A CARIES CONTROL TREATMENT USING GLASS-IONOMER CEMENT
(DRAFT)

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SUMMARY

A glass ionomer cement fluoride-sealant caries-control treatment (CCT) has been developed for the prevention and control of dental caries. The primary use is in field locations for high-risk, under-served patients. With a double-gloved finger, type 2 glass-ionomer cement is applied to open carious lesions as a caries control treatment and to sound pits and fissures as a combination fluoride reservoir/sealant preventive procedure. CCT is simple, safe, painless, effective and low-cost. Auxiliaries, under a dentist's supervision, can perform it as safely and efficiently as a dentist. The entire posterior dentition can be completed in three minutes. This procedure is controversial among dentists but is well received by patients and parents. It has not been tested in controlled studies but was used for 10 years without incident on over 150,000 teeth.

INTRODUCTION

Caries prevalence and incidence have decreased significantly in some populations but others are experiencing a caries epidemic.[1-4] For high-risk children, comprehensive care is rare, caries recurrence is common and tooth extraction is relatively routine. They need an interim treatment to prevent pain and tooth loss until the primary teeth exfoliate and for their permanent dentition, they need to delay caries progression until definitive treatment can be obtained. In addition to being effective, a sustainable caries control treatment must be simple, fast, low-cost and painless.

CCT PROCEDURE

General Description

Caries Control Treatment (CCT) is the placement of glass ionomer cement (GIC) over pits and fissures and into open, asymptomatic carious lesions.

Indications and Contraindications

CCT is used whenever conventional treatment is not feasible and the patient will not be harmed by the treatment. After the patient and parents are questioned about any history of painful teeth, visual screening identifies all teeth for which CCT is contraindicated (**Table 1**).

Materials

Table 2 lists the easily obtained equipment and supplies. All items that contact the patient are disposable.

For CCT, the desirable properties of GIC are listed in **Table 3.**[5-7] Chemical bonding of GIC to enamel, dentin and partially demineralized dentin reduces marginal leakage. A hydrophilic setting reaction provides a leeway in moisture control. Fluoride release aids remineralization and reduces the production of bacterial acid.

Method

Table 4 lists the main steps in the CCT procedure. The clinician performs all steps, unless otherwise indicated. The following is a detailed description of each step.

Step 1. From a tube, the assistant squeezes petrolatum onto the back of the clinician's newly gloved hand, which will prevent cross-contamination. The clinician then lightly coats his/her finger tip(s) with petrolatum, which will keep the GIC from sticking to the glove.

Step 2. With a dry toothbrush, remove debris and plaque from the occlusal surfaces and all cavitations. As an option, you may place polyacrylic on the brush to increase retention and to encourage the development of the anti-cariogenic fused layer of GIC/tooth structure.

Step 3. Place gauze, or a cotton roll, between the patient's posterior teeth and have him/her close. This will reduce moisture on the occlusal surfaces. Drying with compressed air is undesirable because the GIC bonding and setting reactions are hydrophilic. CCT is contra-indicated in the presence of debris, swollen gingiva or blood because they are not displaced by GIC. Plaque, pellicle and biofilm reduce bonding but do not prevent the action of fluoride released from GIC.

Step 4. An assistant mixes the GIC with a triturator and then ejects a small amount from the disposable capsule onto the clinician's finger tip(s). Only the end of the disposable capsule touches the finger. Neither the assistant nor the GIC applicator (re-useable) touches the clinician or the patient.

Step 5. With firm finger pressure, place small amounts of GIC on the occlusal pits and fissures of intact teeth. Small amounts and firm pressure minimizes the thickness of the sealant to avoid occlusal interference in an area of the tooth where there is normally little, if any, inter-arch tooth contact. If placed according to these instructions, there is almost no chance of having occlusal interference when GIC is placed on intact occlusal surfaces or in cavitations.

GIC forms a chemical bond upon contacting relatively clean tooth surfaces, including partially demineralized tooth structure (caries). Excess GIC on the occlusal must be meticulously avoided because after three minutes it becomes increasingly difficult to remove with hand instruments and after 15 minutes rotary instruments are required. The final set and bonding process between GIIC and the tooth structure continues to mature and strengthen for days.

Step 6. Apply a light coat of petrolatum over the GIC to protect it from oral fluids and to prevent any possibility of inter-arch adhesion of GIC.

Step 7. Without directing the patient, hold the chin and firmly tap the arches together in centric occlusion until you feel and hear enamel-to-enamel contact.[8] Although GIC products differ among manufacturers, in general, GIC is malleable for only three minute after mixing starts. The tapping displaces any minor occlusal excess and avoids the need to remove interferences after the GIC has set. Because there is no anesthesia, patients can tell immediately if their "bite" isn't normal. If Step 5 has been performed properly, the "bite" should feel normal to the patient. However, if there is an occlusal interference, then immediately use articulating paper and a sharp hand instrument (carver or excavator) to remove the excess. This is easy to do within the three to five minute period. The most likely teeth to have interference are those most posterior and those without steep cusps. Remember, after the first five minutes hardening proceeds rapidly.

Step 8. Place a folded-gauze under the tongue and out between the anterior teeth. This keeps the dental arches apart, allowing initial set to proceed undisturbed. The gauze also absorbs saliva from the submaxillary and sublingual glands that might contaminate and dissolve the surface GIC. Finally, it allows the patient to be dismissed from the chair (but not from the treatment area) so the next patient can be immediately seated. The dismissed patient waits for two minutes before throwing the gauze into the infection control waste container. This is the last chance before being dismissed to ask that patient about occlusal interference. "Do your teeth close normally?" By their speaking you confirm they can open their mouth and there is no inter-arch adhesion. While inter-arch adhesion would seem to be an impossibility due to the many step that are designed to prevent it, it happened once when an operator, 1) applied far too much GIC, 2) didn't apply the petrolatum, 3) didn't check the occlusion 4) didn't place gauze between the anterior teeth and didn't ask the patient a post-treatment question. This series of five human errors proves that Murphy's Law exists and that even trained professionals can fail to follow simple procedures or consider their responsibility for the patient's safety.

Step 9. The clinician performs hand washing while the assistant seats the next patient. Because the assistant has no contact with the clinician or the patient, the assistant doesn't need to wash hands between each patient and the GIC applicator can be reused. For the clinician, double gloving with antiseptic wiping of the under-glove is an alternative to hand washing between each patient. Proper decontamination of the skin via hand washing takes three minutes, as long as it takes to perform the procedure. Human skin can only withstand a certain number of correct hand washings over a continuous period and therefore hand washing frequency, three minutes per patient, and muscle fatigue are the limiting factors on how many patients can be treated by one clinician in one day. Double gloving between more than doubles productivity (cost per patient) and saves the skin of the operator.

Manufacturer's Instructions

The manufacturer's instructions for Type 2 glass ionomer cement are based on its intended use as a restorative material. However, CCT is a preventive procedure and has less stringent requirements e.g., retention for months instead of years.

For CCT, the tooth surface is not as clean or dry, as recommended, and pre-treatment with polyacrylic acid (tooth conditioner) is not normally used, because of the time factor and the unpleasant taste for young patients. It might be possible to put tooth conditioner on the brush to increase the potential for the development of a fused interface (true chemical bond) between GIC and tooth structure. It might also be possible to treat the carious surface with an antibacterial agent like silver nitrate or silver diamine fluoride. Without a study, it cannot be known what the effect of a cleaner or dryer surface or the antibacterial agent would have on retention, or more importantly, the treatment goals. Based on clinical experience, the GIC remains long enough to produce remineralization. There have been instances where only a small speck of GIC has remained in the base of a large cavity, but the caries remineralized and was hard to an explorer point. Whether cleaning the cavities and tooth surfaces with tooth conditioner warrants the need for additional instruments and time, would require a controlled study. Even if plaque, pellicle and biofilm totally prevented bonding of GIC with the tooth structure, the GIC will conform to the cavity surface to provide an intimate and continuing source of fluoride as long as it is retained. Any leakage will not exacerbate the caries process because fluoride is in contact with the surface and fluoride is a bacterial toxin as well as a remineralizing agent.

Unlike a restorative procedure, CCT is not an “all or nothing” procedure. If some of the GIC is not retained, the remainder is still a source of fluoride and does not increase the risk of exacerbating caries, which is a factor in a fractured restoration or a partially sealed Bis-GMA sealant. The procedure can be performed in only 3 minutes at a relatively low cost, which means it is preferable to repeat the procedure on a frequent cycle, e.g. every six months, rather than spend a significant amount of treatment time for a resin sealant in order to produce a small increase in retention and effectiveness.

The manufacturer provides a varnish to protect the GIC surface immediately after placement. The varnish has a strong odor that is unpleasant to children and it requires sterile or multiple disposable applicators. Odorless and inexpensive petrolatum is an adequate varnish substitute for initial protection against GIC dissolution in oral fluids.[9-11] Although the petrolatum contaminates the outer surface of GIC, it doesn’t affect the bond between the GIC and the tooth structure. Petrolatum also masks the slight acidic taste of GIC.

Facilities and Equipment

CCT can be performed almost anywhere. Natural or artificial lighting is sufficient and water is only needed for hand washing. Compressed air and suction are unnecessary and even undesirable. Patients can sit, stand, kneel or lie on their backs to be treated. Although GIC can be hand-mixed, a capsule system with a mechanical mixer significantly improves cost-effectiveness by quickly and consistently producing high-quality mixes. It saves time, reduces the number of instruments, and eliminates the need for sterilization equipment. A standardized mix is very important. A hand mix can take one minute, thereby reducing treatment time, the freshness of the mix, and the thickness of the mix – all crucial factors in achieving consistent results, avoiding occlusal excess and maximizing application time before GIC set. If electric current is unavailable, unreliable or too expensive, then a mixer can be made that is powered by a coiled spring or batteries. There are new resin-modified glass ionomer materials that mixes the material in the delivery instrument. This would eliminate the need for a triturator and electricity. However, the mix has less body making application with a finger more difficult. The effectiveness of this mixing method has yet to be tried in a clinical situation.

Instruments

There are many advantages to using a finger as the primary, and usually the only, intra-oral instrument for CCT. The finger provides direct, safe, non-threatening, sensitive and versatile application of GIC. Graduated pressure over the entire occlusal surface cannot be achieved any other way. Fingers are also used to retract the tongue and to apply the petrolatum. This saves time, money and materials with increased effectiveness.

Personnel

CCT requires two individuals who perform five distinct functions. A dental hygienist, dental therapist or dentist would normally apply GIC, but responsible individuals with normal dexterity and intelligence with an above average sense of responsibility can learn to perform CCT with minimal training. The assistant is essential for infection control, cost-effectiveness and patient management. Because CCT can be performed in approximately three minutes, as many as 15 patients can be treated in less than one hour. It is useful for the assistant and the clinician to exchange roles to prevent muscle and mental fatigue.

The first function is diagnosis -- to determine which teeth **should not** be treated. This is the only function that must be performed by a dentist or specially trained dental therapist. The second function is placement of GIC – quickly and without occlusal interference. The third function is patient management and teamwork between the

clinician and assistant. Patients can be as young as 16 months and the treatment room can be crowded and noisy with other children watching and waiting their turn. The fourth function is assisting and infection control. The fifth function is collecting and recording the patient information. It is highly desirable to have a third person perform this last function to maintain consistency in data collection, to manage the patients before and after treatment, allowing the clinician and assistant to focus on the patient being treated.

Cost

The *per capita* personnel cost is the salary of a clinician/assistant(s) team, prorated for 3-4 minutes. The *per capita* cost of supplies is less than $2.50 (1995), excluding the toothbrush. One GIC capsule is usually sufficient for all primary and/or permanent molars excluding third molars. Any remaining material can be used for premolars. If there are cavitations then additional capsules will be needed. The total cost in time and materials is less than an office fluoride-gel, rinse or varnish application with greater safety and much greater caries prevention and caries control. The difference would depend on the presence of other sources of fluoride in the water and diet. However, fluoride gel is most effective against interproximal caries and is ineffective against pit and fissure caries or open cavities. Caries reduction in these latter two sites is the specific objective the CCT although prevention of interproximal caries has been demonstrated, especially in the primary dentition and the proximal surface adjacent to a Class II CCT.

DISCUSSION

Minimal Treatment

Toothaches and fear of dental treatment still exist despite major advances in caries prevention, pain control and patient management. Conventional restorative treatment is not pleasant and does not prevent dental caries. There is support in the dental literature for a minimal interim, noninvasive treatment. This is especially important for children with high caries activity and for young children who can't understand or can't cooperate during restorative treatment. In 1908, Dr. G. V. Black described the management of caries in children as, "... one of the most difficult subjects in dentistry." [12] His objectives were to arrest or delay the caries process without causing pain – the same objectives as CCT. The treatment he used combined two physically painless procedures – the proximal slice in which only enamel was removed, combined with cauterization and disinfection of the carious dentin with silver nitrate. Dr. Black's method did not remove caries and did not restore tooth form or function.

Table 5 contains quotations excerpted from Dr. Black's textbook. A complete reading of this chapter is preferable and shows that these quotations accurately represent his views and are not taken out of context. His observations are still applicable today, one hundred years after they were written, and they provide a conceptual basis for CCT. In the 1960s, the United States Indian Health Service used Black's proximal slice to delay caries in primary molars of children living on remote Alaskan islands. In the 1970s Craig used silver fluoride for painless caries treatment of children living in Australian orphanages who were difficult to manage.[13-15] In the 1990s, the World Health Organization recommended an atraumatic restorative treatment (ART), developed by Pilot and Frencken, which applies glass ionomer cement over partially excavated caries using a low technology approach.[16] More recently, the Academy of Pediatric Dentistry has issued a policy on Interim Therapeutic Restoration (ITR) with similar goals and treatment methods as ART.

These examples show that a minimal treatment method is needed for: 1) poor countries with limited treatment capabilities; 2) inner city and rural children in industrialized countries where access to conventional care is limited; 3) affluent developing countries

where caries experience is outpacing treatment capabilities;[17] 4)home-bound individuals, and; 5) patients who need painless caries control pending their ability to withstand treatment that takes more time and patient management (e.g., toddlers and the mentally or physically disabled who otherwise require general anesthesia).

CCT History - 1985 to 1997

CCT was developed and used over a twelve-year period at the Saudi Aramco Oil Company in the Kingdom of Saudi Arabia. During that time there were over 150,000 teeth treated. CCT underwent a significant metamorphosis starting as an experimental, no-alternative treatment, then a treatment of last resort, and ultimately an official interim treatment in the written policy of the Dental Services Department. CCT was eventually used for all children who were scheduled for restorative treatment under general anesthesia and conceptually accepted by nine of the ten pediatric dentists. Despite the highly critical scrutiny of the general dentists, there were no verified reports of CCT being associated with adverse pulpal response or exacerbation of caries. Parents praised it and asked the Director of Dental Services why this procedure hadn't been offered before? Nevertheless, most of the general dentists did not include CCT in their treatment plans in any of its three functions: a fluoride reservoir, a long-term temporary treatment or a pit and fissure sealant. The only explanation for the acceptance by pedodontists and lack of acceptance by general dentists is that the former received a direct benefit by reducing complaints from parents whose children were on the OR waiting list while the latter saw no direct benefit to their practice and possibly additional work (treating the same tooth twice). Nonetheless, CCT was used in a large school program with 20,000 students and for drop-ins at the Maternal and Child Health clinics.

Necessity is the Mother of Invention

CCT was born of necessity due to a caries epidemic in an affluent population where high quality dental care was readily accessible. The author was the preventive dentistry coordinator in a JCHA accredited group dental practice that had over 120 salaried dentists and dental hygienists providing highly subsidized comprehensive care for 50,000 employees and 150,000 dependents of a large company in the Kingdom of Saudi Arabia. Despite these favorable conditions, the increase in caries incidence continually outdistanced the ability to provide care, and the willingness of the parents to control their children's cariogenic lifestyle or to obtain care before a toothache occurred. As a result, the waiting list for restorative and surgical treatment lengthened and the number of emergency patients increased. In reaction to this epidemic, new staff members were hired, new facilities were constructed, and fees were increased (to pay for increased costs and to discourage unnecessary utilization). These measures did not control the excess demand for treatment of children with caries. The problem was so critical that a preventive dentistry coordinator was hired "to design and implement a comprehensive preventive program that will reduce the need for and cost of dental treatment." When faced with these conditions, the preventive dentist (the author of this paper) had no choice but to look for a procedure, like CCT, to restrain the caries process pending definitive restorative treatment.

Case Histories

CCT was first tried on a five-year-old boy who was referred by a pediatric dentist for "preventive care". He was at the bottom of a one-year waiting list for comprehensive care under general anesthesia. The boy was screaming as his father carried him into the preventive dentistry clinic. They were accompanied by the boy's mother and his younger sister, who had never been to a dentist. He had a number of asymptomatic Black Class II open lesions and two missing primary first molars that had been emergency extractions.

This patient was the first of many in similar circumstances. It was obvious that the standard preventive services -- fluoride application and dental health education – were not going to avert additional emergency extractions during the next 8 to 12 months. Something more effective was needed to slow the caries process, to prevent food from being packed into the cavitations, to prevent extractions, and to stop the cycle of crisis care. For the treatment to be effective and sustainable it had to be practical, which meant quick and painless. Without any other obvious alternative, there was nothing to lose by filling the open cavities with GIC to provide a continuous low concentration fluoride where otherwise there would be snack foods and sugar drinks.

The only possible disadvantage to this course of treatment was the expected criticism from colleagues for not excavating the caries and the possibility that the GIC would be quickly lost. The chance of exacerbating existing caries was remote. To provide no treatment or the previously ineffective treatments, were not acceptable alternatives. If GIC were retained for only one day it would more effective and safer than a 4-minutes fluoride gel application.[15] If it stayed for weeks or months it could produce long-term caries control. Table 6 lists the advantages of CCT with emphasis on management of children, including those deemed "uncontrollable for standard restorative treatment."

The boy's parents accepted this temporary, untried measure in order to gain time until their child eventually reached the top of the OR waiting list. While this was being discussed with the parents, the boy stopped crying but it was clear that any attempt to excavate caries or use standard equipment (operating chair and light or air-water spray and suction) would revive his fears based on his prior extractions, thus causing the preventive treatment to be aborted.

Consequently, the brother and sister were seated on their parents' laps, while their parents brushed their teeth without water or dentifrice. Having successfully completed this 'procedure', they were shown the GIC 'toothpaste mixing machine and the toothpaste' that would be placed on their teeth with a finger. To relieve the boy's anxiety, his 'innocent' younger sister was treated first. One tooth was dried with gauze and GIC was quickly applied. Having seen his sister 'survive' the boy accepted the treatment. Two weeks later the GIC was still present, the parents were pleased and the remaining teeth were easily treated.

On bi-monthly inspections most of the CCTs were intact and those that were lost were easily replaced or repaired, as needed. Eight months later, the scheduled restorative treatment was completed by a pediatric dentist under local anesthesia, without additional tooth loss.

The second patient was a four-year-old boy referred directly to the preventive clinic by an endodontist who was a social friend of the boy's father. The parents adamantly refused to have their son subjected to "an injection and drilling" because his son's teeth weren't causing pain. Upon examination, six of his eight primary molars had obvious, Class II asymptomatic lesions. Two lesions were deep (one millimeter from the pulp on x-ray), two others were less extensive open cavitations and two were only detectable on a radiograph. CCT was offered as a "temporary" alternative. The parents were fully informed about the unconventional nature of the treatment and they accepted the possibility of failure.

The treatment was slightly different from the first patient because this patient was able to cooperate although, like most children, he was wary. This allowed partial excavation with hand instruments, the same as what was later called Atraumatic Restorative Treatment (ART) and still later, Interim Therapeutic Restoration (ITR). The excavation

was attempted primarily to deflect the anticipated criticism from other dentists. For these initial patients, the author accepted the conventional wisdom that removal of some caries might increase GIC bonding and retention. Excavation was stopped as soon as there was any sign of discomfort from the patient (real or imagined). This ensured that the parents would bring their child back for another appointment and that he would continue to cooperate. It could also be used to mollify dentist by showing an attempt was made to remove the caries. GIC was applied, but unlike ART, there was no attempt to restore tooth form and function i.e. to make it 'look' or 'function' like a restoration. This was 1985, before ART had been reported in the literature or known to the author.

For the second patient, it was anticipated there would be many short appointments to replace lost GIC [12]. As it turned out, the scheduled appointments were always missed. Instead, the patient was only brought in when partial or complete loss of the CCT resulted in gingival irritation from food impaction. There was always some GIC remaining at the base of the cavity and the exposed caries was hard. Radiographs did not show any significant pulpal extension. Despite the fact that some of the CCTs had to be replaced, the parent could not be convinced to go to the pediatric dentist for conventional restorative treatments. Their reasons were the same as expressed at the first appointment – their son didn't have pain plus now the risk hadn't increased.

Despite re-educating the parents at each appointment (including appointments of his younger siblings), there was no improvement in the family's dental health habits. As a result, two years after the first appointment, one incipient Class II lesion had developed into a small open cavitation. Minimal excavation was performed and GIC was placed.

After two years caries was controlled **Fig. 1**. A chart review showed that two of the initial four CCTs had been retreated on one or more occasions but caries had not progressed. The parents finally decided that their son, now eight, was 'old enough' to withstand the stress of conventional treatment, meaning an injection. However, after a thorough examination, the pediatric dentist decided there was no reason to remove the intact CCTs or to restore the teeth with conventional materials. Three years later, at age 11 (seven years after the initial visit), the entire primary dentition had exfoliated without the injection or the invasive treatment that his parents had feared and rejected. By age 13 he had a caries-free permanent dentition with intact GIC fluoride-releasing sealants. The high caries activity and high-risk behavior of both the child and the parents had not been appreciably improved but the consequences of their cariogenic habits had been successfully managed with a low cost, non-painful, non-invasive, minimal, long-term, so-called "interim" treatment regimen.

THE CONTROVERSIES

CCT is a multi-purpose, non-invasive, painless, preventive procedure that was well received by the patients, parents and dental program managers, while at the same time it was opposed or ignored by most clinicians, except for a few pediatric dentists. The controversies at the source of this difference are listed in **Table 7**. Each of these factors will now be discussed in detail.

No Caries Removal

Failure to remove caries is the root of the dentist's opposition to CCT. With few exceptions, the cardinal injunction of restorative treatment is "remove all caries". Dentists who break this rule face censure and ridicule from their peers. A review of the literature (from G.V. Black to Loesche to Mertz-Fairhurst) fails to support this time-honored rule and, in fact, it shows that covering or chemical treatment (e.g., silver nitrate or silver diamine fluoride) of visible caries can control caries progression, does not increase the probability of recurrent caries, and does not adversely effect the treatment prognosis.

The lack of a consistent rationale for this time-honored rule can be seen from the many exceptions to the rule: uncooperative children (aborted treatment), very deep cavities (indirect pulp cap) and inability to immediately treat the patient.[18] These exceptions suggest that removing all caries or leaving caries intact for long periods is not as significant to the dentists as is the rule itself. So it is breaking the rule that is the motivation for their censure and not the harmful consequences, against which they say they are protecting the patient. What is most important is the rule that says, 'thou shalt follow standard practice regardless of the evidence or lack there of'. The crime is to not follow the rule regardless of the negative consequences to the patient's health. For example, how can it be acceptable to treat a single tooth and leave caries in the remaining teeth untreated (standard practice) while at the same time it is unacceptable to leave any visible trace of carious tooth structure once the treatment of a tooth is begun? Complete caries removal is deemed critical because it is thought that caries contains harmful bacteria that will allow the disease process to progress, yet it is a well-known fact that cariogenic bacteria remain under all standard restorations. Just as contradictory, how can an exception be made for leaving purportedly highly contagious carious dentin adjacent to the pulp when performing an indirect pulp cap, while allowing no exceptions for superficial caries? The standard answer for pulp capping is that deep caries cannot be removed without creating a pulp exposure, which, in turn, will necessitate pulp removal or mummification. The reasoning continues that it is better to give the tooth a chance to recover and if the pulp dies (which includes pain), then the patient will willingly agree to more extensive treatment (direct pulp treatment), which they might have resisted if there had been no pain. The alternative is immediate pulp extirpation and root canal treatment on a tooth that the patient perceives as asymptomatic. This is much more difficult to explain to the patient because they may think the dentist has made a mistake and is covering it up. The large cost of the RCT and crown adds to this notion. Even after the initial root canal treatment there can be painful sequelae, which the patient may also blame on the dentist, if the tooth had not been painful when treatment was initiated. After all, before the patient entered the office that tooth may not have been painful or the pain was intermittent and tolerable. So this is the rationale for leaving in caries when a lesion is near the pulp and it trumps the issue of bacteria next to the pulp.

What happens when caries is just into dentin? When caries is just into dentin and is relatively easy to remove, most dentists insist that it must be removed completely even though leaving it will not harm the patient in the short-term or the long-term. This problem has become the subject of research because clinicians fear that they might be sealing in caries and could be censured for doing this or causing 'hidden caries'. Interestingly, they don't fear censure if secondary caries develops under restorations they have placed. This dichotomy demonstrates that their concerns about sealing in caries or removing all caries is not evidenced-based but is based on tradition, conventional wisdom and similar pragmatic factors, such as criticism by their peers or from a patient. Only recently has the Academy of Pediatric Dentistry approved what it calls, Interim Therapeutic Restoration (ITR) which they carefully distinguish from Atraumatic Restorative Treatment (ART) although they are the same treatment and very similar to CCT. The American Academy of Pediatric Dentistry has two policies that sanction covering caries but both remove some caries. [R, R]

Although CCT is not a restorative treatment, dentists still judge it by the standards for restorative treatment. The fact that CCT is patently safe and the patient has given informed consent are apparently of no importance.[19] A rule is a rule until the rule is changed and then that is the new rule - no exceptions. This is illogical and should be reconsidered in the light of present knowledge, especially for the treatment of patients whose access to conventional treatment is nonexistent, insufficient or indefinitely

delayed and when it is clear that the prognosis will be enhanced by an alternative, albeit non-standard or interim treatment. Unfortunately, non-standard treatments are usually viewed as "second class" treatments and are deemed unacceptable, even for those who the dental profession already tacitly treat as 'second-class" patients.

Figure 2 illustrates a sagittal section of a Black's Class II cavitation in the distal of a mandibular first primary molar before the CCT procedure. **Figure 2a** is a photograph of a similar situation. The caries that remains is only partially demineralized. There is enamel demineralization on the proximal of the adjacent second primary molar but no cavitation. **Figure 3** illustrates CCT after GIC is placed over the caries and the surrounding enamel. **Figure 3a** is a photograph of a similar situation. Oral fluids are sealed out and bacteria are sealed in. Most studies have shown that sealing will arrest bacterial growth.[20-23] GIC provides a good, albeit not a perfect seal.[24,25] However, the fluoride that is continually released from the GIC neutralizes cariogenic bacteria [26-29] and remineralizes tooth structure, including caries.[31-36] **Figure 4** is a photograph of a patient whose condition could have been prevented by CCT.

There is no evidence-based advantage to removing the outer, surface layer of caries and leaving the inner layer, which is the procedure for ART and ITR. In fact, the demineralized dentin (caries) acts as a natural barrier between the outer environment and the pulp. Removing the outer layer may remove some of the bacteria but it also reduces the thickness of the layer over the pulp. If the objective of caries removal is to stop the caries process by eliminating the bacteria, then this approach is patently false without the use of an antibacterial agent, such as silver nitrate or silver diamine fluoride. The fluoride in GIC is an antibacterial agent. It is a fact that the remaining bacteria are cariogenic only if they have a continuous substrate from which they can produce the acid that demineralizes enamel and dentin. This is the justification for dietary changes in caries prevention and is also justification for sealing in the remaining cariogenic bacteria, which denies them the necessary substrate. The placement of GIC accomplishes this objective. If pulp protection is the objective then decreasing the amount of tooth structure over the pulp, even the partially demineralized tooth structure, is unnecessary, counterproductive and probably harmful.

Effect on the Pulp

CCT will not cause pulpal irritation or pain.

First, teeth with a high risk for a pulp reaction are eliminated as candidates for CCT (See **Table 2**). The lack of signs and symptoms of pulpal pathosis indicates that the pulp is probably vital in spite of high-risk conditions.

Second, GIC is considered one of the most biocompatible of current treatment materials.[37-39]

Third, unlike restorative treatment, there is no local anesthesia to mask the pain emanating from a pulpal reaction to the treatment.

Fourth, CCT does not produce pulpal pressure, dehydration, or significant temperature changes, as do many restorative procedures and materials.

Fifth, the caries and the remaining dentin (both intact and partially demineralized) are protective barriers between the GIC and the pulp. If all the caries were removed, the newly exposed dentinal tubules would provide a direct avenue to the pulp for bacteria and toxic elements in the treatment materials.[40] This is why cavity liners are so popular and necessary.

Sixth, GIC stops macroleakage of cariogenic nutrients and allows less microleakage than most other treatment materials.[24,41,42]

Seventh, GIC releases fluoride to counteract the effects of any microleakage.

Eighth, if neither CCT nor conventional treatment is performed, then the cavities will be constantly filled with fermentable dietary products, and caries will progress unless the patient or parent cleans if carefully and frequently. Otherwise, a painful abscess will occur followed by a traumatic emergency extraction.

Gingival Contact

A Class II CCT is less likely to cause gingivitis than a Class II amalgam restoration. GIC actually reduces plaque, especially mutans Streptococci, because of its fluoride release.[7,43] CCT eliminates the food trap and locates a fluoride reservoir where caries risk is the highest – the proximal surface of the adjacent tooth (**Fig. 2**).[44-48] This benefit clearly outweighs the loss of the ability to floss between these teeth.

A matrix band is not used because it would defeat the purpose by:
1) eliminating the added adhesion to the adjacent proximal surface;
2) eliminating the natural retentive undercut;
3) increasing treatment time;
4) precipitating gingival bleeding and
5) creating unnecessary patient management problems.

Conventional wisdom suggests that the rough GIC surface would encourage plaque development but this is not the case because the fluoride release is toxic to the bacteria.

Retention

Retention for CCT ranges from days to years, depending on treatment conditions, occlusal forces, the patient's diet and the definition of retention. The GIC surface is eroded by acids including those found in soft drinks. As might be expected, retention is greatest where there is no occlusion. This is one of the reasons why occlusal form and function are not restored in CCT. As a sealant, the long-term macroscopic retention of GIC is not as good as a Bis-GMA resin sealant.[49-51] However, there is a high degree of microscopic retention of GIC particles in the pits and fissures and as fused GIC/toothstructure, both providing long-term caries protection via low-concentration fluoride release.[51,52] Thus, caries prevention and arrest, rather than visible retention, are the important measurements of effectiveness.

Effectiveness

The World Health Organization has studied and endorsed an atraumatic restorative treatment (ART), which uses GIC and has the same rationale as CCT. The American Academy of Pediatric Dentistry and the U.S.P.H.S Indian Health Service have approved an Interim Therapeutic Restoration (ITR). Both have the same rational and almost the same treatment as CCT with two significant differences.

First, CCT purposely does not remove caries while ART/ITR attempts to remove caries without anesthesia and without inducing pain. However, there is no objective way to determine when removal of caries will induce pain, so it is likely that some pain will be induced from the last 'scoop' of caries.

Second, the only goal of CCT is caries control, while restoration of form and function are goals of ART/ITR. ART has been evaluated as a restoration and the results are good when compared with conventional amalgam restorations.[53] ITR is a policy but, like CCT, it isn't evidence-based.

The major advantage of ART over conventional restorative treatment (CRT) is the lower training requirement for the clinician and the ability to be performed in less sophisticated circumstances. If ART were evaluated only for caries control (vs. retention etc.), the

results would probably be even better. [R] **Table 8** is a procedural comparison or CCT, ART/ITR, ABT (Antibacterial Treatment such as, silver nitrate and silver diamine fluoride, CHX-chlorhexidine, F-fluoride, Xylitol) and CRT (Conventional Restorative Treatments).

The concepts, methods and materials of CCT are proven as separate elements but the combination used in CCT has not been specifically studied. Studies were not permitted at the organization where it was developed because research was not its mission and it didn't want the paying patient to be research subjects. Although CCT was demonstrated at an International Conference, no one has been willing to test it because they considered it too controversial. It will be tested only when it is perceived that the need is so great (high caries and no treatment funds) that there will be no other choice. We may be approaching that point in specific populations in the United States and have long ago reached this point in most of the world. The most important element is the anticaries characteristic of GIC, which have been widely reported.[54] GIC sealants have been shown to equal or exceed Bis-GMA in caries prevention despite poorer retention.[51] GIC is bacteriostatic for mutans Streptococcus, the primary bacterium associated with caries initiation.[26-29] Sealing over caries reduces caries activity by denying substrate to the bacteria. In addition to aiding remineralization, fluoride, and perhaps other elements in GIC [55,56] reduce the number of bacteria and their ability to produce acid.[35] A GIC fluoride reservoir is the ultimate method for fluoride application – always present at a low/safe concentration when demineralization is occurring.[57,58] The fluoride that leaches out of GIC is replaced by fluoride from any external source with a higher concentration e.g., dentifrice.[59-61] If GIC were only retained for one day (1440 minutes), the fluoride contact-time at high-risk sites would be up to 360 times more than a four-minute fluoride-gel treatment, plus much safer and more effective.

Unlike restorative treatments or even resin sealants, CCT can have a successful outcome even if GIC is not completely retained.[57,62] Partially-retained GIC acts as a fluoride reservoir and is not a source of increased caries-risk like a fractured amalgam or a leaking Bis-GMA sealant. In one study, GIC was completely removed one month after placement and the level of fluoride in the enamel remained above normal for over six months compared to two weeks for an application of high-concentration fluoride gel. [63, R]

Informed Consent

Informing patients that the tooth decay has not been removed and explaining what might happen if definitive treatment isn't obtained, does not guarantee that the patients will seek follow-up care. Regardless of the procedure, there will always be the problem of patient's failing to follow clearly explained instructions for follow-up care. A misunderstanding about the treatment objectives is the least likely reason for failure to complete a treatment plan. Patients often fail to return for definitive treatment because: 1) their initial complaint (pain or lost filling) has ben resolved; 2) their treatment objectives are different from the dentist's and; 3) they want to avoid further discomfort or expense. In addition, there are always situations where the parents will not give consent for specific treatment for fear of how their child might react. In these circumstances, CCT is a far superior choice to no treatment at all and can be completed at the initial appointment.

Follow-up Care

What happens when a patient with a CCT goes to another dentist and presents with GIC on an asymptomatic tooth? The clinician must first determine if the GIC is:

1) a sealant;
2) a poorly performed definitive restoration;
3) a temporary restoration or;
4) something else.

The dentist should question the patient and the patient/parent should be able to respond with valuable information. If caries is directly visible or there is radiolucency on the radiograph then a determination must be made whether there is active caries. These are diagnostic questions that dentists normally don't have to ask because they start with the assumption that all the caries has been removed and, if not, that all caries is active and should be completely removed.

These questions are not as difficult or troublesome as they may first appear. The shape and size of the GIC on the radiograph will indicate if it is a sealant, CCT or a restoration. The amount of remaining dentin over the pulp is the most important factor in deciding on a treatment plan. For a shallow and intact Class 1 GIC there is no treatment required whether it is a sealant, a CCT or a restoration. A follow-up radiograph in 6 month will indicate if there is any change consistent with active caries.

A Class II CCT in a permanent tooth should be replaced with a definitive restoration regardless of signs or symptoms. This is because the CCT is not a restoration and will not last 10 - 70 years, the potential for a definitive restoration. This rule doesn't apply to primary teeth because their lifetime is much shorter, 6-10 years and the roots begin to resorb three year before exfoliation. In primary teeth, if there is radiolucency under the GIC and there is less than one millimeter of remaining dentin, then the CCT should be replaced with a restoration unless root resorption is more than 50 percent. If the radiograph is inconclusive on the presence of caries then there are two options: 1) monitor with a radiograph in 6 month or 2) remove the GIC to examine for caries. Other factors being equal, clinicians familiar with CCT are more likely to choose option 1 and those with less experience will choose option 2. If there is a partial loss of GIC and no other reason for retreatment then the defect can be repaired by direct addition of GIC. [64]

Conflicting Views

Although dental health is the shared goal of dentists and patients, they often have conflicting views about how to reach that goal. From the dentists' viewpoint, caries could be eliminated if patients flossed and brushed their teeth daily, optimized the use of fluoride, didn't snack, and had regular dental appointments. In the patients' ideal world, there would be no oral hygiene requirements, no restrictions on eating, no toothaches and no dental appointments. Dentists want patients to take full responsibility for their dental health and patients want dentists to provide an easy, foolproof, low-cost solution for a problem for which they feel the punishment (toothaches and dental treatment) doesn't fit the crime (snacking and inconsistent oral hygiene). These opposing views toward reaching a shared goal hamper cooperation between the clinician and the patient. If both would forgo their "all or nothing" attitude, then their viewpoints could be partially reconciled by accepting caries control as a realistic intermediate goal i.e., not eliminating caries but preventing the serious sequelae - pain, tooth loss and loss of arch space, at least until the patient decides a more definitive treatment is desirable.

Dental Profession's Reputation

Dentists have expressed concern that CCT will damage the dental profession's reputation. Among the comments have been: "it is incomplete treatment that must be redone", "it gives the patient a false sense of security" and "patients deserve the best and nothing less!"

Although dentists have been uncomfortable with the CCT objectives and limitations, the patients have been very accepting. CCT won't damage the reputation of the profession if patients are fully informed, which is true of any treatment.

Ethical Issues

The CCT procedure raises important ethical questions:

Can a dentist leave caries untreated knowing that the patient might not return for follow-up care?

Does the dental profession have any responsibility for sponsoring outreach programs and treatments for children whose parents do not, or cannot, obtain conventional care for them?

Do dentists have an obligation to offer a minimal treatment that can prevent pain and tooth loss even if it isn't a definitive (comprehensive) treatment?

Should dentists wait until parents bring their children for emergency extractions before initiating care or should dentists seek out high-risk children and provide low-cost CCT with parental consent?

It is difficult to consider these ethical questions realistically unless faced every day with real children who have gross caries and real parents who do not understand or do not want to understand or think they can't afford to understand, the consequences of failing to take action to stop, or at least control, the caries process and to treat existing lesions.

The dental profession must have an alternative between the extremes of crisis care and comprehensive care. To meet its ethical and professional responsibilities, dentists must have an interim caries control option even though the results may seem sub-optimal.[12] A preventable toothache is not only parental neglect; it is also professional neglect. [65]

Evaluation of CCT

CCT should be evaluated on its stated objectives:

1) to prevent caries in posterior teeth,

2) to prevent premature loss of primary teeth,

3) to slow or arrest the caries process, and

4) to prevent a painful tooth or painful tooth treatment.

The potential for negative side effects and cost-effectiveness should also be evaluated. However, CCT should not be evaluated on criteria for a restoration (caries removal, GIC retention, form, marginal integrity, occlusal function) because these are not germane to its objectives.

Ideally, a research study should compare CCT, ART, ABT (antibacterial treatment), and CRT (**Table 8)**. Outcomes to be compared would be: symptoms, retention, pulpal infection, tooth loss, cost-effectiveness, patient acceptance, and ease of application in both clinical and non-clinical settings, caries prevention, caries progression and prevention of premature tooth loss. The controlled variables would be: tooth type, post-eruption tooth age, salivary fluoride level, cariogenic bacteria, caries-pulp distance and stage of root resorption in primary teeth.

Resolution of the Controversies

Dentists criticize CCT because it is used to treat lesions for which a restoration is the conventional treatment. They fear that the patient will think CCT is a definitive treatment and the results will damage dentistry's reputation. This fear can be resolved by informed consent because ultimately the choice and responsibility belongs with the parent or patient. It would also help if dentists had a better understanding of the caries process so

they could feel more comfortable about situations in which caries removal is not the treatment of choice.

Disease control and cavity restoration are complementary rather than conflicting objectives. Theoretically, there would be no controversy if CCT were retained for only a short time and caries underneath was visible or detectible. Unfortunately, complete caries removal and ideal cavity restoration do not prevent future disease. In the long-term, a significant proportion of these "ideally treated" teeth eventually have recurrent caries, endodontic therapy or extraction.

CCT has been developed to meet the needs of most of the world's population, especially children, who have untreated caries without access to comprehensive care. A dentist, whose patients are affluent and have a low caries rate, may think CCT is unnecessary or even poor practice. However, in every community there are sub-populations with high caries rates for whom only emergency care is provided. There are also communities where the caries activity is so severe that excellent restorative treatment is destroyed by recurrent caries and there are still other communities where conventional treatment services are absent or can be only provided under general anesthesia. In these circumstances, CCT neither conflicts with nor should be misunderstood as a substitute for a restorative service.

The need is great and the controversy could be resolved by conducting definitive studies that take into account different levels of caries activity, treatment availability and concerns of patients. The ethical issues can only be resolved through open discussion.

CONCLUSION

CCT is a multi-purpose procedure that uses GIC to prevent and control caries. It is an adaptation of accepted concepts, methods and materials. This simple, low-cost procedure combines a fluoride-reservoir, sealant and caries control treatment into one procedure. CCT needs to be studied under controlled conditions to clearly establish its safety and effectiveness in comparison with alternative treatments. CCT is controversial among dentists and raises a number of important technical and ethical issues that have wider implications for preventive and restorative dentistry.

TABLES

Indications:	• **All Class I tooth surfaces without signs of caries.** • **All cavitated tooth surfaces, except teeth with:**
Contraindications:	• **History of tooth pain.** • **Probable need of pulp therapy or extraction** • **Signs or symptom of an abscess.** • **Impossible to treat, e.g., debris, blood.** • **Existing restoration.**

Table 1. Indications and Contraindications for CCT

- **type 2 glass ionomer cement (capsule system, 1 per patient)**
- **capsule activator and applicator (2 sets per clinician)**
- **triturator (1 per clinician)**
- **petrolatum in squeezable tube**
- **gauze (4 pieces per patient)**
- **toothbrush (1 per patient which the patient keeps)**
- **infection control supplies (gloves, tray coverings, glasses, plastic disposable bag)**
- **articulation paper (ideally not used)**
- **cleoid/discoid carver (three per clinician and ideally not used)**

Table 2. Equipment and Supplies for the CCT Procedure

hydrophilic set	**bacteriostatic**	**fast setting**
chemical bonding	**fluoride release**	**biocompatible**
compressable		

Table 3. Properties of Type 2 Glass Ionomer Cement

A. Debride the occlusal surfaces and cavitations with a toothbrush.
B. Reduce moisture on occlusal surfaces with gauze.
C. Press GIC into cavitations, pits and fissures.
D. Coat GIC before set with petrolatum.
E. Tap teeth together in centric occlusion.
F. Keep teeth apart until initial set of GIC (five minutes from start of mix).

Table 4. Main Steps in the CCT Procedure

safe	**painless**	**low skill**	**non-threatening**
fast	**low risk**	**effective**	**expanded function**
simple	**low cost**	**multi-purpose**	**low technology**

Table 6. Advantages of Caries Control Treatment

- **Caries is not excavated.**
- **Plaque and saliva are not completely removed.**
- **A finger is used to place GIC.**
- **GIC is placed over caries.**
- **Visible long-term retention of GIC is less than other procedures**
- **GIC is left in direct contact with gingiva.**
- **Flossing between posterior teeth may be prevented.**
- **Manufacturer's recommended instructions are not followed.**

Table 7. Contentious Facts of the CCT Procedure

Parents ... are likely to put off all effort at treatment until the child has had a sleepless night with a toothache. (p. 256)

Much too frequently the dentist's first meeting with a child is when it (sic) has been wrought up with pain until its nerve endings are all on the alert ready to take fright at the least suggestion of further suffering. (p. 235)

We must temporize in our treatment. How can we temporize to our advantage, becomes the question. (p. 248)

Leave the decayed material in the dentin where it is. Do not disturb it or attempt to remove it. The removal of this is particularly painful to the child. (p. 249)

...if some decay is left or some dentin is exposed, it should be treated with silver nitrate. ... The object in this treatment is to fill the part of the dentin softened by decay with the insoluble salt of silver ... and incidentally to destroy the organisms in it. (p. 249)

Generally decay is effectually (sic) stopped by this treatment if the teeth and cut surfaces are kept fairly well cleaned. ... (p. 250)

... and the teeth, although mutilated and out of shape, will be useful to the time of their shedding. (p.251)

We may, if decay is again starting up in some part of a surface that has been treated in this way, treat it again and stop it again, and again, if necessary. (p.252)

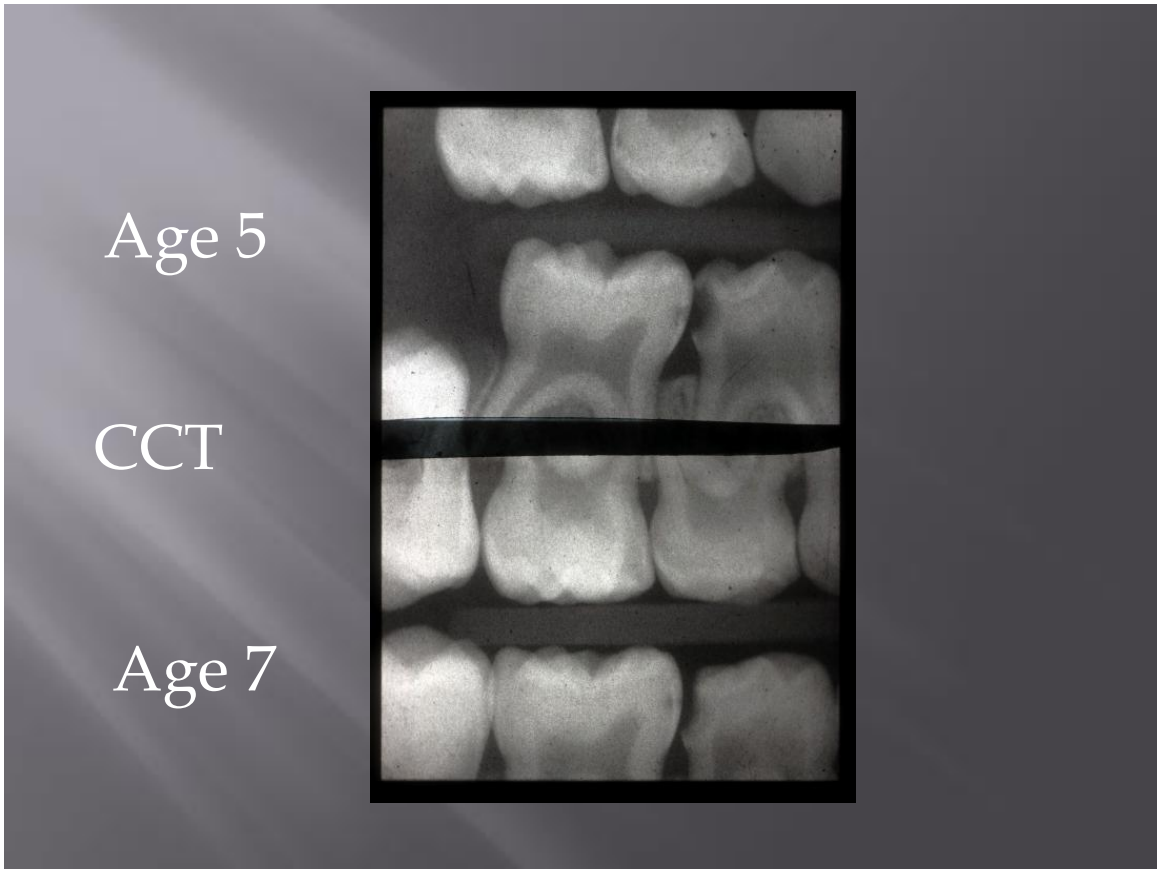
We will not always succeed well with this process; sometimes the sensitiveness will remain and hinder us from making a sufficient excavation, but the case will be the better for the ... limiting of the decay that will occur, even if we do not entirely succeed. (p. 253-254)

Table 5. Quotations from G. V. Black on the Management of Children's Teeth in A Work on Operative Dentistry in Two Volumes, Volume I. p. 235-257(1908).

AREAS OF COMPARISON		CCT	ABT	M-ITR	ART/ ITR	CRT
Objectives	• painless procedure.....	yes	yes	yes	almost	no
	• prevents caries.....	yes	yes	yes	yes	no
	• delays caries recurrence.....	yes	yes	yes	yes	yes
	• arrests caries ……....	yes	yes	yes	yes	yes
	• prevents or delays tooth loss.....	yes	yes	yes	yes	yes
	• removes caries	no	no	no	some	all
	• removes cariogenic bacteria	no	no	no	some	some
	• kills cariogenic bacteria	no	yes	yes	no	no
	• covers caries	yes	yes	yes	yes	no
	• repairs tooth form and occlusion.....	no	no	yes	yes	yes
Treatment Criteria	• all posterior teeth except those that are painful or abscessed.....	yes	--	yes	yes	--
	• all restorable carious teeth.....	yes	yes	yes	yes	yes
Procedure	• local anesthesia.....	no	no	no	no	yes
	• excavates all caries ……..…	no	no	no	no	yes
	• partial caries excavation …….....	no	no	no	yes	no
	• no caries removal……..	yes	yes	yes	no	no
	• prepare cavity for restoration.....	no	no	no	yes	yes
	• restore form and function with GIC.....	no	no	?	yes	no
	• restore form and function w amal/comp.	no	no	no	no	yes
	• apply GIC over caries and pits/fissures	yes	--	yes	yes	no
	• single visit for all carious teeth…….	yes	yes	yes	yes	no
Utilities	• electricity.....	no	no	yes	yes	yes
	• compressed air …….....	no	yes	yes	yes	yes
	• water under pressure……...	no	no	no	yes	yes
Personnel	• dentist.....	no	no	no	no	yes
	• expanded functions for auxiliaries.....	yes	yes	yes	yes	yes
	• dental assistant required.....	yes	?	?	yes	yes
Equipment	• operating light and dental chair.....	no	no	?	yes	yes
	• mechanical mixer……....	yes	no	?	no	yes
	• water spray.....	no	no	?	yes	yes
	• forced air…….……	no	yes	yes	yes	yes
	• suction….....	no	no	?	?	yes
Instruments	• standard restorative hand instruments...	no	no	no	yes	yes
Infection Control	• instrument sterilization required.....	no	no	no	yes	yes
Material	• GIC - capsule system, self-cure.....	yes	no	yes	yes	no
	• GIC - hand mix, self-cure.....	no	no	yes	yes	no
	• amalgam, composite, gold.....	no	no	no	no	yes
Treatment Time	• three – five minutes per <u>patient</u>….....	yes	yes	no	no	no
	• fifteen minutes per patient	no	no	yes	no	no
	• over fifteen minutes per <u>tooth</u>….....	no	no	no	yes	yes

Table 8. Comparison of CCT (Caries Control Treatment)
ABT (Anti-Bacterial Treatment e.g., SN, SDF, CHX)
ART (Atraumatic Restorative Treatment + GIC sealant)
ITR (Interim Therapeutic Restoration – ART without GIC sealant)
M-ITR (Modified ITR = ABT/SDF + GIC-ITR)
CRT (Conventional Restorative Treatment)

Figure 1. Radiographs before treatment at age 5 and after treatment at age 7



Note: At the age 7 visit, the GIC is partially lost on the distal cavitation of the lower first primary molar but the caries appears to be remineralized and there appears to be seconday dentin protecting the pulp that was absent at age 5. The radiolucency into the dentin on the adjacent mesial surface of the second primary second molar has reduced in size and the radiolucency at the dej on the mesial of the upper first primary molar is no longer visible.

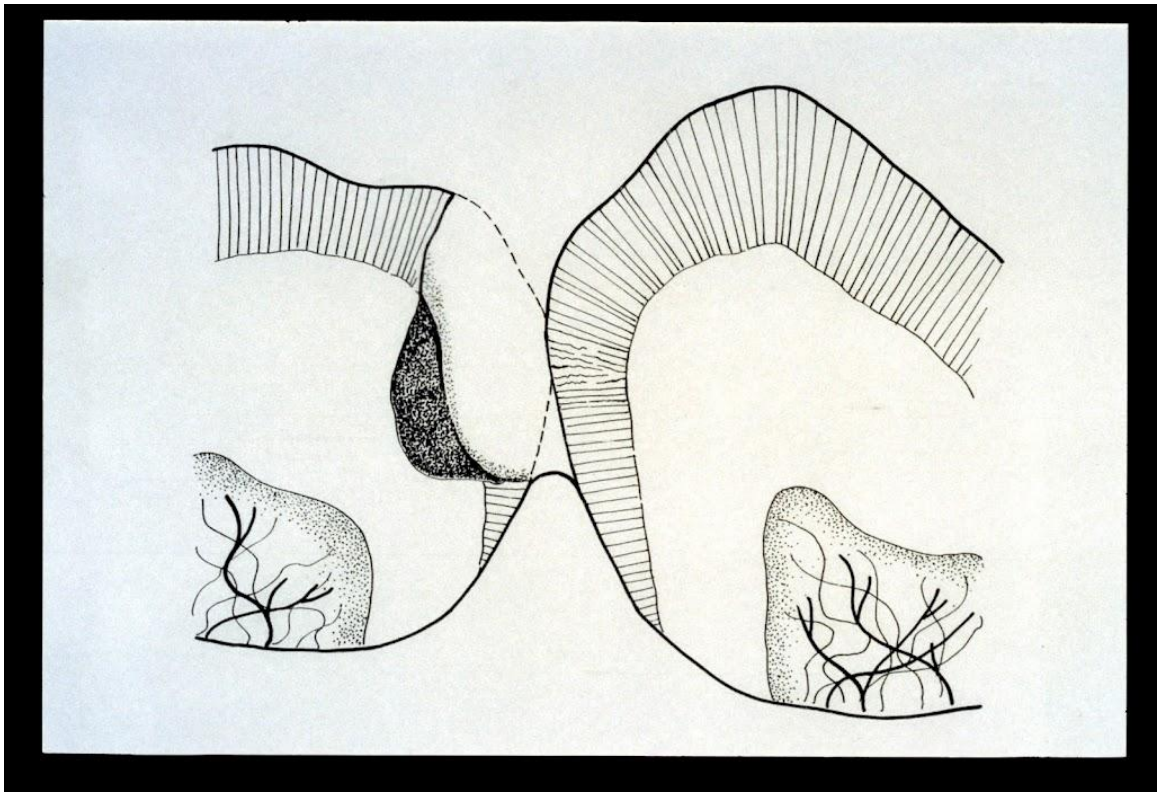


Figure 2. A sagittal section before application of GIC. Illustrated is a Class II cavity, bacteria, enamel, dentin, caries, pulp, gingival papilla and initial caries on the adjacent proximal surface.

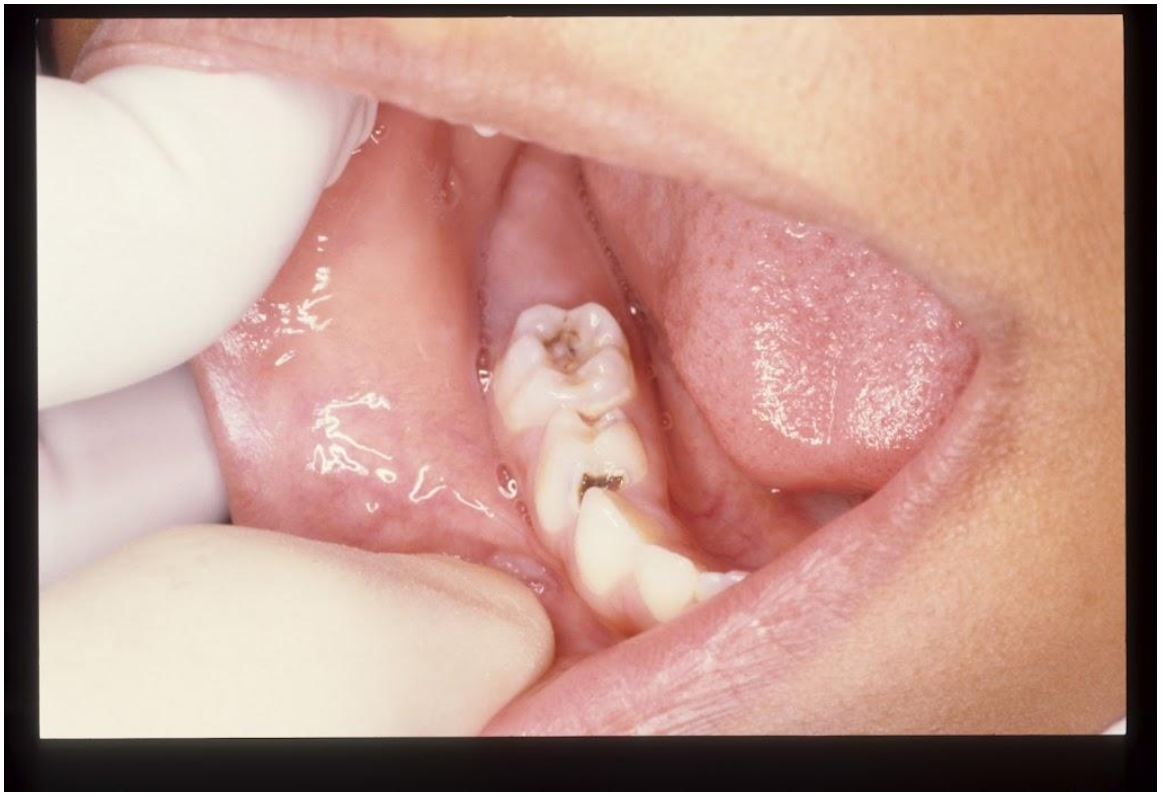


Figure 2a. A patient photograph of Fig. 2

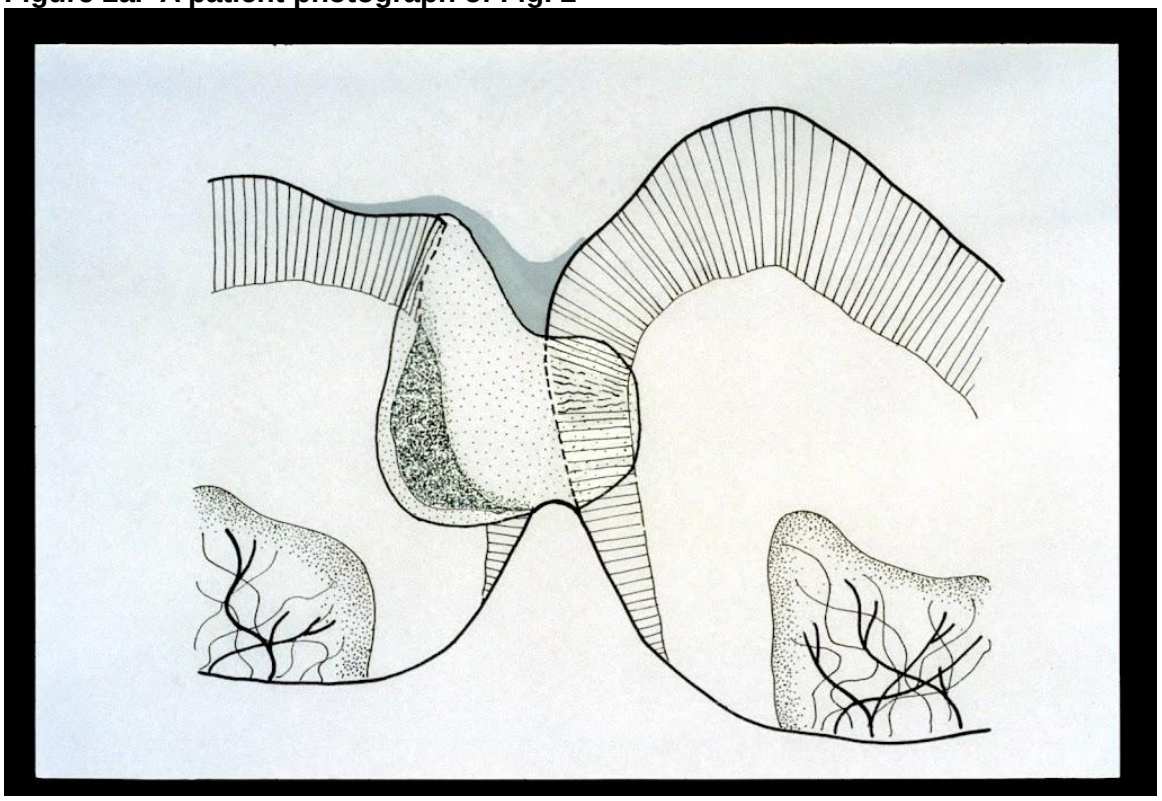


Figure 3. The same view as Figure 2 after placement of GIC and petrolatum.

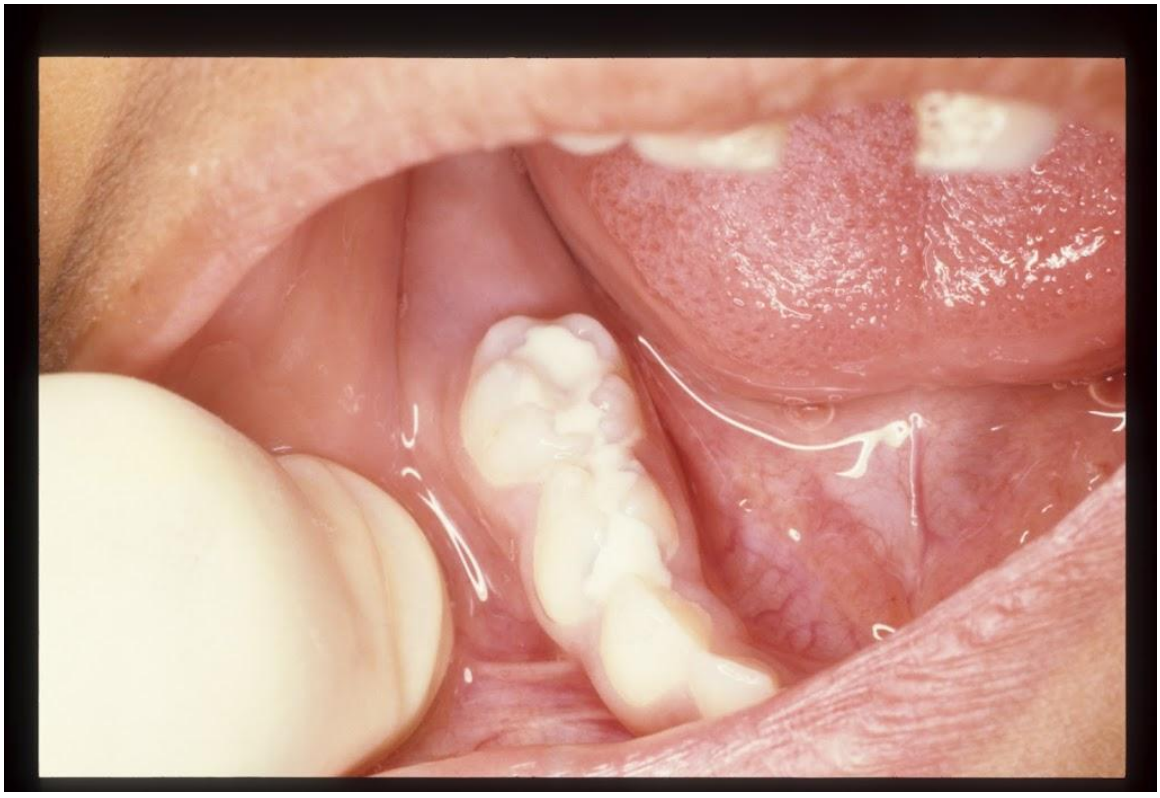


Figure 3a. A patient photograph of Fig. 3.

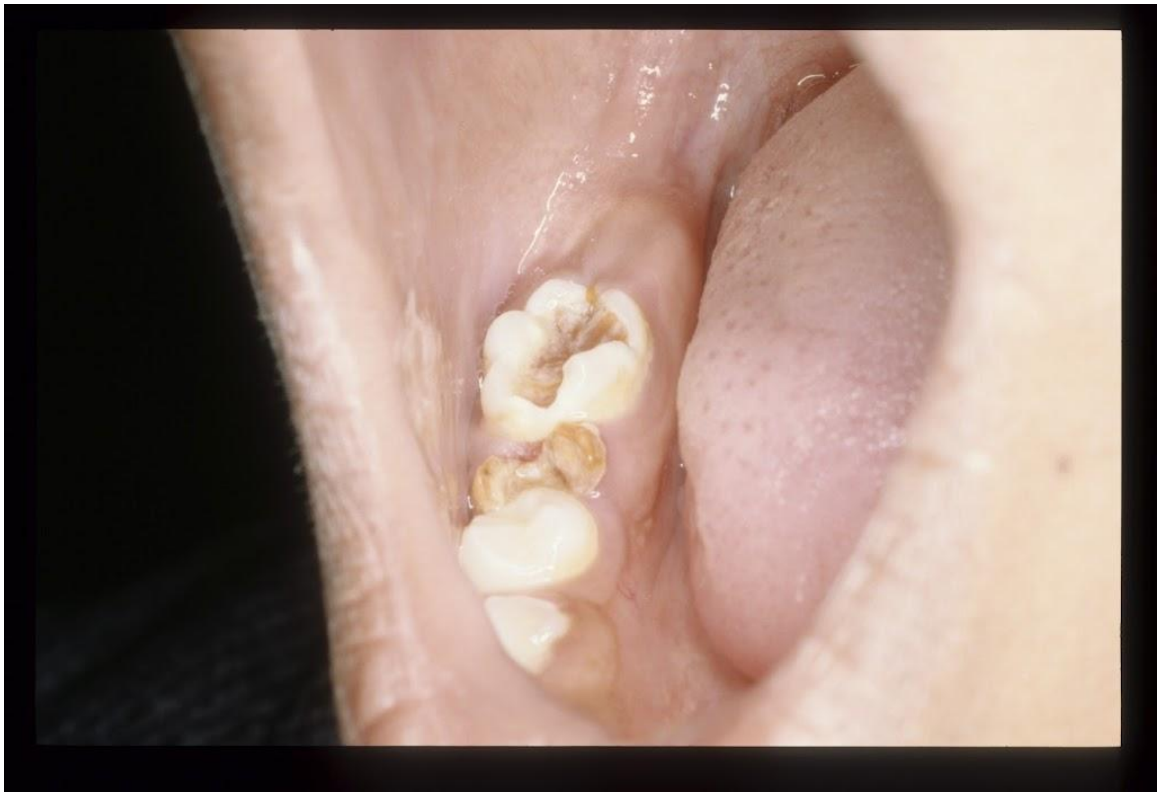


Figure 4. CCT could have prevented this.

On the following two web links are uncaptioned slides from three presentations describing GIC, CCT and their application in a MCH and a School Program.

REFERENCES

1. Marthaler, T.M. Explanations for changing patterns of disease in the Western World. In Cariology Today. Ed. Guggenheim B. pp 13-25. International Congress, Karger 1983/1984.
2. Allukian M. Introduction in Oral Disease: The neglected epidemic - what can do done? J Pub Hlth Dent 1993 53:45.
3. Smith A.C., Lang W.P. CPITN, DMFT, and treatment requirements in the Nicaraguan population. Comm Dent Oral Epid 1993 21:190-193.
4. Flanders R.A. School dental health in Honduras. J Pub Health Dent 1988 48:168-171.
5. MacLean J.S., Wilson A.D. Fissure sealing and filling with an adhesive glass ionomer cement. Br Dent J 1974 136:269-276.
6. Mount G. Glass ionomer cement: Clinical Considerations. In: Clinical Dentistry Vol 4 Ch 20A Philadelphia Harper & Row 1984 pp 1-22.
7. Leinfelder, K.F. Glass ionomers: current clinical developments. J Am Dent Assoc 1993 124:62-64.
8. Feigal R., Hitt J., Spleith S. Retaining sealant on salivary contaminated enamel. J Am Dent Assoc 1993 124:88-97.
9. Seeholzer H.W., Dash W. Banding with a glass ionomer cement. J Clin Orth 1988 22:165-169.

9a. http://www.ihs.gov/doh/index.cfm?fuseaction=ecc.display

10. Saleh L.A., Khalil M.F. The effect of different protective coatings on the surface hardness of glass ionomer cements. Saudi Dent J 1994 6:3-7.
11. McKnight-Hanes C., Whitford G.M. Fluoride release from three glass ionomer materials and the effects of varnishing with or without finishing. Caries Res 1992 26:345-350.

11a. http://www.cda.org/library/cda_member/pubs/journal/jo ur0303/hicks.htm

12. Black G.V. Management of Children's Teeth. In A Work on Operative Dentistry, The Pathology of the Hard Tissues of the Teeth, Vol 1. Pp. 235-257 Medico-Dental Pub. Co. 1st Ed., 1908.
13. Craig G.G., Powell K.R., Cooper M.H. Caries progression in primary molars: 24-month results from a minimal treatment programme. Com Dent Oral Epid 1981 9:260-265.
14. Craig G.G. University of Sydney, School of Dentistry, operative dentistry manual. 1986.
15. Craig G.G. Prolonged fluoride application. Com Dent Oral Epid 1971.
16. Barmes D. Towards a better oral health future. Who Oral Health Programme 1993
17. Renson C.E. Global changes in caries prevalence and dental manpower requirements: 1. Assembling and analyzing the data. Dent Update, September 1989.
18. Nikiforuk G. Understanding Dental Caries. 1. Etiology and Mechanism. Basic and Clinical Aspects. pp 286, 287 Karger 1985.
19. Handelman S.L., et al. Dentists' preferences in management of incipient caries in young adults. 1990 J Dent Res 69 (Spec Iss):281.
20. Handleman S.L., Washburn F. Two-year report of sealant effect of a fissure sealant on bacteria in dental caries. J Am Dent Assoc. 1973 98:1189-1191.
21. Going R.E., Loesche W.J., Grainger D.A., Syed S.A. The viability of microorganisms in carious lesions five years after covering with a fissure sealant. J Am Dent Assoc. 1978 97:455.
22. Mertz-Fairhurst E.J., Schuster G.S., Fairhurst C.W. Arresting caries by sealants: results of a clinical study. J Am Dent Assoc. 1986 112:194.
23. Mertz-Fairhurst E.J., Curtis JW Jr., Ergle JW, Rueggeberg FA, Adair SM. Ultraconservative and cariostatic sealed restorations: results at year 10. JAD. 1998, Jan;129(1):55-66.
24. Kidd E.A.M. Cavity sealing ability of composite and glass ionomer cement restorations. An assessment in vitro. Br. Dent J 1978 144:139.
25. Thornton J.B., Retif D.H., Bradley E.L. Marginal leakage of two glass ionomer cements: Ketac-Fil and Ketac-Silver. Am J Dent 1988 1:35-38.
26. Svanberg M., Krasse B., Ornerfeldt H.O. *Mutans Streptococci* in interproximal plaque from amalgam and glass ionomer restorations. Caries Res 1990 24:133.

27. Svanberg M., Mjor I.A., Oratavik D. *Mutans streptococci* in plaque from margins of amalgam, composite and glass ionomer restorations. J Dent Res 1990 40:11.
28. Berg J.H., Farrell J.E., Brown L.R. Class II glass ionomer/silver cermet restorations and their effect on interproximal growth of *mutans streptococci*. Ped Dent 1990 12:20.
29. Forss H., et al. Fluoride and *mutans streptococci* in plaque grown on glass ionomer and composite. Caries Res 1991 25:454-458.
30. Seppa L., et al. Fluoride content of enamel and plaque in teeth adjacent to glass ionomer restorations. J Dent Res 1992? Abst 43.
31. Siritapetawee M. et al. Salivary fluoride released by glass ionomer or HF sealants. J Dent Res 1990 April Abst 81 pp 1106.
32. Swift E.J. Jr. Effects of glass ionomers on recurrent caries. Op Dent 1989 14:40.
33. Skartveit L., Tveit A.B., Totdal B. *In vivo* fluoride uptake in enamel and dentin from fluoride containing materials. J Dent Child 1990 57:97-100.
34. Ikeda M. et al. *In vivo* fluoride uptake by dentine from fluoride-releasing glass ionomer. Caries Res 1993 Abst 103 pp 236.
35. Weerheijm K.L. et al. The effect of glass-ionomer cement on carious dentine: an in vivo study. 1993 Caries Res 27:417-423.
36. Benelli E.M. et al. *In situ* anticariogenic potential of glass ionomer cement. 1993 Caries Res 27:280-284.
37. van Dijken J. Three-year evaluation on effect of surface bonding of glass ionomer cement in cervical abrasion lesions. Scand J Dent Res 1992 100:133-135.
38. Croll T.P., Riesenberger R.E., Miller A.S. Clinical and histological observations of glass ionomer-silver cermet restorations in six human primary molars. Quint Int 1988 19(12):911-9?
39. Gotjamanos T., Lamplough H.G. Pulp response to treatment of carious primary teeth with silver fluoride and glass ionomer cermet. J Dent Res 19?? Abst 31.
40. Stanley H.R., Pulpal responses to ionomer cements – biological characteristics. J Am Dent Assoc 1990 120:25-29.
41. Swift E.J. Jr., Le Valley B.D. Microleakage of etched-dentin composite resin restorations. Quint Int 1992 23:505.
42. Kidd E.A.M., Toffenetti F., Mjor I.A. Secondary Caries. Int Dent J. 1992 42:127.
43. DeSchepper E.J., et al. Antibacterial effects of glass ionomer. Am Dent J 1989 2:51-56.
44. Telford A. Uses of glass ionomer cements in children's dentistry. Dent Outlook 1983 9:75.
45. Tanaka M., et al. Use of a fluoride-containing sealant on interproximal surfaces. J Dent Res 1990 Abst 1391.
46. Derkson G.D., Richardson A.S., Jinks G.M. Clinical evaluation of a restoration containing fluoride: two-year results. Ped Dent 1989 11:286-290.
47. Stratman R.G. and Donly K.J. Enamel remineralization on teeth adjacent to and contacting Class II glass ionomer restorations. J Dent Res IADR Abst 1709 pp 317.
48. Svanberg M. Class II amalgam restorations, glass-ionomer tunnel restorations, and caries development on adjacent tooth surfaces: a 3-year clinical study.
49. Nakornchai S. A comparison of retention in two types of sealants. J Dent Res 1990 68(4) Abst 75.
50. Forss H., Saarni U-M, Seppa L. Comparison of glass ionomer and resin-based fissure sealants: a 2-year clinical trial. Caries Res 1992 Abst 69.
51. Mejare I., Mjor I.A. Glass ionomer and resin-based fissure sealants: a clinical study. Scan J Dent Res 1990 98:345-350.
52. Seppa L., Forss H. Resistance of occlusal fissures to demineralization after loss of glass ionomer sealants *in vitro*. Ped Dent 1991 13:39-42.
53. Pilot T., Frencken J., Phantumvanit P., Songpaisan Y. Development of a model for primary oral health care in refugees and displaced persons encampments. Report on fifth six months (May-Oct 1993) WHO Collaborating Centre for Oral Health Services Research. Nov 1993.
54. Leinfelder K.F. Letter to the editor. Observations on glass ionomer cement - Dr. Leinfelder's response. J Am Dent Assoc 1994 125:128.
55. Kleber C.J., Putt M.S. Inhibitory effect of aluminum on fissure caries formation in rats. Caries Res 1992 26:53-55.
56. Kleber C.J., Putt M.S., Milleman J.L. Dose response of aluminum in dentifrice on rat dental caries formation. J Dent Res 1993 Abst 102 pp 236.
57. Stamm J.W. The value of dentifrices and mouthrinses in caries prevention. Int Dent J 1993 43:517-527.

58. Axelsson P. Current role of pharmaceuticals in prevention of caries and periodontal disease. Int Dent J 1993 43:473-482.
59. Strang R. et al. Fluoride uptake and release from a glass ionomer. Caries Res 1993 Abst 102 pp 236.
60. Marinelli C.B. and Donly K.J. Effects of a fluoridated dentifrice on fluoride release of composite resin and glass ionomer cement. J Dent Res 1993 Abst 1707 pp 317.
61. Seppa L. And Ogaard B. The effect of fluoride application on fluoride release and antimicroial property on glass-ionomer *in vitro*. J Dent Res 1993 IADR Abst 949 pp222.
62. Hatibovic-Kofman S., Koch G. Fluoride release from glass ionomer cement *in vivo* and *in vitro*. Swed Dent J 1991 15:253-258.
63. Komatusu H. et al. Retention of fluoride in enamel after removal of applied glass-ionomer cement. J Dent Res 1990 68(4) Abst 893.
64. Komatusu H. et al. Caries preventive effect of glass-ionomer sealant reapplications: 3-year results. J Dent Res 1993 IADR Abst 217 pp 131.
65. Jessee, S.A. The neglect of our youth: A dental perspective. J Dent Child 1993 Nov-Dec. pp 361-364.
66. McDonald, S.P. A clinical comparison of non-traumatic methods of treating dental caries. Int Dent J 1994 44:465-470.

Additional References.

Rosenblatt A, Stamford TC, Niederman R. Silver diamine fluoride: a caries "silver-fluoride bullet". J Dent Res. 2009 Feb;88(2):116-25. Review. PubMed PMID: 19278981.

McDonald SP, Sheiham A. A clinical comparison of non-traumatic methods of treating dental caries. Int Dent J. 1994 Oct;44(5):465-70. PubMed PMID: 7814117.

Mertz-Fairhurst EJ, Curtis JW Jr, Ergle JW, Rueggeberg FA, Adair SM. Ultraconservative and cariostatic sealed restorations: results at year 10. J Am Dent Assoc. 1998 Jan;129(1):55-66. PubMed PMID: 9448347.

Ricketts DN, Kidd EA, Innes N, Clarkson J. Complete or ultraconservative removal of decayed tissue in unfilled teeth. Cochrane Database Syst Rev. 2006 Jul 19;(3):CD003808. Review. PubMed PMID: 16856019.

Mickenautsch S, Yengopal V. Absence of carious lesions at margins of glass-ionomer cement and amalgam restorations: An update of systematic review evidence. BMC Res Notes. 2011 Mar 11;4:58. PubMed PMID: 21396097; PubMed Central PMCID: PMC3060833.

Jo E. Frencken, Soraya Coelho Leal, Maria Fidela Navarro. Twenty-five-year atraumatic restorative treatment (ART) approach: a comprehensive overview. Clin Oral Investig. 2012 Jul 24; Department of Global Oral Health, College of Dental Sciences, Radboud University Nijmegen Medical Centre, Philips van Leijdenlaan 25, 6525 AX, Nijmegen, P.O. Box 9101, 6500 HB, Nijmegen, The Netherlands, j.frencken@dent.umcn.nl.

Martin A van 't Hof, Jo E Frencken, Wim H van Palenstein Helderman, Christopher J Holmgren. The atraumatic restorative treatment (ART) approach for managing dental caries: a meta-analysis. Int Dent J. 2006 Dec ;56 (6):345-51
WHO Collaborating Centre for Oral Health Care Planning and Future Scenarios, Radboud University Medical Centre, College of Dental Sciences.

a. Indirect Pulp Treatment (IPT)
http://www.aapd.org/media/Policies_Guidelines/G_Pulp.pdf

b. Interim Therapeutic Restoration (ITR)
http://www.aapd.org/media/Policies_Guidelines/P_ITR.pdf
http://updates.ihscde.com/presentations/CariesStabilization(Bruce).pdf
http://www.ihs.gov/doh/documents/ecc/DentalDocs/InterimTherapeuticRestorations.pdf

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