, and allergy to local anaesthesia.

g: amelogenesis imperfecta and others

3.3 Mortality, morbidity, and complications of general anaesthesia.

General anaesthesia is a procedure that is not without risk, the risks are difficult to quantify, and the technique is extremely valuable either for the very young or for those with extensive disease (Holt *et al.*, 1992). The use of anaesthetic drugs and muscle relaxants for oral rehabilitation procedures increases the risks and recovery time after the procedure (Harrison and Nutting, 2000).

The number of general anaesthesia procedures performed on dental patients in non-traditional settings such as office or outpatient facilities has risen over the last few years. The need for GA have increased, reimbursement levels for in-hospital procedures have decreased, and safety and effectiveness of drugs and monitors have improved significantly (Haupt, 2000).

The provision of dental general anaesthesia is a controversial topic which was illustrated by a report in 1990 in the United Kingdom that concluded that general anaesthesia should be avoided and other techniques should be used whenever possible (Poswillo, 1990). Nevertheless, the use of general anaesthesia for the extraction of teeth in children and adolescents is still a common practice in the United Kingdom (Smallridge *et al.*, 1990; Holt *et al.*, 1992).

3.3.1 Mortality under general anaesthesia

Mortality rates are commonly used as indices of safety when referring to general anaesthesia. The decision to utilize general anaesthesia always involves a judgment based on the known medical risks, although the mortality rate associated with dental general anaesthesia is considered to be extremely low. In England and Wales, the number of deaths associated with dental treatment under general anaesthesia has declined but the mortality rates in the dental office did not change significantly from 1971 to 1990 (Murray, 1993).

The classic survey of ten hospitals by Beecher and Todd (1952) involving nearly 600,000 anaesthetic cases between 1948 and 1952 suggested that mortality primarily attributed to the anaesthesia occurred 1 in 2680 or 3.7 in 10,000. A study by Dornette and Orth (1956) showed similar findings.

The report from the Confidential Enquiry into Perioperative Deaths (CEPOD) in 1987 indicated that mortality attributed to anaesthetic alone was 1 in 185,000 (0.054 per 10,000).

Coplans and Curson in 1993 reviewed deaths associated with dentistry in England and Wales during the decade 1980-1989, and compared it to the period 1970-1979. They reported that the number of deaths in dental anaesthesia (including sedation, local and general anaesthesia) were 120 and 71 in the two study periods respectively. However, the frequency of general anaesthesia being directly responsible for death had decreased from 54 cases in the 1970's to 18 cases in the 1980's. According to the authors, the reasons for this change were difficult to establish. However, it could simply be a reduction in use of general anaesthetics for dental procedures.

In Australia, a 1998 report found 116 anaesthesia-attributable deaths during the period 1991-1993. Considering that 7.8 million general anaesthetics were administered, the national incidence of deaths attributable to general anaesthesia was around 1 per 68,000 patients. There were fewer deaths in young children (Working Party Report of ANZCA, 1998).

More substantive conclusions can be drawn from a review of more than 100,000 general anaesthetics given over a 30-year period in the USA. This study showed a mortality rate of 1 to 2 deaths per 10,000 anaesthetics that were delivered in hospital, to all types of patients (Keenan, 1994). During the period 1974-1992 in the USA, the reported mortality rate for patients who underwent dental office anaesthesia (outpatient) was 1 in 30,000 (D'Eramo, 1992).

In 2003, Lee and Roberts did a survey on more than 22,000 GA cases over a 10-year period and did not report any deaths related to the provision of dental general anaesthesia in the American Hospital Association (AHA) hospitals.

Table 3.2 summarizes some of the mortality rates related to GA in the literature:



Table 3.2: Studies reporting on the mortality rates related to DGA.

Authors/year	Country	Study period	Age range (years)	Types of GA	No. of deaths*	No. of death under DGA	Mortality rate of dental anaesthesia (GA+LA)
Goldman 1960	UK	1952-1958	-	out-patient	100	100	1:219,000
Bishop et al 1961	UK	1939-1959	57	out-patient	1	1	1:103,000
Bourne 1970	UK	1966-1970	5-63	out-patient	16	15	-
Tomlin 1974	UK	1963-1968	5-65	in- & out-patient	48	43	1:15,000 (in-patient) 1:300,000 (out-patient)
Lytle et al 1980	USA	1973-1977	-	-	-	-	1:860,000
Coplan et al 1982	UK	1970-1979	Male: 28.9±19.4 female: 35.9±22.2	36 in-patient 8 out-patient	120	100	1:69,500
Lytle et al 1989	USA	1968-1987	17-83	out-patient	7	5	1:673,000
Jastak et al 1991	USA	1974-1989	1.75-59	out-patient	13	13	-
Krippaehne et al 1992	USA	1977-1992	2-42	98% out-patient 2% in-patient	35	20	-
Coplans et al 1993	UK	1980-1989	male: 38.4±23.1; female: 35.8±22	in- & out-patients	71	42	-
Murray 1993	UK	1971-1990	-	40% hospital 60% dental office	166	119	1:215,000
Nkansah et al 1997	Canada	1973-1995	-	out-patient	4	4	1.4:1,000,000

* number of deaths related to dentistry

GA: general anaesthesia

LA: local anaesthesia

3.3.2 Morbidity of general anaesthesia

Morbidity is considered to be a more useful variable than mortality when discussing complications associated with general anaesthesia, as it describes to some extent the nature of the problems encountered. Although life-threatening complications rarely occur after general anaesthesia, discomfort that prolongs or complicates recovery is common.

In paediatric anaesthesia, the most commonly reported post-operative complications are sore throat, headache, muscle pains, nausea and vomiting and post-operative pain (Smith *et al.*, 1976; Smith *et al.*, 1978; Ogg *et al.*, 1983; Enger and Mourino, 1985; Bridgman *et al.*, 1999). Libman and co-workers (1979) emphasized that the most frequent complication is post-operative fever (hyperthermia), which represented 97.5% of all complications noted in their study. Other reported complications included distress, oral pain, extubation spasm, stridor, hypotension, bradycardia, restlessness, prolonged recovery, coughing, hiccups, drowsiness, shivering, sickness, prolonged bleeding, discomfort, laryngeal oedema, laryngospasm, traumatic injury, aspiration, upper respiratory tract infections, dehydration, enuresis, continued crying, psychological trauma, continuing bad memories, apnea, depression and recurrent nightmares (Libman *et al.*, 1979; Persliden *et al.*, 1980; Ogg *et al.*, 1983; Holt *et al.*, 1991; Bridgman *et al.*, 1999).

The morbidity following extractions under general anaesthesia in general dental practice is common. The longer the period of observation the greater the opportunity for symptoms to occur and so to be reported. Bridgeman and co-workers (1999) reported that 92% of the children complained of one or more symptoms after general anaesthesia. Bleeding and emotional distress were common during the immediate post-treatment period but nausea and vomiting seldom occurred. By contrast, the frequencies of various complications changed after the children reached their homes with nausea and vomiting increasing whilst pain, crying and bleeding being reduced. Even after a month, the experience of dental general anaesthesia had imprinted a distress memory in some children. The parents were also under stress when they faced these situations.

Patients have different degrees of rectal temperature elevations after dental rehabilitation under general anaesthesia. The general temperature pattern shows a decrease in the pre-operative and immediate postoperative periods, followed by a rise through the next four-to-eight-hour period. Then a gradual temperature decrease occurs back to the admission temperature. After twenty-hours, the temperature can be expected to have returned to the admission level. The temperature elevation is not related to pre-operative oral hygiene scores and gingival index, extraction or amount of soft tissue trauma (Morrow *et al.*, 1986). Also there is no association between post-operative temperature elevation, number of dental procedures and types of treatment performed under paediatric dental general anaesthesia (Holan and Fuks, 1993).

Only a weak correlation has been found between the frequency of complications and the age of the patient, duration of general anaesthesia, and handicapping conditions. In a study of 352 subjects it was reported that the prevalence of post-operative complications was 1.4%. None of the patients suffered any sequelae, or required prolonged postoperative care (Persliden and Magnusson, 1980). No significant relationship was found between the patient's preoperative physical status, trauma introduced during intubation, types of anaesthetic used, length of surgery and the complications occurring postoperatively (Enger and Mourino, 1985).

Pulmonary complications are one of the most serious, life-threatening situations in anaesthesia and cause anaesthesia related morbidity. Yanko and co-workers (1996) described two cases of pulmonary oedema that developed following routine intensive dental treatment under general anaesthesia. The post-extubation obstructions of the upper airway and/or heart failure were possible aetiologies of these complications. Also, the authors further commented that dental treatment under general anaesthesia usually lasts longer than most major surgeries, and although less invasive, the long duration of anaesthesia increased the risk of the complications.

The main airway complications are laryngospasm and stridor. Laryngospasm is usually a transient event but it can be potentially life threatening due to involuntary closure of the glottis by the intrinsic laryngeal muscles. A study on the incidence of laryngospasm

during 156,064 anaesthetics delivered to 136,929 patients reported that the frequency of occurrence was 7.9 per 1,000 anaesthetics and showed that laryngospasm was more common in children than adults. Children up to the age of 9 years had an incidence of 17.4 events per 1000 patients compared to 8.7 per 1000 for the whole population. It was postulated that bronchial asthma and respiratory tract infection was associated with an increased incidence of laryngospasm in children (Olsson and Hallen, 1984).

Stridor is a symptom of many different problems that produces a narrowed, partially obstructed airway. Post-extubation subglottis oedema (croup) occurs occasionally in patients between 1 and 8 years of age (Betts and Downes, 1997). In spite of proper selection of a tube, children that undergo long anaesthetic procedures can still experience post-intubation croup. This is possibly secondary to surgical manipulation of the jaw against the endotracheal tube during the surgery. Dysrhythmia, a common serious cardiac complication associated with general anaesthesia, was reported as the most common intra-operative complication occurring in 112,721 patients at a major teaching hospital (Cohen *et al.*, 1986). A high incidence had also been reported during general anaesthesia for minor oral surgery (Thurlow, 1972; Ryder and Townsend, 1974). Non premedicated children undergoing dental extractions with a halothane-nitrous oxide-oxygen anaesthetic have also been noted to experience cardiac dysrhythmias (Thurlow, 1972; Plowman *et al.*, 1974; Haden, 1985). Other precipitating factors for dysrhythmias include carbon dioxide retention (hypercarbia), tracheal intubation, anoxia or severe hypoxia, and the duration of the general anaesthetic. Occasionally, disturbances of cardiac function may occur with the introduction of throat packs, or associated with the placement of props or gags (Braid, 1989).

Atan *et al* (2004) reported the following:

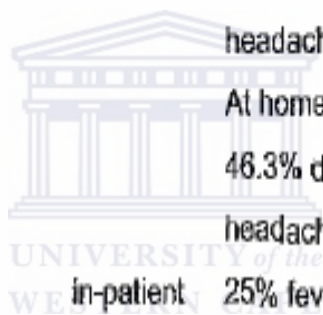
- The morbidity related to GA is less than the morbidity related to dentistry.
- The numbers of subjects complaining of nausea, sleepiness, weakness and dizziness tailed off quickly after the first post-operative examination.
- Dental treatment under GA had a significant effect on the post-operative morbidity.
- Pain following dental GA was the most prevalent and long lasting symptom.

Table 3.3 summarizes the frequencies of complications during and after dental general anaesthesia in the literature:

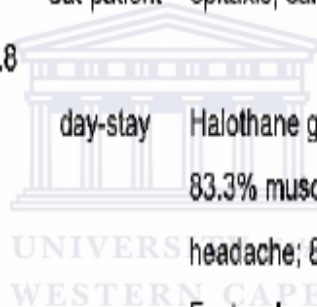


Table 3.3: Studies reporting on the complications of DGA

Authors/ Year	Country	Study period	Sample size	Age range (years)	Types of GA	Complications
Allen 1967	USA	-	-	2-8 median: 4	-	2 persistent vomiting; 1 postoperative stridor; 2 severe hypotension and bradycardia
Robertson et al 1973	UK	1970-1972	199	3-adult	day-stay	1 case of spasticity with chest deformity required bronchial suction; 4 post-operative vomiting.
Smith et al 1976	UK	1973-1974	95	16-60 mean: 29.8	day-stay	In hospital: 72.6% drowsiness; 50.5% dizziness; 18.9% vomiting; 47.4% nausea; 81.1% headache; 27.4% muscle ache; 6.3% pain at injection site. At home: 46.3% drowsiness; 40% dizziness; 8.4% vomiting; 30.5% nausea; 57.9% headache; 33.7% muscle ache; 6.3% pain at injection site.
Nazif 1976	USA	-	80	1.5-16	in-patient	25% fever; 3.75% bleeding; 3.75% hoarseness; 1.25% pneumonia.
Smith et al 1978	USA	1972-1976	318	mean: 6.59	out-patient	7.5% patients developed complications. 5% croup; 2% temperature elevation; 0.3% acute pulmonary edema; 0.3% bleeding; 33% nausea and vomiting.
Libman et al 1979	USA	1970-1978	600	0->31	out-patient	40.3% developed complications. 97.5% post-operative fever.



Authors/ Year	Country	Study period	Sample size	Age range (years)	Types of GA	Complications
Persliden et al 1980	Sweden	1976-1979	352	0-16	-	laryngospasm; allergy to curare; vomiting, hiccup; apnea.
O'Brien et al 1983	Australia	12 years	1316	1.3->15	day-stay	3.8% vomiting; 0.4% extubation spasm; 0.5% restlessness; 0.7% prolong recovery; 1.4% others (sore throat, sore eyes, swollen lips or fever).
Ventura et al 1981	Israel	1972-1978	4000	2-12 mean: 5±0.8	out-patient	epitaxis; cardiac arrhythmias; hoarseness; apnea.
Ogg et al 1983	UK	-	60	16-49	day-stay	Halothane group: 83.3% muscle pain; 62.5% drowsiness; 20.8% nausea; 8.3% vomiting; 62.5% headache; 87.5% sore throat; 20.8% dizziness. Fentanyl group: 8.6% muscle pain; 43.5% drowsiness; 31.4% nausea; 17.4% vomiting; 47.8% headache; 21.7% sore throat; 21.7% dizziness.
Enger et al 1985	USA	1977-1982	200	1-52 mean: 7.7	in-patient	35.5% nausea with vomiting; 11.5% fever; 7.5% cough, sore throat; 4% bleeding; 1.5% lower lip swelling; 1.5% delay recovery.
Morrow et al 1986	USA	-	38	1.5-17 mean: 4.7	in-patient	All the patients had temperature (rectal) elevation. 45% had a significant temperature elevation.



Authors/ Year	Country	Study period	Sample size	Age range (years)	Types of GA	Complications
Holt et al 1991	UK	1/1989- 5/1989	103	9.0±4.4	day-stay	51% oral pain; 27% sore throat; 45% drowsiness; 21% headache; 21% nausea; 20% vomiting; 29% haemorrhage; 12% muscle pain; 14% others.
Bridgman et al 1999	UK	-	80	5-15	day-stay	<p>Immediate post-operation: 28% pain; 44% crying; 11% nausea; 6% vomiting; 7% bleeding; 30% drowsy</p> <p>Journey home: 24% pain; 39% crying; 31% nausea; 5% vomiting; 37% bleeding; 55% drowsy.</p> <p>Immediate post-operation: 19% pain; 37% crying; 18% nausea; 12% vomiting; 15% bleeding; 27% drowsy; 11% not eating.</p>
Enever et al 2000	UK	1996-1997	55	3-17 mean: 10.7	day-stay	<p>Disabled patients: 18% pain; 18% nausea and vomiting; 18% drowsiness; 3% bleeding</p> <p>Anxious but healthy patients: 14% pain; 21% nausea and vomiting; 14% drowsiness; 7% bleeding.</p>



For those children who remain difficult to treat in the dental chair, including medically compromised patients, mentally or physically handicapped children, general anaesthesia offers the opportunity for all the necessary work to be undertaken and so promotes the long-term welfare of the child (Rule *et al.*, 1967). In many cases, properly performed general anaesthesia can represent the best combination of patient safety and acceptable clinical working conditions for the paediatric dentist treating children. General anaesthesia allows a degree of control not possible with conscious sedation and deep sedation (Saxen *et al.*, 1999). It must be emphasized that only under strictly controlled conditions can dental anaesthesia truly be considered to be safe for the treatment of patients. The training, skill, and experience of the anaesthetists as well as the adequacy of the facilities will determine the mode of management (Solomon, 1987). It is also most important to understand that no matter how good the anaesthetic agents or the anaesthetist, or how simple the dental procedure, a real risk is encountered. When general anaesthesia is employed, there is no such thing as minor general anaesthesia. So no one should be given a general anaesthetic without due justification. The application of appropriate selection criteria is imperative (Troutman and Mayer, 1971).

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General anaesthesia has advantages which include the provision of treatment that is safe, efficient and convenient; extensive high quality treatment performed in a single visit, with minimal discomfort to the patient; less physical and mental stress for both the patient and the dentist (Lee and Roberts, 2003; Anderson, Drummond and Thomson, 2004; Wilson, 2004; Atan *et al.*, 2004) and immediate improvement in the Quality of Life (QoL) for both children and their families (Filtstrup *et al.*, 2003; Anderson, Drummond and Thomson, 2004). Peretz *et al* (2000) found that GA is more stressful to the parents than sedation.

3.4 General consideration for provision of dental treatment for children under general anaesthesia.

The decision to perform dental treatment under general anaesthesia is based upon age, ability to cooperate in normal setting, medical status, and extent of treatment required (Clinical Guidelines, AAPD 2005-2006).

Clear justification for the use of general anaesthesia, can be made (AAPD, 1999-2006). Numerous factors must be considered before, during and after the use of general anaesthesia. A full medical history must be taken to determine the child's level of health and hence the ability to cope with the anaesthetic. Consent must be obtained from the parents or guardian after a formal and clear explanation of the benefits and relative risks involved and any alternative methods of pain control, such as conscious sedation or relative analgesia that may be available.

3.4.1 GA and effect on behaviour:

General anaesthesia is a stressful procedure for both the parents and the children, especially at the time of the procedure (Hasting *et al.*, 1994; Peretz *et al.*, 2000). Anaesthesia in an unfamiliar operating room, awakening in a strange recovery room, and strangers all around are all factors for increasing the stress.

Parental behaviour is an important consideration when planning paediatric general anaesthesia. Parents may feel a lack of empowerment to question the decision, and they often describe the period prior to the operation as the most tense and nervous for themselves. The anxiety is further reinforced on the day of the operation. Some parents even feel guilty about putting their child through such an unpleasant experience (Hasting *et al.*, 1994; Peretz *et al.*, 2000). In spite of their misgivings and bad feelings, many parents consider that general anaesthesia is one of the best options because it is painless, requires minimum numbers of appointments for all the dental treatment to be completed.

In spite of all the stress provoked, there is an immediate improvement in the quality of life of the children and their parents (Anderson, Drummond and Thomson, 2004), and an improvement in eating and sleeping capacities (Acs *et al.*, 2001).

General anaesthesia per se does not improve the cooperative behavior of the child. The child still needs to be guided back to cooperate in normal dental appointments after GA (Kupietzky, 2004; Savanheimo *et al.*, 2005).

3.4.2 Local anaesthesia considerations during sedation and general anaesthesia

All local anaesthetic agents can become cardiac and central nervous system (CNS) depressants when administered in excessive doses. There is a potential interaction between local anaesthetic and sedatives used in paediatric dentistry. This can result in enhanced sedative effects and/or untoward events. Therefore, particular attention should be paid to doses used in children (Silver *et al.*, 1994; Wilson, 2000; Wilson *et al.*, 2000).

To avoid excessive doses for the patient who is going to be sedated, a maximum recommended dose based upon mg/kg or mg/lb should be calculated. The dose of all sedatives and local anaesthetics administered must be recorded on the time-based record for each patient. It is beyond the scope of this document to recommend specific dosages of local anaesthetic agents.

Local anaesthetics containing vasoconstrictor agents such as epinephrine for the reduction of post-operative pain, or control of haemostasis during surgical procedures are commonly administered under general anaesthesia. However, the interaction of the epinephrine and halothane could lead to increased cardiac irritability, which may cause cardiac arrhythmias and even fibrillation. The strongest concentration of epinephrine acceptable for use as a haemostatic agent is 1:100,000 or in a dose not to exceed 10ml/10minutes (Troutman and Mayer, 1971). Newer agents, such as Enflurane and Isoflurane possess less potential for causing cardiac complications and safer for use with vasoconstrictors at least in older children and adults.

3.5 Considerations in dental rehabilitation provided under GA.

The strategy for the provision of dental treatment under general anaesthesia is based on the belief that all of the operative and/or surgical procedures have to be completed in one visit (Roberts, 1990). The outcomes of the various treatment modalities and the general health of the child need to be seriously considered prior to the provision of general anaesthesia. Restorative procedures with relatively higher success rates should be selected. In young children or handicapped patients, extraction is usually a preferred treatment option when there is any doubt about the prognosis of a particular treatment procedure. Numerous treatment sessions under local anaesthesia are undoubtedly complicated, time-consuming, and deleterious to the relationship of the paediatric dentist and the child. Hence there are reasons related to the actual procedures to be performed they may affect the decision to opt for general anaesthesia.

3.5.1 Dental treatment under general anaesthesia.

In the planning of dental treatment under general anaesthesia, the current concept is to encourage more radical treatment so as to reduce the need for future repeated general anaesthetic administration (Mason *et al.*, 1995). This is similar to the postulate that extractions should be planned symmetrically, and that simple restorative procedures be adopted for those teeth known to have a doubtful prognosis (Rule *et al.*, 1967). Most studies confirm that restorative procedures and simple extractions are the commonest types of treatment modality in children (Rule *et al.*, 1967; Legault *et al.*, 1972; Mitchell and Murray, 1985; Smallridge *et al.*, 1990; O'Sullivan and Curzon, 1991; Nunn *et al.*, 1995).

Pulp therapy only constitutes a small proportion of all treatment procedures and when used, vital pulpotomy is more frequently employed than pulpectomy. However, pulpotomy is not recommended for those patients with cardiac problems (Harrison and Roberts, 1998). Only a few studies have reportedly included pulpectomy in their treatment options (Legault *et al.*, 1972; O'Brien and Suthers, 1983; Enger and Mourino, 1985; Su *et al.*, 1992; Gizani, 1998).

Some authorities think that extraction is preferred for those teeth with pulp exposures (Allen and Sim, 1967; Robertson and Ball, 1973). It is indicated that no attempt should be made to preserve either anterior or posterior teeth with necrotic pulps but extraction be done (O'Sullivan and Curzon, 1991). By contrast, others have found the preservation of incisors by pulp therapy in children aged three years or younger, even though abscessed or non-vital has proved to be a highly successful procedure (O'Brien and Suthers, 1983; Gizani, 1998).

3.5.2 Clinical outcomes of restorative treatment under general anaesthesia

Definitive, durable, comfortable and functional restorations with a minimum amount of time spent in the dental office are in the child's best interest. Ideally, a restoration should last until the primary tooth is naturally lost through exfoliation (Al-Eheideb and Herman, 2003).

Few studies that have reported the treatment outcomes and the frequencies of retreatment after dental general anaesthesia (Rule *et al.*, 1967; Legault *et al.*, 1972; Roeters and Burgersdijk, 1985; O'Sullivan and Curzon, 1991; Berkowitz *et al.*, 1997). General anaesthesia allows dental treatment to be rendered under optimal conditions, theoretically ensuring ideal outcomes (Tate *et al.*, 2002). A study by Eidelman, Faibis and Peretz (2000) showed that the quality of restorative treatment performed under general anaesthesia was better than the quality of treatment performed under conscious sedation. In this study, over 90% of the restorations placed under general anaesthesia were rated as successful based on the marginal adaptation and anatomic form. Less than 3% had recurrent caries, and 90% of composite strip crowns had good marginal adaptation.

General anaesthesia provides optimum conditions for restorative treatment such as maximum contamination control, immobilization of the patient, efficiency and effectiveness, and elimination of reflexes. In spite of providing optimum conditions for restorative procedures, high restorative failure rates are reported in the literature for treatments provided under GA (Tate *et al.*, 2002).

About 40% of children with management problems needed further treatments in a mean time period of 15.6 months after initial treatment (Legault *et al.*, 1972). In another study 54% of the children developed new smooth surface carious lesions that visibly extended into dentine. This problem occurred mostly in the younger aged children (Berkowitz *et al.*, 1997).

Gizani (1998) mentioned that about 30% of the restorations failed after one year. The result indicated that of the failed restorations, 10% were due to loss of the filling; 7% loss of fillings with caries; and 10% had recurrent caries. In addition, half of the restorations placed in anterior teeth failed mostly due to loss of the restorations, after 12 months, and 20% of the restorations placed on primary molars failed because of recurrent caries. None of the pulpotomized or pulpectomized teeth showed any clinical or radiographic signs of failure of the pulp therapy procedures at the 1-year recall.

The placement of a restoration in a massively decayed tooth will often fail largely due to marginal deterioration resulting from highly demineralized and undermined enamel surfaces. Restorations dependent on the integrity of enamel show high failure rates (Al-Eheideb and Herman, 2003; O'Sullivan and Curzon, 1991).

The UK study by O'Sullivan and Curzon, (1991) reporting on the success rates of different types of restorations under general anaesthesia indicated approximately 33% of the composite resins and glass ionomer restorations failed. The success rates of amalgam restorations and sealants were over 80%, and the stainless steel crowns were the most successful restorations with only 3% needing replacement.

Almedia *et al.*, (2000) found in their study that 17% of the patients treated for ECC required retreatment under GA within two years of the initial full-mouth rehabilitation. Seventy nine percent of the patients required subsequent restorative treatment or extraction at the recall visits which was similar to Legault *et al.* (1972) findings. O'Sullivan and Curzon (1991) evaluated 80 children treated under GA for comprehensive dental treatment from 1984 to 1987, with a minimum of 2-year follow up period. They

found the stainless steel crowns (SSC) and vital pulpotomies showed low failure rate of 3% and 2% respectively, and 29% for amalgam or composite restorations.

Holland *et al.* (1986) demonstrated that the average survival time for an amalgam restoration in primary teeth was only 31 months, and that the age of the child at the time of placement was directly related to the longevity of the restoration (the younger the child the sooner the failure).

The following table (**Table 3.4**) summarizes the frequencies of various caries management techniques provided under GA various studies:



Table 3.4: Studies reporting on various caries techniques under GA.

Authors/year	Country	Study period	Sample size	Age range (years)	Mean number of treatment procedures per patient						
					Rest	Ext	Seal	Pulp	SSC	Strip crown	Surg
Rule et al 1967	UK	1959-1965	225	1.8-15	7.9	6.6	-	-	-	-	0.1%
Allen 1967	USA	-	-	2-8							restorations and extractions
Legault et al 1972	Canada	4 years	300	5.8	4.1	2.1	-	0.6	1.1	-	0.13
Robertson et al 1973	UK	1970-1972	100	3-adult	1.25	1.74	-	-	-	-	
Keniry 1974	UK	6 months	1307	1-16	0.05	2.3	-	-	-	-	0.01
Nazif et al 1976	USA	84 weeks	80	1.5-16	12.3	3.2	-	0.2	0.7	-	-
Smith et al 1978	USA	1972-1976	318	6.59	7.3	4.9	-	-	-	-	-
Persliden et al 1980	Sweden	1976-1979	352	1-16							restorations and extractions
Ventura et al 1981	Israel	1972-1978	4000	2-12 mean: 5							restorations and extractions
O'Brien et al 1983	Australia	12 years	1316	1-15+							restorations and extractions
Enger et al 1985	USA	1977-1982	200	1-52 mean: 7.7	6.1	3.7	-	0.8	3.0	-	0.06

Rest: Restoration; Ext: Extraction; Seal: Sealant; Pulp: Pulp therapy; SSC: Stainless steel crown; Surg: Surgical procedure

3.5.3 Repeat general anaesthesia for paediatric dental treatment.

Sheller *et al* (2003) concluded some factors that may influence the need for a **second** dental general anaesthesia (DGA):

- Patient factors: continued use of the bottle at the time of the GA; difficult personality of the child as reported by the parents; 100% involvement of the maxillary incisor teeth at the time of GA, and poor cooperation in the medical/dental setting.
- Parent factors: failure to return for check up appointments; not brushing the child's teeth, and being in a dysfunctional social situation.
- Strategies that form improved success with high-caries risk patients: aggressive treatment of caries, active postoperative follow up, and education of caregivers.

Albadri *et al.* (2006) found that more radical treatment planning at the first GA appointment incorporating the use of radiographs, identification of the high-caries risk patients and involvement of both the parents and the child in dental prevention and dental education may avoid the use of further treatments under GA. Grant *et al.* (1998) recommended that strict treatment protocol based on the longevity of the various types of restorative procedures need to be developed and followed. The use of pre-general anaesthetic screening and post-operative preventive programs are effective ways of eliminating the need for repeated dental general anaesthesia for retreatment (Gizani, 1998). The child will not voluntarily alter diet or improve oral hygiene habits. The responsibility for changing these habits lies with the caregiver. Parents after GA give more attention to the child dental care especially if a monitoring strategy was applied. Monitoring strategy is an oral-hygienist appointment arranged for child/caregiver couple providing dental education and painless preventive treatment (Savanheimo *et al.*, 2005).

The implementation of these regular review visits after completion of dental rehabilitation under general anaesthesia must be utilized in order to gain a child's cooperation and confidence by providing treatment that is preventive rather than invasive.

Such visits can encompass advice to the parents and children on diet, oral hygiene, and fluoride supplements. Utilization of fissure sealants is important for prevention of caries on newly erupted teeth. The follow-up of these children by the same person is suggested so as to make them feel more relaxed during the dental visit (Gizani, 1998). A similar strategy was used by Sheller *et al.* (2003) also used a similar strategy before the GA which improved the success rate of oral rehabilitation.

While the benefits of performing dental treatment under general anaesthesia are well recognized, it is unjustifiable to subject a child and the parents to the risks of an avoidable repeat general anaesthetic. Therefore, further treatment for these children should be attempted by various behavioural management techniques and performed, if possible, without the use of general anaesthesia (Nunn *et al.*, 1995; Wong *et al.*, 1997).

3.5.4 General anaesthesia and Early Childhood Caries (ECC)

Early Childhood Caries (ECC) is a relatively new term used to describe rampant caries in infants and toddlers (Tinanoff and O'Sullivan, 1997). ECC can be **defined** as the presence of one or more decayed (occult or detected caries), missing (due to caries), or filled teeth in any dentition before the age of 71 months. Contemporary clinical management of ECC is often accomplished using general anaesthesia due to the extensive involvement of the dentition (Berkowitz *et al.*, 1997; Almeida *et al.*, 2000). General anaesthesia allows treatment (oral rehabilitation) to be rendered under optimal conditions, theoretically ensuring ideal outcomes. Despite the high risk for new and recurrent decay in children with ECC following dental treatment under general anaesthesia, few children return for follow-up after treatment (O'Sullivan and Curzon, 1991; Eidelman, Faibis and Peretz, 2000; Tate *et al.*, 2002).

In a study of 300 paediatric patients treated under general anaesthesia, rampant caries was the most common indication for treatment and behavioral management problems the second (Legault, Diner and Auger, 1972). Similar indications were reported when the clinical features of 933 patients of varying ages, who received dental care under GA were examined (Vermeulen, Vinckier and Vandenbroucke, 1991). Sheller *at al.* (2003)

reported that patients' mental or physical condition is the third most common reason for dental treatment under GA after the previous mentioned indications. Non-clinical factors include the availability or convenience of GA facilities in a locality and the attitude to dental general anaesthesia (DGA) (Hastings *et al.*, 1994).

Children with ECC who were treated under general anaesthesia demonstrated significantly higher subsequent caries rates than a control group who were caries-free at the time of GA (Almeida *et al.*, 2000). The authors concluded that a more aggressive approach might be warranted for children with ECC who require treatment under general anaesthesia. Best outcomes following dental rehabilitation under GA may result from aggressive, definite treatment planning of caries management, active follow-up and education of parents (Sheller *et al.*, 2003; Vinckier, Gizani and Declerck, 200; Harrison and Nutting, 2000; Almeida *et al.*, 2000).

The study by Foster *et al.* (2006) summarized the issues concerning paediatric patients rehabilitated for ECC under general anaesthesia:

1. Following the aggressive treatment of ECC using general anaesthesia, more than half of the children (61%) fail to attend their immediate post-operative follow-up appointment.
2. Almost all of the children (87%) attended at least one 6-month recall appointment within 2 years.
3. A trend was found that relapse might be more likely in those that fail to attend immediate follow-up appointment.

Part two: Longevity of restorative materials in primary dentition

The AAPD guidelines for 2005-2006 indicated the following:

“The restorative treatment shall be based upon the results of an appropriate clinical examination and ideally be part of a comprehensive treatment plan.”

1. The restorative part of the paediatric treatment plan shall take into consideration:

- The developmental status of the dentition.
- A caries-risk assessment.
- The patient’s oral hygiene.
- Anticipated parental compliance and likelihood of timely recall.
- The patient’s ability to cooperate for treatment.

2. The restorative treatment plan must be prepared in conjunction with an individually tailored preventive program.

A survey by Forss and Widström (2003) indicated that irrespective of the restorative material, the life-time of restorations in primary and young permanent teeth is shorter than in adults. Primary caries is the predominant reason for placement and replacement of restorations in the primary and the young permanent teeth. (Dunston *et al.*, 1978; Qvist *et al.*, 1990; Majör *et al.*, 2002).

The most frequently used materials for the restoration of teeth in children are amalgam, composite resin, glass ionomer cement, stainless steel crowns and compomer. It is proposed to review the effectiveness over time of these materials.

3.6 Amalgam

Dental amalgam is easy and fast to place and relatively inexpensive (Dunne *et al.*, 1997). Therefore, it can be used by clinicians with minimal experience and expertise. This material has the least operator sensitivity affecting the durability when compared with composite resin and glass ionomer cement. Even in a contaminated operative field, when the amalgam is compromised, it still provides an acceptable treatment outcome.

The dimensional changes are limited but the aesthetics are less than desirable. The toxicity of the mercury component in the amalgam has attracted much criticism and some countries in Scandinavia have abandoned the use of amalgam in children and adolescents. In spite of many challenges and continued disputes, dental amalgam still remains one of the most widely available and frequently used restorative materials for children.

The factors that constitute failure of class II amalgam restorations in primary molars comprise diagnostic error, occlusion error, anatomical error, technical error, tooth fracture and fracture of the material itself (Myers, 1977). Thus, proper management of these factors is essential for the success of a restoration. This is consistent with the results reported by Nelson and Osborne (1981) who showed that four different brands of high copper amalgams in one-and two-surface restorations in primary teeth had a wide difference in the fracture rates at the margins of the different amalgams after 3 years. The minimum periods of success reported for class I and class II for younger children were 48 months and 55 month respectively for those children who had their treatment when younger than 4 years of age (Levering and Messer, 1988).

Webster and Mink (1981) showed that the durability of amalgam restorations is associated with the level of training of the operators. The calculated median survival time of amalgam restorations placed by general dental practitioners in England was 52.8 months and the 5-year survival rate was 45.3% (Wong and Day, 1989). A similar study in Sweden showed that the failure rate of amalgam was 16% after 5 year, which was lower than glass ionomer cements and zinc oxide eugenol restorations (Wendt *et al.*, 1998).

Multisurfaces amalgam restorations consistently display a markedly low survival rate. After one year, the survival rate was just under 80% and after 4.5 years, the rate was well below 40%. Thirty-eight of the 66 amalgam restorations (58%) had to be replaced. The most frequent reasons for the replacement of multiple surfaces were fracture or marginal splitting, and the occurrence of new carious lesions or secondary caries (Einwag and Dunninger, 1996).

Studies also compared the clinical performance of multi-surfaces amalgam with stainless steel crowns (Braff, 1975; Dawson *et al.*, 1981; Wong *et al.*, 1990). More than 88% of multi-surfaces amalgam fillings needed subsequent retreatment over the 33-month study period (Braff, 1975). By contrast, 70% of the stainless steel crowns did not require any further treatment. When treatment was required, 47.8% of the retreatment was only recementation (Braff, 1975). Similar results from a study, which was performed in a hospital dental clinic, showed that 43% of the restorations needed replacement (Dawson *et al.*, 1981). Of these, over 70% of multi-surfaces amalgam restorations in first and second molars, and one-surface restorations in first molars needed replacement. Recurrent caries and fractures were the commonest reasons for replacement. The average service periods of one-surface amalgam restorations and multi-surfaces restorations were 20 and 23 months in first molars respectively; while in the second molars, they were 29 and 28 months respectively. The longevity of stainless steel crown was on average 31 months (Dawson *et al.*, 1981).

A retrospective study compared amalgam and stainless steel crowns reported that 64% of the amalgam restorations needed retreatment, and only 49% of the amalgam restorations remained in the mouth after five years (Eriksson, 1988). Subsequently, Wong and co-worker (1990) calculated the 5-year survival rates of one-surface and multisurfaces amalgams to be 59.6% and 46.7%, respectively. The median survival time of one-surface restorations was longer than multisurfaces restorations. It was concluded that the life span of the restorations was strongly related to the age of patients at the time of treatment, the existence of pretreatment radiographs, the type of amalgam restoration, and the caries susceptibility of the patient (Wong and Day, 1990).

The cavity form also influences the longevity of amalgam restorations. In a short-term study on children with high caries activity, Fuks and coworkers (1984) showed that 90% of class II amalgam restorations were acceptable after twelve months. However, in a 10-year study by a single operator, in children and adolescents attending a specialist paediatric dental practice, the overall failure rates for class I and II restorations in primary molars were 16.7% and 14.7%, respectively (Roberts and Sherriff, 1990). After excluding carious lesions on the proximal and other fresh sites, the corresponding true failure rate reduced to 4.1% and 11.6%. The survival time for amalgams in first and second primary molars was 6.84 years and 8.8 years respectively (Roberts and Sherriff, 1990). Welbury and co-workers (1991) also reported that the failure rate of amalgam in class II restorations was found to be 20.2% after five years and the mean survival time was 41.1 months, which was even lower than the results by Roberts and Sherriff (1990). In general, failures occurred more frequently and sooner among class II than class I amalgams (Fuks *et al.*, 1984; Levering and Messer, 1988; Robert and Sherriff, 1990).

Recurrent caries accounted for 46.5% of the total failed restorations (Welbury *et al.*, 1991), and most of the failures were in class II restorations were due to isthmus fracture or dislodged proximal boxes (Llewelyn, 1977).

The tooth type also influenced the survival rate with the median survival time less than 2 years for first primary molars compared to 3 years for primary second molars. The complexity of the restorations also influences the survival rate. Class I restorations had greater durability than class II and will last longer than any subsequent restorations of the same type in the same tooth (Holland *et al.*, 1986). In addition, amalgam fillings in the mandibular first and second molars exhibited higher failure rates than their maxillary counterparts (Llewelyn, 1977; Vaprio, 1981).

The technique insensitivity of amalgam was verified by a retrospective study in which dental students had placed the restorations. The failure rate of the amalgam restorations alone was 15% (Llewelyn, 1977). A similar finding that was made by Straffon and Dennison (1988) after comparing amalgam restorations to sealants over a period of seven years. By contrast, 21% of one-surface and 26% of two-surface amalgam restorations

placed by expanded-function dental auxiliaries, after 6 months, did not meet the clinical standards and needed to be replaced (Webster and Mink, 1981). The findings of this study demonstrate that the training of the operator has a dramatic influence on the life span of amalgam restorations.

Age at the time of treatment was a significant factor in Vaprio's paper (1993). Children who had restorative treatment at 3 to 5 years of age had a high chance of replacement treatment. In the Levering and Messer (1988) study, 18% of amalgam restorations were judged to be true failures and increasing the age of the child at the time of first placement, the percentage of true failure decreased. More than half of class II amalgam restorations failed among children younger than 4 years old. The 5-year predicted success rate of class I and II amalgam restorations was 79% and 51% respectively. This contrasted with 83% and 70% for class I and class II amalgam restoration respectively, in children older than 4 years (Levering and Messer, 1988). In addition, the existence of age being a significant factor was also found by Hickel and Voss (1990) in a prospective study comparing amalgam and Ketac-Silver restorations in small cavities in 4 to 10 years old children, although, they found no significant difference in cumulative failure/survival rates. In general, the restorations in older children consistently had better results (Wong *et al.*, 1990; Hickel and Voss, 1990).

The association of the longevity of the amalgams and the time of first treatment was postulated in a retrospective study, which analyzed the durability of the amalgam restorations in a group of children less than 10 years of age. The median survival time of amalgam restorations in primary molar teeth of children less than 3 years old was 11.1 months. The median survival time improved to 44 months at age 7 to 8 years (Holland *et al.*, 1986). This study also indicates that the age at that time of placement is a significant variable determining the failure rate, a result similar to the findings by Oldenburg and co-workers (1985) and Vaprio (1981).

The efficacy of several restorative materials in a dental school environment was compared. The median survival time of amalgam was more than 5 years and the 4-year survival estimate was approximately 60%. Which was better than 40% for composite

resins and 5% for glass ionomer cements (Papathanasious *et al.*, 1994). Tonn and co-workers (1980) also reported that the replacement rate of class II amalgam restorations, followed over a two-year period, was lower than for autopolymerized composite resin. The amalgam restorations had better wear resistance than the composites (Tonn *et al.*, 1980). By contrast, if the restorations are placed under optimum conditions, the failure rates of amalgam in class I and class II cavities in primary teeth were higher than the composite resin (Tonn *et al.*, 1980; Roberts, 1985). A large proportion of the failures occurred in the class II amalgam restorations in primary teeth (Oldenburg *et al.*, 1985).

In a prospective study in a Swedish university, amalgam performed less well than light-cured composite resin (Barr-Agholme *et al.*, 1991). Only 68% of the amalgams ranked Alfa or Bravo after two years compared to 88% of the composite restorations. The majority of failures in the amalgam restorations were due to isthmus fracture. Neither the caries activity nor age of the patient at the time of placement of the restoration nor the tooth types seemed to influence the success rate of the proximal restorations (Barr-Agholme *et al.*, 1991).

Qvist and co-workers (1997) confirmed the superiority of amalgam over conventional glass ionomer cement in primary teeth. However, secondary caries was significantly more frequent within amalgam restorations. Glass cermet cement, Ketac-Silver restorations in 5 to 7 years old Canadian children were inferior to amalgam restorations. None of the amalgam restorations had recurrent caries or fractured, and all scored Alfa for the anatomic form after the one-year trial period (Hung and Richardson., 1990). This result is similar to a Swedish study in which a group of children, 4 to 6 years of age, showed that 92% of the amalgam restorations scored Alpha or Bravo after 3 year. Only two restorations required re-placement, which were due to marginal discoloration or secondary caries (Ostlund *et al.*, 1992). Other studies reported that the clinical performance of glass ionomer cement was comparable to amalgam in primary molars (Walls *et al.*, 1988; Hickle and Voss, 1990). Donly (1999) reported that while 30% of the amalgams failed due to secondary caries after three years, the mean survival time of amalgam was 26.2 months. This was similar to the performance of the resin-modified

glass ionomer cements. Walla *et al.* (1988) showed that amalgam displays less wear susceptibility.

The modes of failure of amalgam restoration have been reviewed in many studies. The most frequently recorded reasons for replacement in primary teeth was secondary caries, tooth and isthmus fractures, and poor marginal adaptation (Friedl *et al.* 1994). Similar results were also shown in other studies (Llewelyn 1977, Dawson *et al.*, 1981; Qvist *et al.*, 1986; Einwag and Dunninger, 1996). A retrospective study in Denmark by Qvist and co-workers (1986) assessed the restorative treatment of primary and permanent teeth by general dental practitioners. In primary teeth, more than 50% of the amalgam restorations were for primary caries. While 37% of the newly placed amalgam restorations were replacement for failed previous fillings. The commonest modes of failure were secondary caries, fracture of the old fillings and loss of the restorations. The median survival time of the amalgam restorations in primary teeth was approximately two years, which was slightly shorter than reported in many other studies (Qvist *et al.*, 1986). Several factors influence the durability of amalgam restorations. These include the age at the time of the placement and the complexity of the restoration. Multisurfaces amalgam restorations exhibit the highest failure rates.

Friedl and coworkers (1994) suggested that improvements to the operative technique as well as effective prophylaxis programs and good oral hygiene were essential in promoting the durability of amalgam restorations.

3.7 Composite resin

Composite resin can provide an excellent restoration for primary teeth provided that it is placed with a high quality level of care and skill so as to secure the optimum service period, that is, until the primary teeth exfoliate. Placement of composite resin is complex and moisture control of the operative field greatly affects the success of the final restoration. In addition, shrinkage during polymerization is an inherent problem so small increments of composite resin need to be placed and polymerized in layers so as to minimize the shrinkage. Furthermore, the time required for the placement of composite

resin is longer than of amalgam (Dilley *et al.*, 1990). Therefore, the co-operation of the children must be assured. Composite resin is not cariostatic but it has been stated that it appears to be an acceptable alternative restorative material to amalgam for primary teeth (Nelson *et al.*, 1980).

The marginal discoloration and wear resistance of two composites, in class II cavities, were shown to be inferior to amalgam, although there was no significant difference in the marginal adaptation and occurrence of recurrent caries of these two materials. Nelson *et al.*, (1980) concluded that composite was indeed a reasonable substitute for amalgam for use in the late mixed dentition. When used in a private dental office and evaluated prospectively, 23% of auto-polymerized composite resin restorations needed replacement in comparison to only 13% of amalgam restorations after two years (Tonn *et al.*, 1980). The common modes of failure included excessive wear, marginal failure and recurrent caries (Tonn *et al.*, 1980). Similarly, another Swedish study, also using auto-polymerized composite resin but without bonding agent, in modified class II cavities for the restoration of shallow proximal caries lesions in primary molars produced a similar result (Leifler and Vaprio, 1981). In this study, 63% of restorations were rated as excellent after one year with recurrent caries or fractures being observed in 16% of the teeth. After two years, less than 50% of these restorations were clinically excellent and 18% had failed (Leifler and Vaprio, 1981). Most fractures occurred during the first year, whereas recurrent caries tended to be detected in the second year. At the six years follow up; the failure rate had increased to 46%. The difficulties in clinical manipulation of the composite were stated as the main reason for such high failure rates. The authors recommended that composite resin should not be used for restorations in primary teeth in caries-active children (Vaprio, 1985; Vaprio, 1993). This result is in contrast to the study by Roberts and co-workers (1985), which also used an autopolymerized strontium glass-filled composite resin in primary molars. Their results showed that more than 80% of composite resin restorations had neither evidences of discoloration nor changes in anatomic form and marginal adaptation after 24 months, which were similar to amalgam. However, there was a tendency for the composite resin to change colour and for the margins to stain gradually over time (Roberts *et al.*, 1985). These findings suggest that

composite resins could be successfully used in the restoration of primary molars, particularly in late mixed dentition.

The clinical performance of the light-cured composite resin in primary molars in class II cavities was evaluated according to the United States Public Health Service (USPHS) criteria (Cvar and Ryge, 1971). The ratings for colour match, cavosurface margin discoloration and anatomic form, in term of Alfa and Bravo, were more than 95% after 2 years (Tonn and Ryge 1985). Eight percent of the composite resin restorations had recurrent caries which was comparable to amalgam in the control group. By four years, approximately 80% of the restorations rated as Alfa for colour match, cavosurface margin discoloration and anatomic form and 2% had recurrent caries (Tonn and Ryge, 1988).

Cavity preparation of a design consistent with producing the optimum results from a material should be used. Hence various different cavity preparations have been suggested for the class II composite restorations.

The longevity of composite restorations using a modified preparation with, and without a bevel, and conventional preparation with a bevel were compared in a 2-year study (Oldenburg *et al.*, 1985). There were no statistically significant differences among the three types of preparations or between the two materials used. However, the colour of the materials deteriorated during the observation periods. The failure rates were for the conventional preparation 8.3%; for the modified preparation 21.4%, and the best was the conventional bevel preparation 1.3% (Oldenburg *et al.*, 1985). The 4-year evaluation (Oldenburg *et al.*, 1987) found the conventional bevel preparation had a failure rate of 8.3%, the conventional preparation was 15%; and the modified preparation was 34%. The conventional bevel preparation was recommended for composite restorations of primary teeth (Oldenburg *et al.*, 1987a). The same investigators, Oldenburg and co-workers (1987), using a different light-cured composite resin in another 2-year prospective study concluded that composite resin, owing to limited wear resistance, can not be recommended as a restorative material for young permanent posterior teeth even when placed using rubber dam (Oldenburg *et al.*, 1987 b).

The filling techniques used for composite resin are likely to affect the microleakage at the gingival margin. The study reported by Jorgensen and Hisamitsu (1984) indicated that incremental placement and polymerization reduced the microleakage. A similar result was reported by Liu and co-workers (1987). However, 40% of class II composite restorations had defects at the gingival margin upon radiographic examination, even when placed under local anaesthesia and rubber dam (Eidelman *et al.*, 1989). This study also showed that composite resin performed well at the occlusal margin but presented serious problems in the cervical margin irrespective of whether or not bulk or incremental packing was used (Eidelman *et al.*, 1989).

Holan *et al.* (1996) proposed that a thin layer of amalgam be condensed on the gingival floor of the proximal box to minimize the microleakage at the cervical margin. The 5% failure after 6-30 months was related to secondary caries from the occlusal surfaces and overhangs of amalgam in the proximal box were more common than for composites.

A cross-sectional study which was carried out in Norway (Qvist *et al.*, 1986) reported that 47% of the composite resin restorations placed by the general dental practitioners were used for the replacement of failed composite fillings. The frequencies of replacement were 37% and 35% for primary and young permanent teeth, respectively. The estimated median survival time was less than one year, which was similar to the results for amalgam restorations. According to the authors, neither composite resin, nor amalgam can be regarded as permanent treatment procedures. Secondary caries was the critical mode of failure of composite resins (Qvist *et al.*, 1986; Östlund *et al.*, 1992).

In a study conducted in a dental school, the composite restorations' survival rate was better than glass ionomer cements, but worse than amalgam and stainless steel crowns (Papathanasiou *et al.*, 1994). It was speculated that the young age of the children might have contributed to the high failure rate in the study which highlighted patient cooperation as being an important variable.

In the evaluation of the operating techniques and materials it is possible to find unexpected treatment outcomes. The multi-centres retrospective research in Sweden

reported failure rates that showed the clinical performances of composite resins and compomer were superior to amalgam (Wendt *et al.*, 1998). Another Swedish study evaluating class II restorations in primary molars after two years, concluded that composite resin can be an acceptable alternative to amalgam as a restorative material for primary teeth because the rates of wear were similar (Barr-Agholme *et al.*, 1991).

In summary the overall failure rates of composite resin restorations varied between 2.2% and 39.6%. The longevity of the composite resins restorations is determined by the properties of the material, cavity design, placement techniques, and patient co-operation.

Generally the light-cured composite resins have lower failure rates than autopolymerized composite. The beveled conventional preparation seems to have a higher success rate. The filling techniques to reduce microleakage are still controversial but proper isolation when placing composite resins is essential and a high level of patient co-operation.

3.8 Glass Ionomer Cement

As early as 1977, the glass ionomer cements were being proposed as one of the restorative materials for the primary teeth. Their ability to release fluoride and adhere to enamel and dentine are well documented in the literature. In addition, glass ionomer cements present an additional advantage when treating young and/or difficult children, as they require only a short time to fill the cavities (Hickel and Voss, 1990).

Conventional glass ionomer cements (GIC) were first introduced by Wilson and Kent (1972). GIC are derived from aqueous polyalkenoic acid such as polyacrylic acid and a glass component that is usually a fluoroaluminosilicate. When the powder and liquid are mixed together, an acid-base reaction occurs. As the metallic polyalkenoate salt begins to precipitate, gelation begins and proceeds until the cement sets hard (Wilson and McLean, 1988).

Generally, glass ionomer cements are classified into three main categories: conventional, metal reinforced and resin-modified. In recent years, the condensable or viscous glass

ionomer cements have become available. These were materials which set faster and have a higher viscosity and were originally developed for use with the ART or atraumatic restorative treatment in the developing countries (Phantumvanit *et al.*, 1996; Frencken *et al.*, 1998; Mallow *et al.*, 1998; Ho *et al.*, 1999).

The addition of silver-amalgam particles into conventional glass ionomer cements increases the physical strengths and properties and the radiopacity is also improved (McLean and Gasser, 1985; Williams *et al.*, 1992).

The light-cured resin-modified glass ionomer cements were developed in 1992. In these materials, the fundamental acid-base reaction is supplemented by a second resin polymerization, which is usually initiated by a light-curing process (Sidhu and Watson, 1995).

Glass ionomer cements seem to exhibit a number of advantages over other restorative materials, which could be exploited in paediatric dentistry. However there are also inherent limitations. Glass ionomer cements are widely used in paediatric dentistry and the literatures contains the results of many clinical trials that have investigated the clinical effectiveness of the different types of glass ionomer cements for restoring primary teeth (Kilpatrick, 1993; Cho and Cheng, 1999).

3.8.1 Conventional glass ionomer cement

The absence of undercuts in a cavity does not seem to affect the retention rate of conventional glass ionomer cement restorations in primary teeth because 72% of restorations in cavities without undercut were retained, whilst 77% in undercut cavities were intact (Vlietstra *et al.*, 1978).

Manipulation of glass ionomer cements may well require care because in the study by Fuks and co-workers (1984) in which the treatment was performed by experienced paediatric dentists and under high standard and controlled operative procedures, only 9% of class II conventional glass ionomer cement restorations had acceptable quality after 12

months. Fracture, poor anatomic form and inferior marginal integrity contributed to high failure rate. The authors did not recommend the use of glass ionomer cements to restore carious lesions in children (Fuks *et al.*, 1984).

Glass ionomer cements in class I and II cavities in primary molars, underwent a more rapid rate of loss of anatomical form during the early stages of the clinical trial by Walls *et al.* (1988). The brittle nature of the material and the overall failure rates of glass ionomer cements were not significantly different to amalgam after 2 years. In contrast to Fuks and co-workers (1984), Wall and co-workers (1988) concluded that glass ionomer cement restorations were no worse than amalgam restorations when used to restore primary molars.

Further support for glass ionomer cements came from the study by Forsten and Karjalainen (1990). They evaluated two types of glass ionomer cements in proximal lesions of primary molars. The failure rates were Ketac-fil 16%, and Ketac-Silver 23% after 5 to 14 months. Cavities with, and without the dovetail showed similar success rates. The authors suggested that the glass ionomers were a useful alternative material to amalgam and composite resin for filling small proximal cavities provided they were not subject to high occlusal forces (Forsten and Karjalainen, 1990).

A failure rate of 32.8% for class II glass ionomer cement restorations in primary teeth was reported (Welbury *et al.*, 1991). Most of the failures occurred in children under 8 years old and the mean survival time of glass ionomer cement was only 33 months. The performance of the glass ionomer cement was clearly inferior to amalgam. (Welbury *et al.*, 1991).

Glass ionomer cements were also found to have high failure rates by Papathanasiou and co-workers (1994) and Wendt and co-workers (1998). The 4-year survival estimate of the glass ionomer restoration was only 5%, which was inferior to composite resin, amalgam and stainless steel crowns (Papathanasiou *et al.*, 1994). A similar 5-year failure rate of 36% was reported by Wendt *et al.* (1998). The use of hand mixed type glass ionomer cement which have been shown to be difficult to mix consistently might well account for

the high failure of many glass ionomer restorations (Mount and Makinson, 1978; Billington *et al.*, 1990). Other investigators such as, Qvist and co-workers (1997) have confirmed these findings. They reported that 37% of restorations failed after an observation period of 43 to 50 months, but only two glass ionomer cement restorations failed due to secondary caries over the study period. Recurrent caries has been quoted as a reason for the replacement of glass ionomer cements restorations (Welbury *et al.*, 1991; Wendt *et al.*, 1998). The failed glass ionomer cements restorations frequently fractured at the isthmus in the first and second years (Forsten and Karjalainen, 1990; Ostlund *et al.*, 1992; Qvist *et al.*, 1997).

Interproximal restorations of glass ionomer cement have reported to exhibit failure rates as high as 40% (Ostlund *et al.*, 1992). A retrospective study was done which utilized GIC from the age of six as a routine material for small occlusal and proximal cavities. One-surface restorations (occlusal, buccal and lingual) showed higher failure rate (13%) than the proximal surface restorations (5%) (Vaprio, 1993). Due to the adhesive property of the glass ionomer cement, a proximal microcavity form was proposed and compared to the conventional Black's class II preparations in the study by Andersson- Wenckert (1995). The cumulative failure rate of the microcavity was 25%, and the conventional cavity was 32%. They claimed the restricted dimensions of cavity preparations and the age of the patients could not be ignored.

The recreation of a bulk restorative material might not be an important consideration for the durability of class II glass ionomer cement restorations (Andersson-Wenckert, 1995).

3.8.2 Glass cermet cement

Hickel and Voss (1990) compared the efficacy of the glass cermet cement, Ketac-Silver, with amalgam in primary molars over a period of 44 months. The results indicated that the performance of the cermet was similar to amalgam in term of the marginal integrity and cumulative failure rate in small-sized cavities when placed under rubber dam isolation. By contrast, Hung and Richardson (1990) evaluated the clinical effectiveness of restoring class II cavities in primary molars with Ketac-Silver. After one year, 40% of the

Ketac-Silver restoration had fractured; all were class II and one even had recurrent caries. Therefore, the authors concluded that glass cermet cement did not have the strength to successfully restore interproximal cavities in primary molars. This conclusion was supported by Kilpatrick and co-workers (1995) who compared the durability of Ketac-Silver and a conventional glass in the restoration of class II cavities in primary molar teeth. A total of 23.9% of Ketac-fil and 41.3% of Ketac-Silver restorations failed and the mean survival times were 20.3 months and 25.3 months for Ketac-Silver and Ketac-fil respectively. The proximal margins of the Ketac-Silver restorations were particularly prone to wear and breakdown. The authors postulated that the brittleness of the material, its susceptibility to wear and weaker bond strength to the tooth contributed to the lower durability of metal reinforced glass cermet cements. The authors did not recommend the use of cermet cements for restoring primary molars (Kilpatrick *et al.*, 1995). This recommendation is especially true when large or multiple surfaces restorations are involved because Hoist (1996), who evaluated the clinical performance of Ketac-Silver in primary molars of the children with high caries activity, found that 53.8% had failed after 3 years. The failure rates of one-, two- and three-surface restorations were 50%, 54% and 65% respectively. It can be postulated that the increase in size of a restoration and the number of surfaces per tooth restored will increase the likelihood of failure (Hoist, 1996). Therefore, Ketac-Silver should not be used for restorations in primary molars especially in those with high caries activity (Hoist, 1996; Espelid *et al.*, 1999).

Marks and co-workers (2000) reported results of a one-year study of the improved material Ketac-Molar when applied in "box-only" class II preparations in primary molars. Only two Ketac-Molar restorations showed bulk fracture, one had recurrent caries, no wear was evident; the marginal adaptation and surface texture after one year were comparable at baseline. Possibly the newer versions of the cermet cements will be suitable for use in children.

3.8.3 Resin-modified glass ionomer cement

Resin-modified glass ionomer cements, have been proposed for restoring the primary teeth because of its quick and uncomplicated manipulation. The technique of using

Vitremer Tri-cure System in class II cavities in adjacent primary molars was used by Croll and Helpin (1995). No actual data was available in the article but the authors commented that neither fractures, marginal stains, recurrent caries nor wear subsequently exposed the cavosurface margins in the 250 restorations, and that none of the restorations had required repair, replacement or any other clinical intervention. Although positive, these findings need to be interpreted with caution.

In a controlled study, the clinical performance of resin-modified glass ionomer was evaluated using the United States Public Health Service (USPHS) criteria (Cvar and Ryge, 1971) and compared to amalgam in primary molars by Donly and co-workers (1999). The results showed that the survival times were 26.4 months and 26.2 months for Vitremer and amalgam respectively. This result verified that Vitremer functioned clinically as well as amalgam for class II restorations. In addition, less recurrent caries occurred at the margins of resin-modified glass ionomer (Donly *et al.*, 1999). Resin-modified glass ionomers may, in due time, be a viable alternative material for restoring primary teeth.



3.9 Polyacid-modified composite resin (Compomer)

Recent developments in dental materials technology has led to the introduction of a new category of restorative material, the poly-acid-modified composite resins, also known as Compomers. These materials have two main constituents: dimethacrylate monomers with two carboxylic groups present in their structure, and a filler that is similar to the ion-leachable glass present in glass ionomer cements (Ruse, 1999).

The setting reaction is by resinous photo-polymerization and no acid-base reaction can occur later when the material absorbs water. In the *in vitro* studies, the compomers demonstrate improved physical, chemical and mechanical properties (Attin *et al.*, 1996; Kielbassa *et al.*, 1997), and better wear resistance than traditional, reinforced and resin-modified glass ionomers (De Gee *et al.*, 1997; Gross *et al.*, 2001).

Andersson-Wenckert (1997) evaluated the clinical durability of compomer in class II microcavity restorations in primary molars in multiple centers. The cumulative failure rate after one year was 8% and after two years was 22%, with the operator variation from 12% to 35%. The main mode of failure was loss of retention followed by recurrent caries. These findings suggest that compomers are technique sensitivity.

Dyract was also compared to a hybrid composite resin (Prisma TPH), which was placed in primary molars in a group of 4 to 7 years old children. All restorations were placed under local anaesthesia and rubber dam in this split-mouth designed research. USPHS criteria were used for the evaluation. The wear resistance of Dyract was inferior to TPH, and there was significantly more marginal staining in the Dyract restorations than in the TPH composite. Only one restoration in each group failed and both were class II restorations. The failure could be explained by the proximal slice design for preparing class II restorations, which may not provide adequate retention. The authors suggest that Dyract can be considered as one of the suitable alternatives to amalgam for restoring primary teeth (Hse and Wei, 1997).

Using a similar split-mouth design, the clinical properties of compomer, when compared to amalgam, were reported by the study of Marks and co-workers (1999). The result indicated that the marginal adaptation and surface texture of Dyract were better compared to amalgam after 36 months. However, the colour stability of Dyract was poor, probably due to the water adsorption. The failure rate was low at 4%, but it represented only 24 Dyract restorations which had been reviewed in the study (Marks *et al.*, 1999). A 24-month prospective clinical study also reported similar results for Dyract restorations (Papagiannoulis *et al.*, 1999). This study reported that the failure rates were 0% after 6 and 12 months and increased to 10% at 24 months. Dyract exhibited significant deterioration in the marginal integrity with 44% of the restorations having crevice formation after 24 months. Restorations required replacement due to isthmus fracture and secondary caries located adjacent to cervical margins (Papagiannoulis *et al.*, 1999).

The cumulative failure rates for Dyract and TPH were 8.9% and 15.2% in a 3 years study by Leung (1998). All of the failed restorations were class II restorations. Dyract was

comparable to TPH on colour stability, recurrent caries incidences and anatomic form changes. However, TPH was significantly better than Dyract on marginal discoloration, marginal integrity, and wear resistance (Leung, 1998). The more recently available compomer restorative materials, Compoglass F and Hytac Apltip, were also evaluated in the same clinical trial (Leung, 1998). After 12 months, no dislodgement, secondary caries, post-operative sensitivity nor non-vitality was reported. The similarity of both compomers in colour match, marginal adaptation, anatomic form and wear resistance were also reported (Leung, 1998). Based on the lower failure rates, ease of handling and clinical characteristics of all three compomers, the author suggested that compomer was a suitable alternative to composite resin restorative material for primary teeth. This suggestion was supported by Mass and co-workers (1999), who also showed that the frequency of occurrence of overhangs at the cervical margin of Dyract restorations was less than for amalgam. A suggestion that was also confirmed by Kavvadia *et al.* (2004).

Hse *et al.* (1999) claimed the clinical performance of the polyacid-modified composite resins has not been comprehensively evaluated because they have only been on the market for a few years. Later various studies showed that polyacid-modified resin composites are advocated for use in class II cavity preparation in primary teeth (Duke, 1999; Garcia-Godoy, 2000; Kavvadia *et al.*, 2004)

3.10 Summary of longevity of the restorative materials in the primary dentition:

Hickel *et al.* (2005) reviewed the literature concerning the longevity of the occlusally stressed restorative dental materials in primary teeth and the following was found:

Amalgam restorations:

- Annual failure rate for class I amalgam ranged between 4.4% and 18.4% for class II from 0% to 37.2%; for the multi-surface restorations 19% to 30.7%.
- GIC is comparable to amalgam in 2-year survival period but significantly less durable in 5-year survival periods.

- Main reasons for failures were primary caries, pulpal complications, operator errors, insufficient marginal adaptation and secondary caries.

Glass ionomer restorations:

- Annual failure rates for class I ranged between 0% to 17%, for class II between 2.2% to 25.8%.
- Resin modified glass ionomers showed less annual failure rates than the conventional or cermet glass ionomers.
- Better marginal adaptation and better mechanical properties were reported for Vitremer (a resin modified glass ionomer).
- Main reasons for failures were primary caries and fracture/loss of the restorations.

Composite restorations:

- Great controversies are found in the studies comparing composite to amalgam.
- In the longest running study concerning composite restorations in primary molars (Varpio, 1985) found the failure rate over 6-year period as high as 46%.
- Main reasons for failure were time-dependent: in the first year fractures occur, in the second year recurrent caries is detected, and reduced Occlusal height in the third and fourth years of restoration loading life.

Compomer restorations:

- Compomers have superior esthetic and mechanical properties to all types of GIC restorations.
- Success rate for class I ranged from 74% to 100%, class II from 70% to 93.3%.
- The type of conditioner used had no effect on the success rate.

Many variables have been reported to influence the outcome of the restorative treatments and the longevity of dental restorative materials used in the primary dentition.

CHAPTER FOUR: AIMS AND OBJECTIVES.

The aim of study was to assess the comprehensive dental treatments provided to children under general anaesthesia at Tygerberg OHC.

The objectives of this study were to determine:

- a) The profile of patients treated under GA.
- b) Types of dental treatment provided under GA conditions.
- c) The status of the restorative procedures performed under GA.
- d) The oral health status and practice of the child post GA.



CHAPTER FIVE: MATERIAL AND METHODS.

Study design:

The study was cross-sectional retrospective study, with clinical oral examination of the children treated under GA.

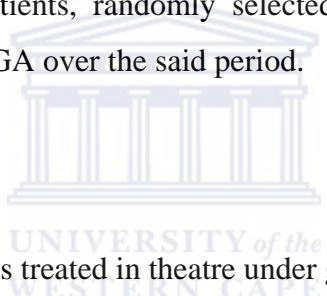
Study population:

Paediatric patients treated under GA at Tygerberg OHC in 2004.

Sample size:

A minimum of 60 healthy patients, randomly selected from the bank of records at Tygerberg OHC, treated under GA over the said period.

Inclusion criteria:

- 
- Healthy pediatric patients treated in theatre under general anaesthesia in 2004.
 - Treatment must have included restorative procedures (extraction only cases will be excluded).
 - Age of the patients ranging from 18 months to 72 months on the day of GA appointment.

Clinical Performance Criteria:

A restoration was assessed to be acceptable/ unacceptable according to **Ryge G. clinical criteria's scores: Alfa, Bravo, Charlie and Delta** (1980). Charlie (**C**) and Delta (**D**) represent the unacceptable results. There are five (5) modified rating scales (classification systems). Of these, only margin adaptation and caries presence were used. Anatomic form, Colour matching and margin discoloration were excluded.

- **Margin adaptation: C:** presence of crevice or ditch along the margin into which the explorer can penetrate and deep enough to expose dentin or base material. **D;** Lost or mobile restoration.
- **Caries presence:** an area at the restoration margin was considered **carious C** if there was evidence of one or more of the following: Softness; Opacity at the margin due to demineralization or undermining, Explorer caught or resisted removal after insertion in the suspected area with moderate to firm pressure.

Presence of plaque was assessed using **Percentage (%) Sites with Plaque Index** using the tip of dental probe moved along the gingival margin and unaided eye for visible plaque. The **%** of Plaque-present surfaces (whole mouth) was calculated for each participant using the following formula:

$$\% \text{ of plaque-present surfaces} = \frac{\text{No. of surfaces with score 1 or more}}{\text{Total number of surfaces}} \times 100\%$$

Presence of gingivitis was assessed using **Percentage (%) Sites with Gingivitis Index**, unaided eye (Inspection) will be used without probing.

Data collection:

Parents were contacted for the oral examination of the paediatric patient. This was done by phone calls and/or letters to inform parents about these examination appointments.

Patients were informed about the study and consent obtained (appendix 1). Two calibrated examiners examined patients. Data was recorded on data collection sheets (appendix 2).

Restorative clinical performance data were tabled in a special form for each patient (appendix 3) for statistical analysis and ease of study.

Examiners Calibration:

Inter-examiner calibration was performed before the study began. Both examiners examined five patients clinically for training and consistency. Intra-examiner calibration was done by a third person (staff member in Pediatric Dentistry Department). During the oral examination of the study population, sterilized dental probes, sterilized oral mirrors and visual inspection were used in examining the restorative treatments' clinical performance. When the two examiners recorded different data concerning a restoration (or more), the different findings were re-assessed by both examiners **together** until an agreement was approved by both.

Data analysis:

Statistical analysis of data was performed in consultation with a statistician. *P* value was adjusted to <0.05. Simple descriptive stats and correlation analysis tests were performed. An appropriate commercially available statistical package was used for analyzing the data (SPSS 13.0, SPSS Inc.).

CHAPTER SIX: RESULTS.

6.1. Profile of the Sample

6.1.1 Age at the GA:

A total of 60 children were examined. Their ages ranged from **21 months** to **70 months**. The mean age for the study population was **44.78 months**. The frequencies of the ages are presented in table the frequencies of the age are presented in **table 6.1**. Sixty one percent (61%) of the sample were younger than 4 years old.

Table 6.1: Sample by the age frequency.

Age Groups (months)	Frequency (N)	Frequency %
21-36	19	31
37-48	18	30
49-60	13	22
61-70	10	17
Total (N)	60	100%

6.1.2. Gender:

Twenty five males (**41.7%**) and thirty five females (**58.3%**) formed the 60-child study sample.

6.1.3. Weight:

Weights of the patients at the time of the GA ranged from **10kg** to **25.5 kg**, with a mean of **14.8 Kg**. Half the study sample weights were below **14** kilograms at the time of GA. Table 6.2 shows the frequencies of the sample weights divided into groups.

Table 6.2: Sample by weight (kg) frequency

Weight groups (kg)	Frequency (N)	Frequency (%)
10 to 13	24	40
14 to 18	26	43
19 to 26	10	17
Total (N)	60	100

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6.1.4. Plaque and Gingivitis:

The plaque percentile index (Table 6.3) had a mean of **37.6%**. Seven children (12%) had no plaque. But eighteen children had plaque on one third of the dental surfaces.

Table 6.3: Frequency of Plaque Percentile Index.

Plaque index %	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 0	7	11.7	11.7	11.7
10	1	1.7	1.7	13.3
25	6	10.0	10.0	23.3
30	18	30.0	30.0	53.3
35	2	3.3	3.3	56.7
40	5	8.3	8.3	65.0
45	2	3.3	3.3	68.3
50	8	13.3	13.3	81.7
60	5	8.3	8.3	90.0
75	3	5.0	5.0	95.0
90	3	5.0	5.0	100.0
Total	60	100.0	100.0	

Gingivitis (Table 6.4) was minimal in comparison to the plaque presence (mean value of the percentile gingival index was **5.8%**).

Table 6.4: Frequency of Gingivitis Percentile Index.

Gingivitis percentile		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	41	68.3	68.3	68.3
	10	10	16.7	16.7	85.0
	25	4	6.7	6.7	91.7
	30	5	8.3	8.3	100.0
	Total	60	100.0	100.0	

6.1.5 dmft and new carious lesions:

The pre GA **dmft** was obtained from the records (pre GA dmft = 10). Any new carious lesion affected the treated teeth on a new surface (other than the restoration margins) was recorded. These new carious lesions ranged from **one new carious** lesion (10 patients) to **ten new carious** lesions in one patient. The mean was **2** new carious lesions. Six children did not develop any new carious lesions (10%) at the time of the examination. Forty four patients (73%) developed two new carious lesions or more.

Table 6.5: Frequency of new carious lesions (post GA).

New caries		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	6	10.0	10.0	10.0
	1	10	16.7	16.7	26.7
	2	26	43.3	43.3	70.0
	3	11	18.3	18.3	88.3
	4	6	10.0	10.0	98.3
	10	1	1.7	1.7	100.0
	Total	60	100.0	100.0	

6.2. Dental treatments and Oral hygiene visits

6.2.1. Oral hygiene visits:

As a part of the GA protocol at the O.H.C. all patients should receive at least two pre-GA appointments. In these appointments preventive measures such as fluoride applications and oral prophylaxis are applied. Patients are also recalled after the GA appointments to assess the status of the oral health. The following Table 6.6 shows the frequencies of number of oral hygiene visits after the GA appointment (mean number of visits was 2). Eleven children (18%) did not keep the appointments of the post GA oral hygiene visits. The rest of the sample attend at least one appointment.

Table 6.6: Frequency of post GA oral hygiene visits.

Post GA O.H.	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 0	11	18.3	18.3	18.3
1	15	25.0	25.0	43.3
2	18	30.0	30.0	73.3
3	8	13.3	13.3	86.7
4	2	3.3	3.3	90.0
5	1	1.7	1.7	91.7
6	1	1.7	1.7	93.3
7	1	1.7	1.7	95.0
8	2	3.3	3.3	98.3
10	1	1.7	1.7	100.0
Total	60	100.0	100.0	

6.2.2. Fissure sealants:

Patients also received fissure sealants on the primary teeth. If the fissure sealant was applied in conjunction with a restorative material this was considered a filling. Fillings were examined according to the clinical performance criteria. Since the age of the study population did not exceed 72 months, fissure sealants applied to first permanent molars were not examined. A total of 52 fissure sealants were applied in 21.7% of the sample (13 children).

Table 6.7: Frequency of fissure sealants applied.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0	47	78.3	78.3	78.3
	2	2	3.3	3.3	81.7
	4	8	13.3	13.3	95.0
	5	2	3.3	3.3	98.3
	6	1	1.7	1.7	100.0
	Total	60	100.0	100.0	

6.2.3. Extractions:

All children had one or more extraction (**Table 6.8**) as part of their treatment. A total of **Two hundred and sixty** extractions were performed on the study population, mean was **4**. Twenty five patients (42%) required more than five extractions at the time of the GA.

Table 6.8: Frequencies of dental extractions.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	9	15.0	15.0	15.0
	2	8	13.3	13.3	28.3
	3	6	10.0	10.0	38.3
	4	12	20.0	20.0	58.3
	5	6	10.0	10.0	68.3
	6	10	16.7	16.7	85.0
	7	3	5.0	5.0	90.0
	8	3	5.0	5.0	95.0
	10	1	1.7	1.7	96.7
	12	2	3.3	3.3	100.0
	Total	60	100.0	100.0	

6.2.4. Fillings:

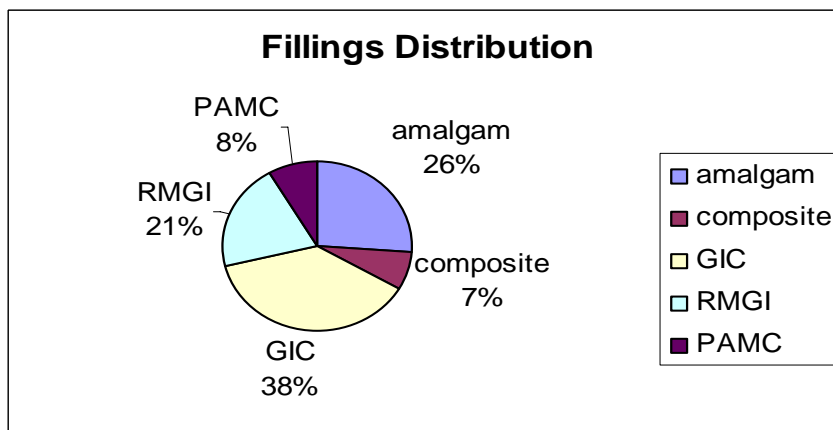
A total of **three hundred** fillings were replaced (**Table 6.9**) with arrange of 1 to 13 fillings per child and a mean of **5**.

Table 6.9: Frequency of fillings replaced.

No. Fillings/ child	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 1	5	8.3	8.3	8.3
2	8	13.3	13.3	21.7
3	6	10.0	10.0	31.7
4	8	13.3	13.3	45.0
5	6	10.0	10.0	55.0
6	13	21.7	21.7	76.7
7	4	6.7	6.7	83.3
8	2	3.3	3.3	86.7
9	6	10.0	10.0	96.7
10	1	1.7	1.7	98.3
13	1	1.7	1.7	100.0
Total	60	100.0	100.0	

The 300 fillings consisted of: **twenty two** composite restorations (7%), **twenty five** poly-acid modified composite restorations (8%), **sixty two** resin modified glass Ionomer (21%), **seventy eight** amalgam restorations (26%), and **one hundred and thirteen** glass ionomer cement restorations (38%). **Figure 6.1** displays the distribution of the fillings by the restorative material.

Figure 6.1: Filling distribution by filling material.



6.2.5 Fillings clinical performance:

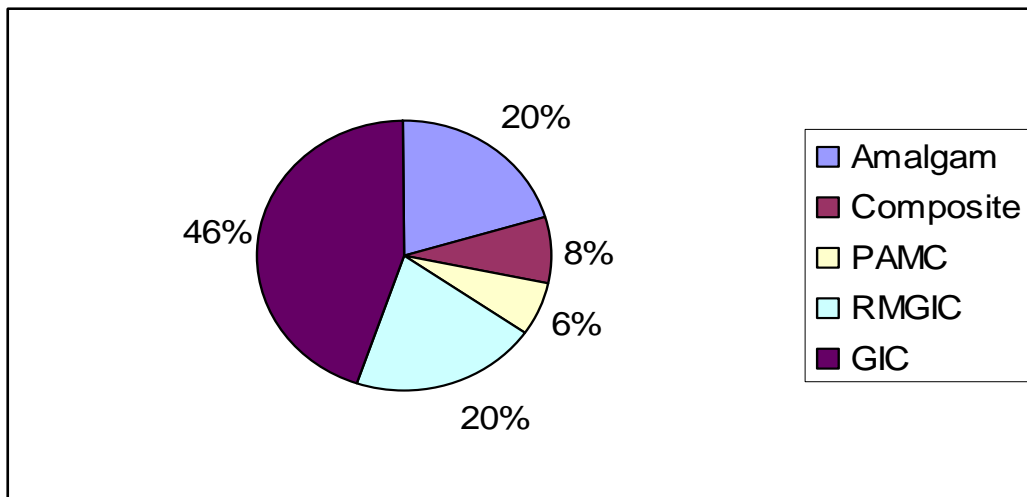
The combined **Charlie** and **Delta** criteria were considered. **One hundred and sixteen** fillings failed with a mean of **2**. Twelve children (20%) had no fillings failure. Forty six children (77%) had one to 4 filling failure.

Table 6.10: Frequency of filling failure.

Failure/child	Frequency	Percent	Valid Percent	Cumulative Percent
Valid 0	12	20.0	20.0	20.0
1	14	23.3	23.3	43.3
2	15	25.0	25.0	68.3
3	8	13.3	13.3	81.7
4	9	15.0	15.0	96.7
5	1	1.7	1.7	98.3
7	1	1.7	1.7	100.0
Total	60	100.0	100.0	

The restorations showed the following: Composite mean failure percentage was **50%**, GIC restoration was **39%**, PAMC was **33%**, RMGI restoration was **31%**, and amalgam was **26%**.

Figure 6.2: Frequency of filling failure by restorative material.

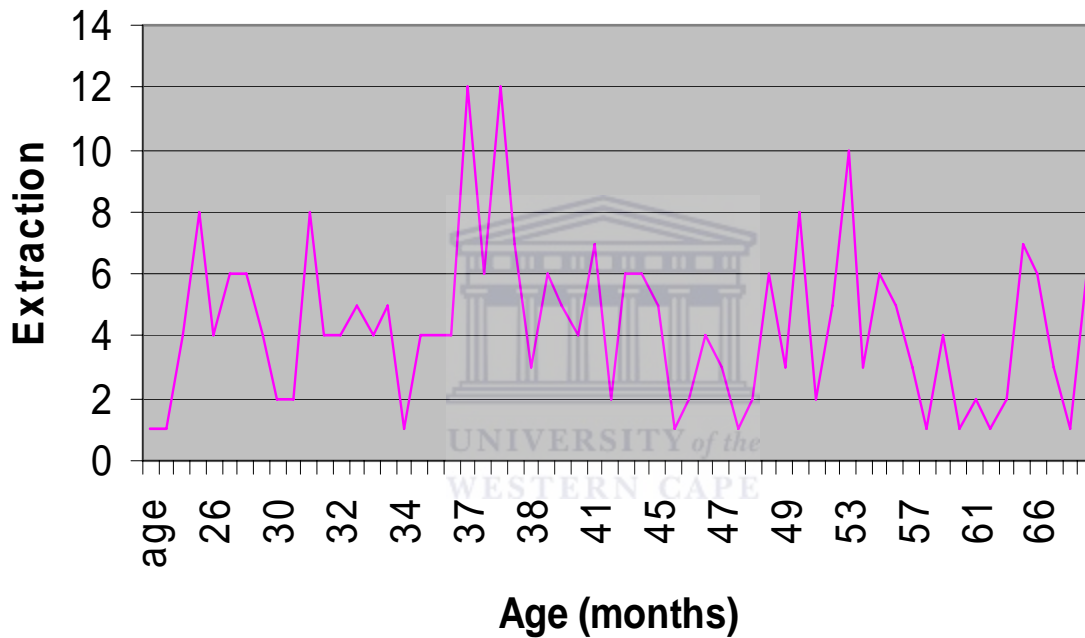


6.3 Statistical Correlations:

6.3.1. Age versus extractions:

For the ease of the statistical analysis, the study population was divided into two age groups (The age 44 months was chosen). No significant correlation in either of the groups was observed ($P=0.22$ and 0.24 respectively). Figure 6.3 demonstrates the correlation.

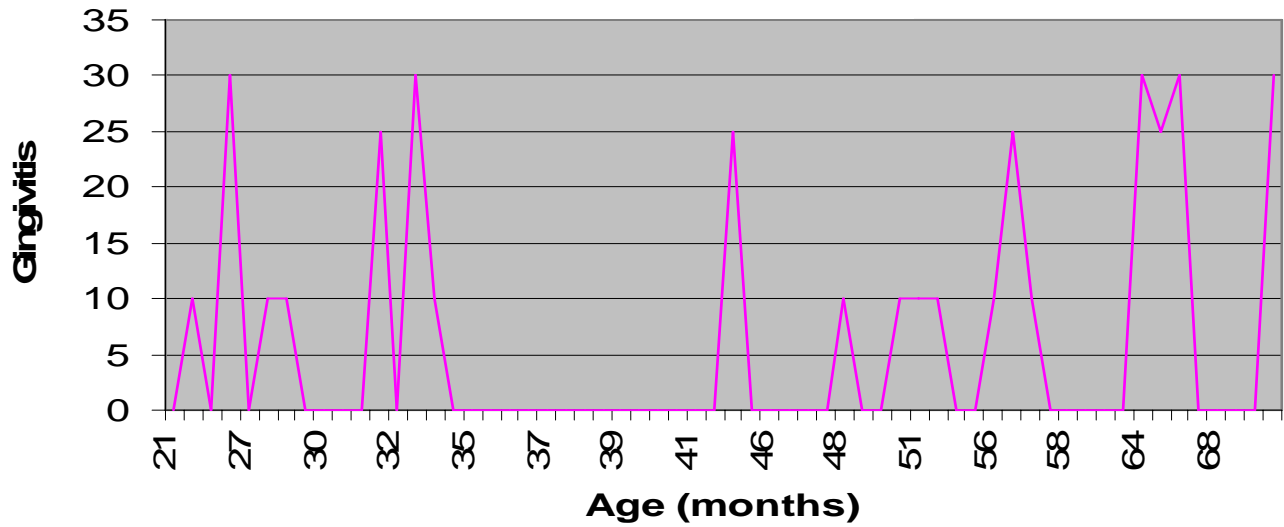
Figure 6.3. Extraction Vs. Age



6.3.2. Age, and oral health.

Plaque and gingivitis were both measured using percentile indices. There was a clinical correlation with plaque presence and gingivitis ($P=0.002$). There was no significant relationship between age and gingivitis (P -value = 0.1).

Figure 6.4: Age Vs. gingivitis.



6.3.3. Age, total fillings and total fillings failure:

Significant correlation was not found between the age distribution and the number of fillings placed or failed.

Figure 6.5: Age Vs. total fillings.

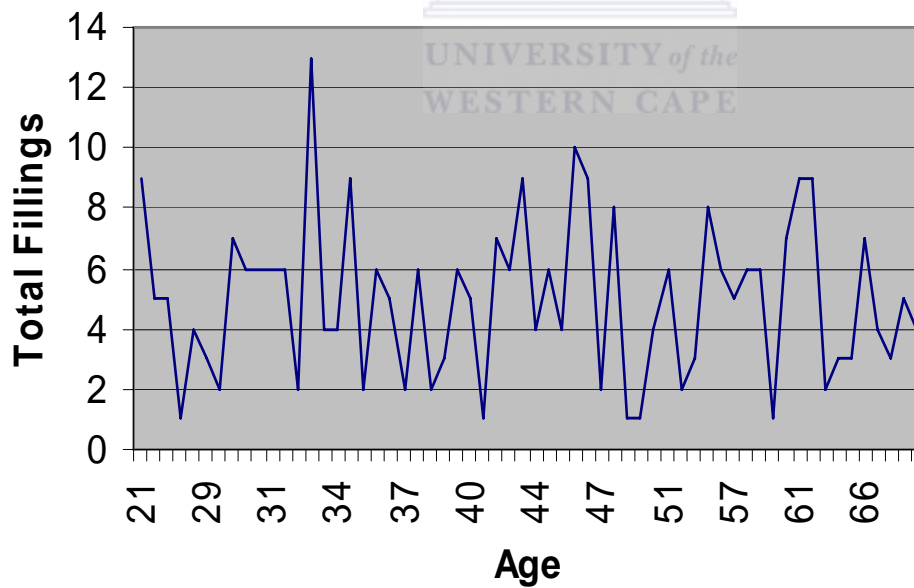
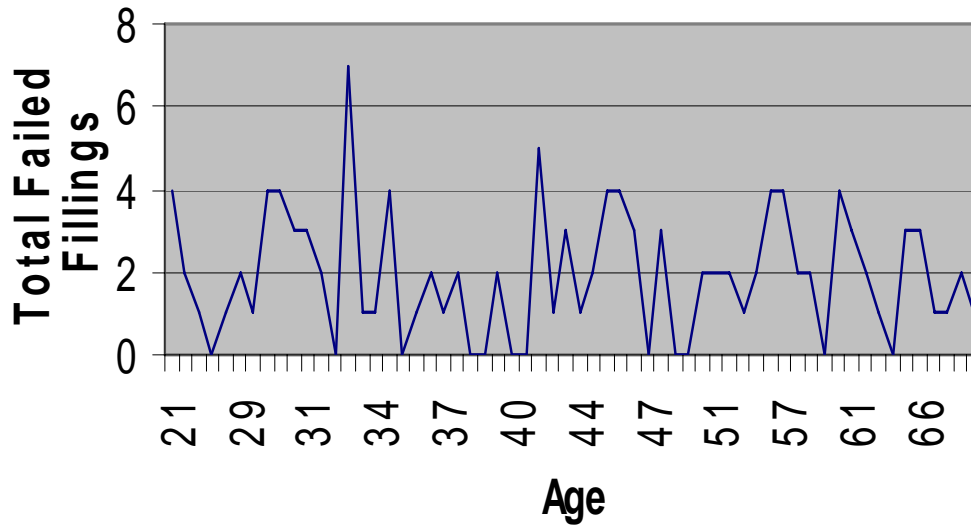


Figure 6.6: Age Vs total failed filling.



6.3.4. Gender, extractions fillings and filling failure:

Gender did not influence the number of extractions, number of the fillings placed nor the number of fillings failed on the study population. In fact the numbers were correlated to the same percentage males and females consisted.

Figure 6.7: Extractions Vs Gender.

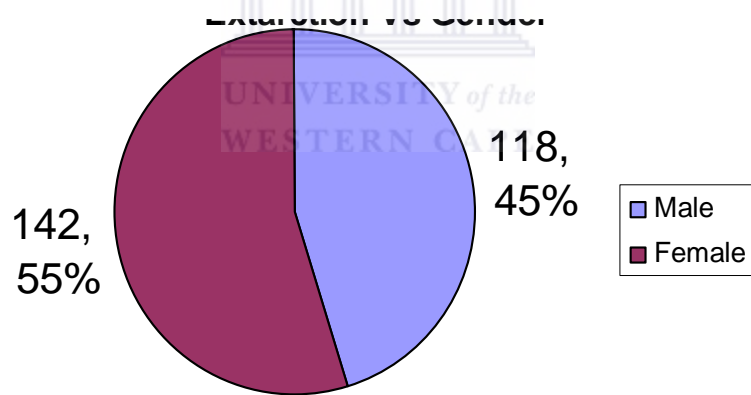


Figure 6.8: Total fillings Vs. Gender.

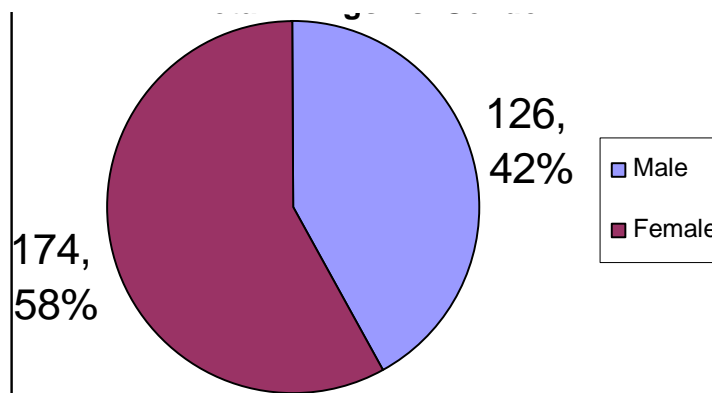
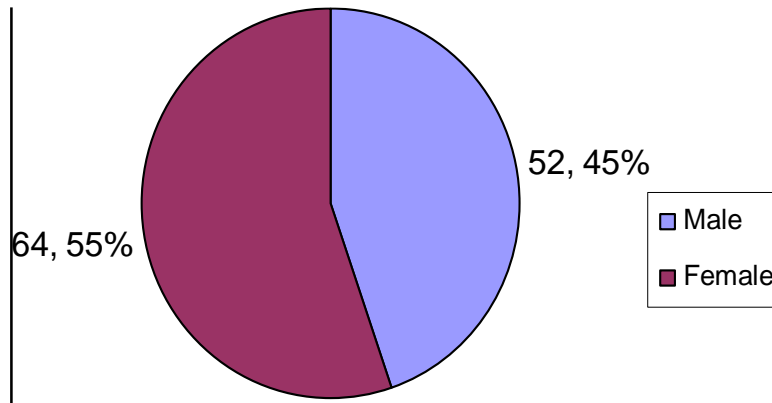


Figure 6.9: Total fillings failure Vs. Gender.



CHAPTER SEVEN: DISCUSSION.

The bank of the records for the year 2004 at Tygervberg Oral Health was examined for the study population inclusion criteria. Two hundred and thirty eight paediatric patients were treated in 2004. Eighty patients met the criteria and were invited to participate in the study by phone calls. Only 60 patients kept the appointment and were examined.

A child's behaviour in the dental environment is one of the crucial factors in determining the treatment modality to offer to that child. Conventional non-pharmacological behaviour management techniques can help most children to expand their boundary of co-operation and let them alleviate, or minimize their fear and anxiety, so as to improve their responsiveness. However, the extent of such boundaries varies amongst individuals.

The study population has suffered from ECC manifestations and required the use of GA for the contemporary management due to the extensive involvement of the primary dentition. This confirms the findings of Berkowitz *et al* (1997) and the more recent Almeida *et al* (2000) studies. The findings show that most children in this study needed at least 5 extractions and four fillings.

Holland *et al* (1986) demonstrated that the age of the child at the time of placement of fillings was directly related to the longevity of the restoration (the younger the child the sooner the failure). In this study the age was not related to the failure ($P = 0.13$). But the study population was very young (age mean value was only **44.8 months**) with extensive treatment need. This may correlate with the findings of the study by Holland *et al.* (1986).

In this study, more girls than boys received dental general anaesthesia. This gender imbalance has been reported in several other studies (Legault *et al.*, 1972; Mclaughlin, 1987; Holt, 1991; Gizani, 1998). In contrast, numerous studies (Vermeulen *et al.*, 1991; Holt and Rule, 1992; Thomson, 1994; Holt *et al.*, 1999) found that more male patients underwent general anaesthesia. There is no evidence to support gender as being a variable of dental caries incidence.

The treatment strategies that had been used for the treatment of children, with ECC, under general anaesthesia were reviewed so that the present treatment protocol can be evaluated. Results from this study showed that restorative treatment techniques were slightly more frequently used in preference to extractions. On average, **10** carious primary teeth were treated in one general anaesthetic session, of which **300** of them were restored with various restorative materials.

In this study, the mean number of restorative procedures (composite resins, amalgams, glass ionomer cements, compomers) and simple extractions per patient were **5** and **4.33** respectively. These figures are similar to those reported in England, USA, Scandinavia and Taiwan (Rule *et al.*, 1967; Smith *et al.*, 1978; Roeters and Burgersdijk, 1985; Bohaty *et al.*, 1992; Nunn *et al.*, 1995).

It is now well accepted in paediatric dentistry that preventive dental treatment should be integrated into every treatment protocol (AAPD 2005-2006). The effectiveness of sealant in caries prevention is well documented (Simonsen, 1991; Gray, 1999). Grindefjord *et al.* (1995) reported that majority of the new carious lesions in young children were located on the occlusal surfaces of second primary molars. The number of teeth restored with fissure sealants (**52** teeth) was small compared to the number of fillings and extractions, **300** and **260** respectively. This may indicate the extensive involvement of the primary teeth at the time of GA.

None of the study population had a repeat GA appointment. Albadri *et al.* (2006) found that more radical treatment planning at the first GA appointment incorporating the use of radiographs, identification of the high-caries risk patients and involvement of both the parents and the child in dental prevention and dental education may avoid the use of further treatments under GA. The population of this study received preventive treatments before the GA appointment. This may have raised the awareness of the parents about the importance of oral health practices in their children.

The low incidence of repeat general anaesthesia of the present study can be explained by a less conservative approach. Our findings showed that on average 4 carious primary teeth were extracted from each child. Badly damaged teeth with a questionable prognosis

and non-vital teeth were routinely extracted; therefore, this probably helped to reduce the incidence of retreatment in the short term of time.

Although, prevention is one important factor determining the outcome of comprehensive dental treatment for children with a high caries experience, parental attitude towards oral health is also important. Therefore, the follow-up of the children who had a high susceptibility to dental caries should include a component to try to modify the oral health habits and knowledge of the family (Gizani, 1998).

General anaesthesia per se does not improve the cooperative behavior of the child. The child still needs to be guided back to cooperate in normal dental appointments after GA (Savanheimo *et al.*, 2005). The child will not voluntarily alter diet or improve oral hygiene habits. The responsibility for changing these habits lies with the caregiver.

Parents after GA give more attention to the child dental care especially if a monitoring strategy was applied. Monitoring strategy is an oral-hygienist appointment arranged for child/caregiver couple providing dental education and painless preventive treatment. (Savanheimo *et al.*, 2005). Sheller *et al.* (2003) also used a similar strategy before GA, which improved the success rate of oral rehabilitation. Population of this study still suffered increase in the dmft after GA. A mean of 2 new carious lesions affected the study population at the time of examination.

In addition, the social and cultural factors need to be considered. Although no specific data are available, most of the parents seemed to be satisfied with the treatment and accepted the value of dental general anaesthesia.

Most parents are unwilling to agree to their child undergoing general anaesthesia for dental treatment a second time. Intrinsic fear, apprehension and guilty may have taken root in the parents' minds. Sheller *et al.* (2003) confirmed the previous findings. It was considered as Parents' factors in their study. Moreover, the attitudes of the dentists towards second general anaesthesia will also influence the parents and finally the numbers of repeat general anaesthesia.

In spite of improving the quality of the restorative techniques and eliminating treatment techniques with poor outcomes, post-operative preventive treatment and oral health education are essential to eliminate further dental disease (AAPD Guidelines 2005-2006). In this study, on average, **two** new carious lesions developed on the primary dentition after the GA appointment. This is similar to Berkowitz *et al.* (1997) and Almeida *et al.* (2000) findings.

As a part of the GA protocol in O.H.C. 'All patients should receive at least two pre-GA appointments. In these appointments preventive measures (Fluoride applications, oral prophylaxis, ART) are applied. Patients are also recalled after the GA appointments to assess the status of the oral health'. Only **18%** (eleven patients) of the study population skipped the post GA oral hygiene visits. Mean number of visits was **2** with a total of **127** visits.

Most of the materials used for restorations were available in the operating theatre. No rigid guidelines had been established for the selection of restorative materials and techniques, so they merely depended on the operators' preference.

Furthermore, a 10-year study in England reported that the true failure rate of class I and II amalgam restorations were 4.1% and 11.6% after exclusion of the fresh caries sites on the teeth. This single operator study presented a better result on the amalgam restorations. It showed that the survival times in primary first and second molars were 6.84 and 8.8 years respectively (Roberts and Sherriff, 1990). Amalgam in our study showed higher failure rate (26%) for class I and class II collectively. Most of the amalgam fillings were class I restorations.

Levering and Messer (1988) indicated that the minimal periods of success for class I and II amalgam restorations were 48 and 55 months for children under 4 years of age respectively.

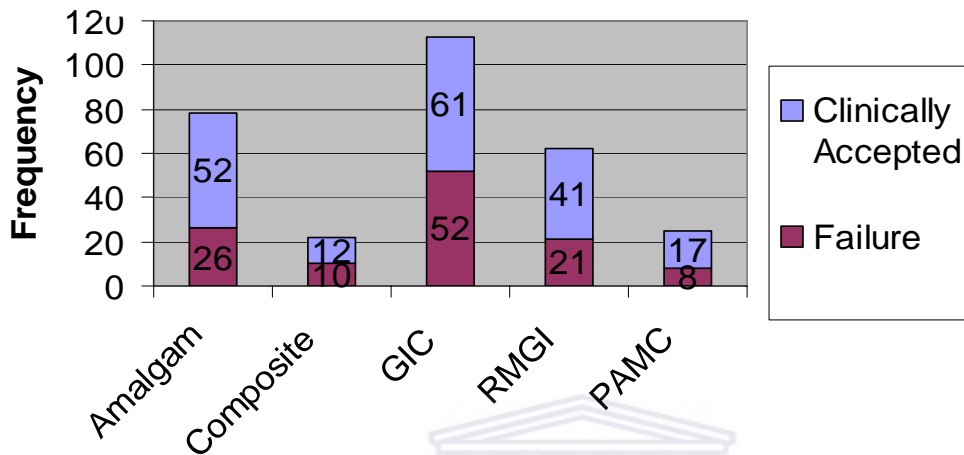
The utilization of the aesthetic restorative materials increased rapidly after the introduction of the light-cured composite resins in the mid- 1980's. Our study reported that **74%** of the restorative procedures were performed using tooth-colored restorative materials. The demand for the tooth coloured restorative material has increased; the improvements in the properties and clinical performance of the composite resins are according to literature, the likely reasons for the increase in the utilization of composite resin in primary teeth. The number of composite restorations in this study was 22 fillings which consisted only 8% of the total fillings placed under GA in 2004. Tonn and Ryge (1988) showed that the clinical performance of composite resins was comparable to amalgam after 4 years. In their study, almost 80% of the restorations were rated Alfa for colour match, cavosurface margin discoloration and anatomic form. In addition, only 2% of these restorations exhibited recurrent caries.

By contrast, the median survival time of composite resin was inferior to amalgam restorations (Papathanasiou *et al.*, 1994). Although the literature extol the clinical efficacy of composite resins for restoring primary teeth, most of these results have indicated that the proximal restorations had a higher failure rate than one-surface restorations. In addition, secondary caries was the other common mode of failures in composite restorations (Ostlund *et al.*, 1992; Holan *et al.*, 1996). Our findings agree with the previous results. The failure rate of composite resins was 50% whilst amalgam were 26%.

Our results showed that glass ionmer cements were the most used in restoring the carious primary teeth. **Sixty two** RMGI restorations (**21%**) and **one hundred and thirteen** GIC restorations (**38%**). This mostly likely resulted from the ease of application. These materials failed with high percentages (**39%** for the GIC and **33%** for the RMGI). Studies have indicated that the failure rates of glass ionomer cement restorations have varied between 25% and 60% (Welbury *et al.*, 1991; Ostlund *et al.*, 1992; Andersson-Wenckert, 1995; Qvist *et al.*, 1997; Wendt *et al.*, 1998). The median survival rate of glass ionomer cement was 25.5months (Kilpatrick *et al.*, 1995) and only 5% restorations survived after 4 years in one study (Papathanasiou *et al.*, 1994).

The failure rate in the present study was high compared to any other study (on average two restorations will fail out of five restorations placed). This failure rate was even higher than the findings of Legault *et al* (1972) and Almedia *et al* (2000).

Figure 7.1: Fillings' status.



The restorative materials showed a failure rate higher than findings of a recent literature review (Hickel *et al.* 2005). This may be due to:

- The use of multi-surface restorations rather than SSC: Stainless steel crowns were not used to treat any of the study population. O'Sullivan and Curzon (1991) evaluated 80 children treated under GA for comprehensive dental treatment from 1984 to 1987, with a minimum of 2-year follow up period. Stainless steel crowns (SSC) and vital pulpotomies showed low failure rate of 3% and 2% respectively, and 29% for amalgam or composite restorations.
- The use of GIC restorations rather than amalgam restorations for posterior restorations.
- Minimum use of compomer and composites, which showed less failure rate in the literature.

This study was a retrospective cross sectional audit of the dental treatment provided under general anaesthesia at Tygerberg O.H.C. theatre. The data collection from the patients' folders in a retrospective manner has its limitations. The difficulties were in locating, even if available, the required information for all of the subjects. Consequently, comprehensive data were not always available. Although a duplicate file was made when the original had been lost, the basic information for each patient who had received dental general anaesthesia, was not available. The tracking of the required patients' folders was always time-consuming and sometimes they could not be located. However, because all of the children had received paediatric dental general anaesthesia at the Tygerberg O.H.C. theatre, the operation information was held in two different sets of patients' records, Therefore, a second method of data collection was theoretically available.

In 2004, five qualified dentists had been involved in the management of the paediatric patients. Hence, there was a lack of a standard layout to the records for the post-operative management and treatments of these children; consequently, some information was unrecorded. For instance, at least one third of the restorative treatments did not mention the classification or number of surfaces of the cavities or the type of material used. These errors were solved during the clinical examination of the study population.

CHAPTER EIGHT: CONCLUSIONS.

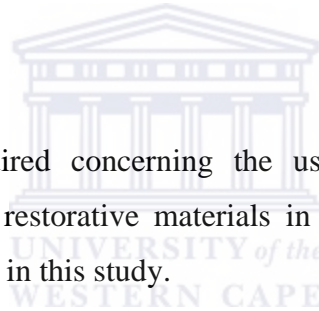
- GA allows the provision of effective dental treatments for the very young patients. The average age of the patients was **44.78** months only. More females were treated under GA.
- GA allows the provision of comprehensive dental treatment. An average of **5** teeth were restored, **4** teeth extracted, and **2** fissure sealants placed in the paediatric dental patients at Tygerberg O.H.C.
- Repeat GA treatments at Tygerberg O.H.C is minimal for healthy paediatric patients. This can be attributed to many factors. Parents' satisfaction, parental fears and attitudes, the preventive programs pre and post GA, and dentists attitudes are possible factors.
- The involvement of the primary dentition is extensive. Plaque accumulation and gingivitis presence are detected. This can explain the high number of extractions and restorations, low number of fissure sealants placed.
- Glass Ionomer Cements, Resin Modified Glass Ionomer Cements, and amalgam were the most used as restorative materials at Tygerberg O.H.C. Composite and poly-acid modified composites were used much less in comparison.
- High failure rates are encountered in all restorative materials used in the treatment of early childhood caries under GA when the combined **Charlie** and **Delta** criteria were considered. Although **three hundred** fillings were placed, **one hundred and sixteen** fillings were clinically unacceptable at the time of the study.
- On average **five** fillings are placed per patient under GA, and after two years, **two** restorations will be clinically unacceptable.

- Failure of the restorations in descending order are: Composite mean percentage **50%**, GIC restorations **39%**, PAMC **33%**, RMGI restorations **31%**, and amalgam **26%**.



CHAPTER NINE: RECOMMENDATIONS.

- GA is a valuable option for the paediatric patients suffering the manifestations of ECC since the dental management usually requires multiple restorations and extractions.
- Based on their very high success rate, stainless steel crowns are recommended for the restoration of teeth with extensive carious lesions. This is more clinically acceptable than multi-surfaced restorations.
- Amalgam restorations should be used in occlusally stressed restorations rather than tooth colored restorations. This can be confirmed by its low restorative failure rate in this study.
- More research is required concerning the use of composite and poly-acid modified composite as restorative materials in primary teeth due to the small sample size encountered in this study.
- Regular check up appointments should follow the GA appointment especially in the following 24 months. Time elapsed from GA to the time of this study ranged from 17 months up to 26 months.



CHAPTER TEN: ETHICAL ISSUES

The proposal of this thesis was presented to the paediatric dentistry department for acceptance. Thereafter it was presented to the ethical and research committee of the University of The Western Cape for discussion and approval. Child/parent pair in this study was invited to participate on voluntary fees-free basis. Child/parent pair was free to withdraw from the study at any time. An informed consent was signed by the caregiver/parent. Study population's children are bona fide OHC patients and were treated for reasons other than this study. The examination of the study population did not include any radiographic examination. Caregivers were informed about any necessary dental treatments and patients were referred for these necessary treatments on further arranged appointments at the OHC. The candidate executing this study treated none of the study population's children.





Appendix 1

Information form FACULTY OF DENTISTRY UNIVERSITY OF THE WESTERN CAPE



Researcher: Dr Manhal Ijbara

The purpose of this study is to assess the oral and dental health status of your child after his/her treatment provided under general anaesthesia in theatre at Oral Health Centre, Tygerberg.

Your child (in this study) will be examined clinically (no radiographs will be taken for this study) in the dental chair in an appointment arranged telephonically and/or by invitation letter.

Participation in this study is on a voluntary basis, free of fees (only for this consultation visit). Refusal to participate will in no way jeopardize your child's future dental treatment at the OHC, Tygerberg or Mitchells Plain. You have the right to withdraw from the study at anytime you and your child wish.

You will be informed of any dental treatment(s) required for your child. This will be clearly recorded in the child's folder so that further consultation and referral could be arranged. The confidentiality of the gathered information will be kept at all times.

Thanking you for your attention.

For any further information, please do **NOT** hesitate to contact:

Dr Manhal Ijbara

(Mitchells Plain, Day Hospital Paediatric Dental Clinic, telephone number: 021 392 5174)



**Faculty of Dentistry & WHO Collaborating
Centre**

For Oral Health

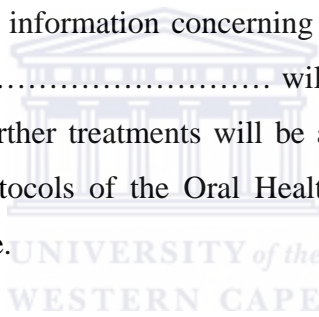
Department of Paediatric Dentistry



UNIVERSITY OF THE WESTERN CAPE

Consent Form

I have read and understand the information concerning this study and I willingly agree that my child..... will be examined and participate in this study. I understand that further treatments will be arranged for my child if needed according to the treatment protocols of the Oral Health Centre, Faculty of Dentistry, University of The Western Cape.



.....
Caregiver name (Print)

.....
Signature

.....
Date

.....
Examiner name (Print)

.....
Signature

.....
Date

.....
Witness name (Print)

.....
Signature

.....
Date

Appendix 2

AN ASSESSMENT OF COMPREHENSIVE DENTAL TREATMENT PROVIDED UNDER GENERAL ANAESTHESIA AT TYGERBERG ORAL HEALTH CENTRE.

Registration No:..... Examination Date:.....

Profile of the patient:

Date of birth:.....

Gender:

Place of permanent residence:.....

Age at G.A. appointment (months):

--	--	--

Weight (Kg) at the time of GA:

--

Procedures under GA:

Extractions (Yes=1; No=2)

--

Number of primary teeth

--	--

Number of permanent teeth

--	--

Restorations

Number of anterior restorations

--

Number of posterior restorations

--

Fissure Sealants (Yes=1; No=2)

Oral Hygiene Visits and Oral Health Status

Pre-GA visits No.

Post-GA visits No.

Oral hygiene of the mouth before GA (brushing, flossing, rinsing)

Oral hygiene of the mouth after GA

Plaque presence (%) at time of examination

Gingivitis (%) at time of examination

Repeat GA visit

Follow -up visit (first visit after GA)

Reason: (Pain=1, check up =2, filling fell out=3, others=4)

How long after GA was the visit?

(Within 1 week=1, within 1 month=2, within 3 months =3, within 6months=4, more than 6 months=5)

dmft (at time of GA)

dmft (at time of examination)

New carious lesions

Appendix 3

CLINICAL PERFORMANCE OF RESTORATIONS EXAMINATION SHEET

Patient No:

Charting:

Tooth Number	Number of tooth surfaces involved (1, 2,3, 4, 5)	Amalgam=1 Composite=2 RMGI=3 GIC=4 PAMC=5 SSC=6 SC=7	Ryge's modified criteria A, B, C, D

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