Introduction to the symposium. Two decades of ART: success through research

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It gives me great pleasure, both as president-elect of the IADR and personally, to introduce this landmark symposium celebrating two decades of Atraumatic Restorative Treatment (ART) - success through research.

While success can be defined in many ways, one definition concerns "the achievement of something desired, planned, or attempted". In many ways this definition applies to the genesis and the evolution of the ART approach. The approach started with the desire of its originator to develop quality and appropriate oral health care which could reach those who rarely have access to care. The promising results from the early field trials then led to the planned dissemination of the ART approach in partnership with the World Health Organization, the FDI World Dental Federation and through symposia organized in collaboration with the IADR. The last and perhaps most difficult hurdle has been the attempt to awaken interest amongst the dental profession to a new way of delivering care in terms of ART and other minimal intervention approaches based on a soundly researched evidence base. Here, as we will learn in this symposium, these latter attempts are eventually succeeding.

It is important, however, to underline that this symposium not only marks the success of the ART approach itself but also marks the importance of research in achieving this success. It bears witness to how research at all levels can contribute individually to a greater whole. For example, if there had not been research which permitted us a better understanding of the caries process, research that led to improved and reliable dental materials and research that allowed the outcomes of new treatment approaches to be effectively evaluated, the ART approach would not be at the stage it is today and we would not be celebrating two decades of ART's success through research.

It is only fitting that this symposium should start with the originator of the ART approach, namely Dr. Jo Frencken (The Netherlands), describing the evolution of Atraumatic Restorative Treatment from its roots as an answer to a problem of delivery care in rural Africa where attempts to manage dental care using "traditional" approaches had failed. He will then go on to describe the establishment of field studies in Thailand and other countries to evaluate ART's potential and reliability. He will then highlight some of the many achievements over the past two decades of ART.

Passing from the macro perspective of ART to a micro perspective, Dr. Gustavo Molina (Argentina) will show the importance of basic research relating to ART covering such aspects as the importance of sealing caries lesions, fluoride release and caries remineralisation.

Moving to the patient level Dr. Soraya Leal (Brazil) will examine whether an approach which purports to be atraumatic can have an effect on patient acceptability of dental care and particularly in relation to dental anxiety and discomfort.

The oral health profession can only advance if existing and future oral health care providers are made aware of new developments and approaches and receive appropriate training so that research can be applied to day-to-day oral health practice. With respect to ART, this implies

more than just technology transfer but involves the transfer of a sound understanding of the logic and research base why new approaches are necessary in oral health care. Here, as an educator and a researcher I will detail results of a study investigating the scenario of teaching ART in my native country Brasil, where two important health programs are starting to be implemented into the whole country, and the outcomes of this investigation can be helpful for the government authority in charge of these programs.

We then learn from Dr. Oswaldo Ruiz (Ecuador) how the ART approach is being incorporated into health care systems in Latin America. This is then followed by a particularly interesting and impressive country example where Dr. Heriberto Vera Hermosillo (Mexico) will detail how ART has been part of Mexico's oral health strategy for almost ten years. This has involved training of dentists, evaluation at each step of its implementation stage, and research on its effectiveness to help determine how the strategy can be improved. This is a perfect example of how research is important at every step of the oral health planning cycle and is an excellent model for other countries to follow.

Even as we celebrate two decades of ART research, the research community must not rest on its laurels but must build on the success it has achieved thus far. For this reason the symposium appropriately ends with a presentation by Dr. Christopher Holmgren (France) taking a prospective view of further research avenues relating primarily to Atraumatic Restorative Treatment but which also have applications in many other areas of caries management and oral health care.

For oral health care to improve and to become accessible to the many who do not have access or adequate access to oral health, targeted research in this important area is essential. This implies adequate funding and competent and willing research personnel. It is hoped that the publication of these symposium proceedings will stimulate all those in the research arena to take notice of the real need of research to improve oral health globally.

Evolution of the the ART approach: highlights and achievements

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ABSTRACT

Atraumatic Restorative Treatment (ART) was initiated in the mid-eighties in Tanzania in response to an inappropriately functioning community oral health programme that was based on western health care models and western technology. The approach has evolved to its present standing as an effective minimal intervention approach mainly because the originators anticipated the great potential of ART to alleviate inequality in oral health care, and because they recognised the need to carry out research to investigate its effectiveness and applicability. Twenty-five years later, ART was accepted by the World Health Organisation (1994) and the FDI World Dental Federation (2002). It is included in textbooks on cariology, restorative dentistry and minimal intervention dentistry. It is being systematically introduced into public oral health service systems in a number of low- and middle income countries. Private practitioners use it. Many publications related to aspects of ART have been published and many more will follow. To achieve quality results with ART one has to attend well-conducted and sufficiently long training courses, preferably in combination with other caries preventive strategies. ART should, therefore, not be considered in isolation and must be part of an evidence-based approach to oral health with a strong foundation based on prevention.

Key words: Atraumatic Restorative Treatment (ART). Developing countries. Dental caries. Health services research.

HISTORY OF EVOLUTION OF THE ART APPROACH

Atraumatic Restorative Treatment (ART) is a minimally invasive approach to both prevent dental carious lesions and stop its further progression. It consists of two components: sealing of carious-prone pits and fissures (ART sealants) and restoration of cavitated dentin lesions with sealant-restorations (ART restorations)[5]. The placement of an ART sealant involves the application of a high-viscosity glass-ionomer that is pushed into the pits and fissures under finger pressure. An ART restoration involves the removal of soft, completely demineralised carious tooth tissue, using hand instruments. This is followed by restoration of the cavity with an adhesive dental material that simultaneously seals any remaining pits and fissures that remain at risk. In practice the adhesive material predominantly used to restore cleaned cavities produced with hand instruments is a high-viscosity glass-ionomer. Restorations that have used rotary instruments for opening the cavity and hand instruments for cleaning the cavity are not considered ART restorations[7]. These so called modified-ART restorations do not differ from conventional restorations[16].

ART was initially developed in response to the need to find a method of preserving decayed teeth in people of all ages in underserved communities where resources such as electricity, piped water, conventional dental equipment and finance were rarely available or non-operational.

Code	Criteria
0	Present, satisfactory
1	Present, slight deficiency at cavity margin of less than 0.5mm*
2	Present, deficiency at cavity margin of 0.5mm or more*
3	Present, fracture in restoration
4	Present, fracture in tooth
5	Present, overextention of approximal margin of 0.5mm or more*
6	Not present, most or all of restoration missing
7	Not present, other restorative treatment performed
8	Not present, tooth is not present
9	Unable to diagnose
C	Dentine carious lesion present

*As assessed using the 0.5mm ball-end of a metal community periodontal index (CPI) probe
score 0 and 1 = survived

Figure 1 - Evaluation criteria for assessing ART restorations

Without this intervention, such teeth would decay further until they were lost through extraction. The approach that ultimately became known as ART was pioneered in the mid-eighties as part of a primary oral health care programme of the Dental School in Dar es Salaam, Tanzania. To support the newly established Dental School, western donors had given 'mobile' cast-iron dental chairs, and drill and suction devices. To become operational in rural Tanzania, this equipment required an electrical generator, petrol and a vehicle to transport it. It soon became apparent that the community oral health care training based on the donated "mobile" equipment was impractical and inappropriate. As cited by the students, the lack of finances for running a mobile programme, purchasing spare parts from abroad for the maintenance of the dental equipment and the lack of a vehicle were factors hampering the implementation of a community oral health programme based on the donated equipment.

So, what could be done? Necessity being 'the mother of invention', a small investigation was undertaken as to the kind of instruments that were available countrywide in dental clinics in Tanzania. It appeared that hand instruments were available, that most of the dental equipment was non-functional and that zinc-phosphate cement was the only filling material available. Consequently, the management of cavitated dentin lesions was based on the use of hand instruments and available restorative material. In practice such an approach was not found to cause any insurmountable problems, since in many cases the cavity opening was large enough for removal of its soft content; there was no need to use a powerful drill to achieve this. Fracturing thin unsupported enamel in order to open relatively small cavitated dentin lesions with a hatchet was also found possible. In the absence of any proper restorative material, the cleaned cavity was then filled with zinc-phosphate cement. The patients preferred this manner of treatment to that provided when the donated rotary equipment was used. Following encouraging responses to these early treatments in rural Tanzania, a decision was made to start a pilot study using polycarboxylate cement, rather than zinc-phosphate cement, to fill the cleaned cavities. Evaluation of 28 restorations in children and adults resulted in only one failure after 9 months. In a number of the restorations the polycarboxylate cement was visibly abraded away but the main outcome was that all these people were free of toothache, except for one whose tooth had to be extracted because of pulpitis. However, this cavity was very large before being filled. The enthusiastic patient response and the apparent success of this simple technique were encouraging. The results of the pilot study were presented at the scientific

meeting of the Tanzanian Dental Association in 1986, and a minimal intervention approach, later called ART, was officially born.

Based on the encouraging results of the pilot study, a field study was started in Tanzania. A permanent restorative material in the form of a medium-viscosity glass-ionomer cement was used instead of polycarboxylate cement. Unpublished results indicated a high level of restoration retention after 3 years. This finding formed the basis for setting up a clinical trial in Thailand in the early nineties, in which the ART approach was compared to the traditional amalgam approach[9,25]. The first set of ART criteria was developed. These included codes for the expected wear of the medium-viscosity glass-ionomer used. As material wear was found to be low at the end of the 3-year trial, the first criteria were amended and developed into the currently used ART criteria set (Figure 1).

At the 6th-month evaluation of the Thailand study in 1992, it became very apparent that the children who had been treated by ART happily participated, whereas those treated with the traditional rotary hand piece approach were very reluctant to do so. Many of the latter children ran away when they saw the operators, thinking that they needed to be treated again. Both groups of children were asked how they had remembered the treatment from 6 months previously. It became clear that there was a high level of acceptance amongst those treated with ART and an unwillingness to be treated again amongst those in the traditional rotary hand piece group. Hence the term Atraumatic Restorative Treatment (ART) was adopted: "Atraumatic" not only because of its low level of pain or discomfort, but also because of its minimal destruction of tooth tissue.

HIGHLIGHTS: RESEARCH AGENDA FOR ART

The Thailand study gained attention from world leaders in oral health and resulted in the adoption of ART by the World Health Organization on World Health Day, in 1994. The ART press-release from WHO gave high responsibility for ensuring that what was transmitted to the outside world could be proven, to the original ART team consisting of Prof. Taco Pilot, Prof. Prathip Phantumvanit, Dr. Yupin Songpaisan and Dr. Jo Frencken.

Meanwhile, ART studies had started in Cambodia[20], Zimbabwe[8] and China[14]. These cohort studies basically investigated the efficacy of ART sealants and ART restorations under field conditions. However, fundamental issues of carious lesion management surfaced as part of the ART studies.

In order to interact with the research community on these fundamental issues, a symposium on Minimum Intervention Techniques for Dental Caries was organised at the 73rd IADR congress in Singapore in 1995. In essence, the meeting was largely devoted to ART and related topics but since the acronym "ART" was not universally known at that time, the title of "Minimal Intervention" was used. It was the 1st ART symposium but under a different name. The most important aspect of the symposium was the development and acceptance of a research agenda on issues related to minimal intervention approaches for caries and, specifically, for ART. A proceeding of the symposium that contained the research agenda was published in the Journal of Dental Public Health in 1996. Setting a research agenda turned out to be of essential importance in stimulating further research related to the ART approach, as a sizable number of researchers based their future research on this agenda.

The 2nd ART symposium took place during the 76th IADR congress in Nice, France in 1998. As in 1995, a proceeding was published; this time in Community Dentistry and Oral Epidemiology, in 1999. It included a paper on the achievements related to the topics of the 1995 research agenda. This paper by Holmgren and Frencken[13] (1999) assisted many in taking up studies on ART. The 3rd ART symposium took place during 2004-FDI congress in New Delhi but no proceedings were published. The 4th ART symposium was held in Bauru, Brasil in 2004 and the proceedings were published in the Journal of Applied Oral Science in 2006. The 5th ART symposium took place in 2009, during the 3rd Pan Latin America

IADR congress in Ilsa de Margarita, Venezuela. All 1st authors of published papers on ART, with workable email addresses, were approached and were asked what they considered to be the future research priorities for ART. The findings have been reported by Holmgren and Figueiredo[12] (2010). By the 1st of December 2009, Pubmed contained 178 published articles on ART, of which 172 are related to the Atraumatic Restorative Treatment approach.

The FDI World Dental Federation set up a committee in 1997 to review the new caries management philosophy of Minimal Intervention Dentistry (MID). The report, describing ART as one of the examples of MID, was published in 2000 in the International Dental Journal and was discussed at the 2002-FDI meeting in Vienna. The General Assembly adopted ART as a minimal intervention approach.

ACHIEVEMENTS

Many researchers from many countries have investigated different aspects of ART. Some of their findings are listed below:

- Survival rates of single-surface ART restorations using high-viscosity glass-ionomers in primary and permanent posterior teeth are high and meet the American Dental Association (ADA) specifications for quality restorations[29];
- Survival rates of multiple-surface ART restorations using high-viscosity glass-ionomers in primary posterior teeth do not meet the ADA specifications[29];
- Survival rates of single-surface ART restorations in permanent posterior teeth, using high-viscosity glass-ionomers, do not differ significantly from comparable traditional restorations using amalgam[10,23];
- Survival rates of single-and multiple-surface ART restorations, using high-viscosity glass-ionomers, in primary posterior teeth do not differ significantly from comparable traditional restorations using composite[3,4] and compomer[19];
- Pain felt during treatment was lower in child populations treated restoratively with ART using high-viscosity glass-ionomers, than when traditional restorative procedures were used[15,21,25,26]. Moreover, ART provided without local anaesthesia was better accepted than traditional treatment with local anaesthesia[28];
- Studies developed to measure dental anxiety contained methodological errors that made it impossible to confirm the hypothesis that ART is less dental anxiety provoking than conventional treatments[17];
- Initial wear rates of ART restorations using high-viscosity glass-ionomers are low[11,18];
- ART restorations using high-viscosity glass-ionomers were more cost-effective after 2 years than comparable amalgam restorations[23];
- ART has been introduced in public and private health services of both developing and developed countries and this process is ongoing;
- A chapter on ART has been included in textbooks on Cariology and Minimal Intervention Dentistry;
- ART courses, sometimes in conjunction with other caries-preventive strategies have been conducted in numerous countries.

These outcomes show that the ART approach using high-viscosity glass-ionomers produces quality restorations in single-surface cavities in primary and permanent posterior teeth, which are the cavities most prevalent in most countries. The ART approach saves teeth that otherwise would have to be extracted and prevents carious lesion development. It enhances the opportunity for providing comprehensive basic oral health care for underserved communities, in combination with palliative, preventive and promotional activities (BPOC)[6]. It may also improve the quality of life of patients and the job satisfaction of dentists, particularly those living in underserved communities. In order to achieve all this, dental practitioners have to participate in well-conducted and sufficiently lengthy (at least 5 days) ART courses; preferably in conjunction with other caries preventive strategies.

CONCLUDING REMARKS

ART is sometimes criticized because it is seen as being merely a restorative treatment performed by dentists. What can restorative care and dentists do to improve oral health

in underserved nations? Those asking these questions may have forgotten that early improvement in oral health in Western countries in the 60-70ties occurred because of the presence of preventive and restorative care supported by self-care. They may also not fully understand the philosophy underlying the ART approach. It is not only a restorative but also a preventive and palliative treatment, performed not only by dentists but also by other operating dental personnel, such as dental therapists. This increases the chance for better oral health in underserved communities in both developed and developing countries.

Many dentists see ART as suitable only for developing countries; such as those in Africa where it originated, where many areas lack water and electricity. They do not see it as proper oral care procedure because it does not use sophisticated equipment. ART has its place not only in poor and underserved communities but also in the most exclusive dental practices, as has been reported from countries like the USA[27], UK[2] and the Netherlands[1].

The following may exemplify its potential. I visited a dental clinic in a suburb of Dar es Salaam, Tanzania in August 2009 where ART had been introduced since 2005. One of the dentists told me enthusiastically: *"since I have started work as a dentist in this health centre, now almost 25 years ago, I have never experienced that people come to have their tooth restored. They always come for extraction. But in recent years, they come asking for restorations. I have seen people even come for a check-up, unheard of years ago. This change is due to the education we dentists have received on oral health prevention and, particularly, on the ART approach. I am very happy to still be around to witness the change in oral care after all those many years of pulling teeth".* She continued: *"the funny thing is that money doesn't seem to matter. They all pay for a restoration which is more expensive than an extraction. What matters for them",* she said, *"is the fact that teeth now can be restored and that it is done very friendly and pain free".*

I was profoundly moved by this dentist's statement, remembering the humble beginnings of ART in that country some 25 years ago. Since the birth of ART, the approach has traveled the world. It has boosted the job satisfaction of many dentists and eliminated the suffering of many people. It was also instrumental in showing that by combining effective prevention with a biologically and scientifically based restorative approach it was possible to give hope to improving oral health for the many billions who do not have access to oral care. The fact that the ART team realized the need to engage in proper research from the very start has paid dividends and will continue to do for many years to come.

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Dental anxiety and pain related to ART

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ABSTRACT

Atraumatic Restorative Treatment (ART) is considered to be well accepted, both by children and by adult patients. The objective of this review is to present and discuss the evidence regarding the acceptability of ART, from the patient's perspective. Aspects related to dental anxiety/fear and pain/discomfort have been highlighted, to facilitate better understanding and use of the information available in the literature. Conclusions: The ART approach has been shown to cause less discomfort than other conventional approaches and is, therefore, considered a very promising "atraumatic" management approach for cavitated carious lesions in children, anxious adults and possibly, for dental-phobic patients.

Key words: Atraumatic Restorative Treatment (ART) Dental anxiety. Dental pain. Discomfort. Dental fear.

INTRODUCTION

The Atraumatic Restorative Treatment (ART) is a minimum intervention approach for managing carious lesions. Only hand instruments are used for cavity preparation and cleaning followed by restoration of the cavity and sealing pits and fissures with an adhesive material such as glass ionomer cement[7].

The "atraumatic" component of the technique can be understood from different perspectives, such as those of tooth tissue preservation and patients' comfort. Undoubtedly, using only hand instruments to open and clean the cavity preserves more sound dental structure than does the traditional approach that recommends the use of the drill[24]. In this respect, the ART approach is definitely less traumatic to the tooth than the conventional method. It also has the capacity to be more comfortable for patients, as the noise and vibration related to the bur are absent. This "atraumatic" effect is further enhanced by the fact that local anesthesia is rarely used in the ART approach[8,10]. This indicates that ART is a treatment that inflicts only a low level of trauma upon the patient. Finally, because the patients are more relaxed when ART is used in treating them, the technique may also reduce operator stress during interaction with the patient; and therefore, prove less traumatic to dentists than traditional methods[13].

The objective of this review is to present and discuss evidence regarding the acceptability of ART from the patient perspective. Aspects related to dental anxiety/fear and pain/discomfort will be highlighted in order to engender better understanding and use of the information available in the literature.

ART ACCEPTABILITY: LITERATURE EVIDENCE

In general, results retrieved from different clinical trials, conducted in different regions of the world, show that ART is well accepted both by children and by adults treated in

accordance with this approach[5,18,22]. Specific methodological designs have been developed in order to demonstrate its effectiveness in terms of reducing patients' dental anxiety and causing less pain than the traditional approaches cause.

To investigate pain associated with both ART (using hand instruments) and a conventional approach (using high and low speed handpieces), in the removal of carious tissues, at the end of the restorative session a group of adolescents were asked whether any pain was felt during treatment. The authors concluded that ART was less painful than the conventional restoration technique[18]. This finding is in agreement with that of Schriks and van Amerongen[19] (2003), who concluded that children treated according to the ART approach experienced less discomfort than those treated with rotary instruments. In both cases local anesthesia was not used. Nevertheless, in the latter study discomfort was not individually reported by the patient, but was assessed through physiological measurements (heart rate) and behavioral observations on specific moments during the treatment (entrance, start, deep excavation, matrix placement, restoration and at the end of treatment). Analysis of behavioral observations and physiological measurements showed only a moderate correlation, while behavioral scores demonstrated that children from the ART group were more relaxed throughout all the treatment procedures than were children treated with rotary instruments. The physiological measurements were able to detect significant differences between the groups during deep excavation only. However, the intercorrelation between different ways of assessing dental anxiety is usually low, which can be explained by the multidimensional fear construct. Each measurement technique taps into a unique part of the process[1].

Due to structural characteristics of dentin, it is expected that more pain will be experienced in relation to deep cavities. This association was demonstrated in a study that aimed to determine the level of sensitivity related to cavity size and lesion depth, experienced by adolescents during ART cavity preparation[5]. The report of pain and discomfort was, in general, low; more frequently experienced in large than in small cavities and in cavities with the floor close to the pulp. Tubules extending through the dentin, that are greater in density near the pulp than at the outer periphery, are the pathway for sensitive stimuli transmission[14]. This explains the association of cavity depth and reports of pain.

Little information is available regarding pain and discomfort related to the ART approach for both adults and young children. Pain assessment is not easily performed in children, as they have difficulties in expressing their emotions and feelings[27]. This problem was described by Menezes Abreu, et al.[12] (2009). Pain experience in a group of young children (4 to 7 years old) after they had been treated according to the ART approach was compared with that of a group treated in accordance with a conventional approach using rotary instruments with local anesthesia and rubber dam. Children from the ART group reported less pain than those from the conventional one. The second finding was that 4 year-old children reported more pain than children aged 5 to 7 years old, independently of the treatment provided. The authors observed that the youngest children had experienced some difficulty in interpreting the pain rating scale used in the study.

In discussing dental anxiety in relation to ART, two contradicting studies have been published[13,22]. Mickenautsch, et al.[13] (2007) concluded that patients (children and adults) treated with the ART approach were less-anxious than those treated by traditional methods using the drill and bur. In this study, patients' anxiety levels were assessed immediately after the restorative session had been completed. Two different interpretations of the results are possible: either the patients experienced less trauma using ART and were therefore less anxious or the patients treated by the ART approach were initially less anxious than those treated according to the traditional approach, and thus experienced less trauma. If dental anxiety in this study would also have been assessed prior to the treatment, the treatment effect could have been established.

In the second study, the authors were not

able to demonstrate any difference in dental anxiety levels amongst children from 3 treatment groups (traditional, ART and ART in combination with a chemomechanical caries removal gel). As in the previously discussed study, the dental anxiety assessment was performed at the end of the treatment session. This method does not follow the common way of assessing dental anxiety, which should be carried out before the start of the dental visit and not after it has been completed. This factor might be the reason for the contradictory findings of the two studies.

On the basis of the information provided, it can be concluded that dental/fear and pain/discomfort related to different restoratives procedures require further investigation. Studies should include confounding factors; such as: age, gender, operator influence and cultural aspects[6,19]. Furthermore, methodological aspects should be given due attention, as both fear/anxiety and pain/discomfort levels may also be influenced by subjective aspects like emotional responses and social determinants[10]. Lastly, fear/anxiety and pain/discomfort assessment instruments should be used according to the instructions described in the original protocols.

ANXIETY, FEAR, PAIN AND DISCOMFORT ASSOCIATED WITH DENTISTRY

Dental anxiety can be defined as a feeling of apprehension about dental treatment, not necessarily related to a specific stimulus[6], while dental fear is a normal emotional reaction to one or more specific threatening stimuli in the dental situation[9]. Both terms are currently being used interchangeably in the dental literature when referring to negative feelings related to dental treatment. According to Panksepp[17] (1982), the difference between fear and anxiety seems to reflect only the intensity.

A critical literature review estimates that 9% of the world population suffers from dental fear/anxiety, with a decrease in prevalence as age increases[9]. The etiology of dental anxiety is multifactorial, being strongly correlated to a history of dental pain in both adults and children[15,26]. A comparison of anxious and non-anxious children demonstrated that fear was more strongly associated with children's experience of pain and trauma than with objective dental pathology[23].

Dental anxiety/fear may negatively impact on a person's life. According to Cohen, et al.[4] (2000), physiological impacts include fright response and feelings of exhaustion after dental appointments, while behavioral impacts include dental avoidance. It is well established that anxious individuals frequently avoid dental treatment, either by failing to appear for their dental appointments or by delaying dental visits for long periods of time[11].

The interaction between anxiety and dental pain, as investigated by van Wijk and Hoogstraten[25] (2005), suggests that people who respond fearfully to pain are at an increase risk of ending up in a vicious cycle of anxiety, as shown in Figure 1. If this cycle is not broken, a severe form of dental fear might develop. This can be defined, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), as a specific phobia - dental phobia. This phobia is characterized by marked and persistent anxiety in relation either to clear discernable situations (e.g.: drill, needle) or to the dental situation in general[3].

Some interesting results related to the prevalence of dental fear and dental phobia in comparison to 10 other common fears and

Figure 1- Vicious cycle of anxiety: modified from van Wijk and Hoogstraten[25] (2009)

subtypes of specific phobia were reported in a recent investigation. The prevalence of dental fear was considered high (24.3%), but lower than that of fear of snakes, heights or physical injuries. Surprisingly, among the phobias, dental phobia was the most prevalent (3.7%)[16]. These findings should alert both researchers and dental practitioners to this very real issue with the objective of seeking ways to improve the condition.

Dental fear usually starts in childhood with a negative experience, commonly expressed as having had a painful event and/or being treated by a rough dentist[2]. Although it tends to decrease with an increase of age[9], dental anxiety/fear can persist into middle and advanced adulthood[16]. It is essential, therefore, that dentists are capable to identify these patients, in order to plan the dental intervention that can reduce each individual's anxiety level.

PERSPECTIVES: ART AS A TOOL FOR PATIENT MANAGEMENT

As previously discussed, dental fear is a potentially distressing condition: not only for the patient, but also for the dentist. The best strategy for dealing with this condition in children would be to employ appropriate pediatric management techniques that could assist the practitioner in identifying dental-anxious children as early as possible and to use dental interventions that cause the least possible psychological negativity.

The most common fear-inducing aspects of the dental treatment are the procedures related to the needle and the drill[20,21]. Individual vulnerability and perceptions of negative dentist behavior also play an important role in patients' dental anxiety development[2].

In light of all these aspects, Atraumatic Restorative Treatment may become an important "tool" for managing carious dental lesions, both for young children and for anxious adults. The ART approach is based using only hand instruments to open the cavity and remove carious tissue[7]. This aspect may have a positive impact on patients' experience of discomfort, as the drill is not used. Because of that, the usual vibration and noise related to this equipment are not present and this facilitates better interaction between patient and dentist. In addition, because of removal of infected dentine only, local anesthesia is almost never required[13]. Thus, the ART technique is considered less traumatic, less painful and friendlier than the conventional restorative interventions. Further investigations, with well- designed research protocols are required in order to confirm these assumptions.

CONCLUSIONS

Dental fear/anxiety and dental pain/discomfort are multifactorial phenomena that can negatively impact on an individual's life. Dentists should be able to identify, and be prepared to treat, fearful patients in a way that reduces their levels of dental anxiety. The ART approach has been shown to cause less discomfort than other conventional approaches and is, therefore, considered a very promising "atraumatic" management approach for cavitated carious lesions in children, anxious adults and possibly, for dental-phobic patients.

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The ART approach: clinical aspects reviewed

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ABSTRACT

The success of ART as a caries management approach is supported by more than 20 years of scientific evidence. ART follows the contemporary concepts of modern cariology and restorative dentistry. It challenges treatment concepts such as step-wise excavation and the need for complete removal of affected dentine. The ART approach so far has mainly used high-viscosity glass-ionomer as the sealant and restorative material. Cariostatic and remineralization properties have been ascribed to this material which requires further research to establish its clinical relevance. The adhesion of high-viscosity glass-ionomer to enamel in pits and fissures is apparently strong, as its remnants, blocking the pits and fissures, have been considered a possible reason for the low prevalence of carious lesion development after the glass-ionomer has clinically disappeared from it. Encapsulated high-viscosity glass-ionomers may lead to higher restoration survival results than those of the hand-mixed version and should, therefore, not be neglected when using ART. Similarly, the use of resin-modified glass-ionomer with ART should be researched. The effectiveness of ART when compared to conventional caries management approaches has been shown in numerous studies. Proper case selection is an important factor for long-lasting ART restoration survival. This is based on the caries risk situation of the individual, the size of the cavity opening, the strategic position of the cavitated tooth and the presence of adequate caries control measures. As the operator is one of the main causes for failure of ART restorations, attending a well-conducted ART training course is mandatory for successful implementation of ART.

Key words: Atraumatic Restorative Treatment (ART). Glass-ionomer cements. Minimal intervention dentistry. Sealants. Restorations.

INTRODUCTION

The Atraumatic Restorative Treatment (ART), by definition, has features that characterize this approach and differentiate it from what we know as "conventional" operative dentistry for the management of carious lesions. Frencken and Holmgren[26] (1999) defined ART as a "maximally preventive and minimally invasive approach to arrest further progression of dental caries. It involves the removal of soft, completely demineralised carious tooth tissues with hand instruments, followed by the restoration of the cavity with an adhesive dental material that simultaneously seals the remaining pits and fissures that remain at risk." Risk assessment is also the driving force behind the use of the preventive aspect of ART. This is achieved through sealing pits and fissures prone to development of carious lesions.

The purpose of this paper is to analyze and discuss the components that define ART, using published study outcomes, to discuss the contribution of ART to the management of carious lesion development in general and to identify issues that require further research.

ART SEALANTS: AN EFFECTIVE MEASURE TO PREVENT CARIOUS LESION DEVELOPMENT

Fissure sealants have been accepted as

effective tools for preventing carious lesion development in (newly) erupted molars and premolars exposed to potential caries-risk factors. They appear to be more effective than the common fluoride varnishes but the evidence is not substantial and is dependent upon local circumstances[30].

Retention of a sealant is usually considered the most important variable indicating its effectiveness. Those who disagree with this view have postulated that its carious lesion preventive effect is the real endpoint and that sealant retention is merely its surrogate[26]. These two variables do not necessarily correlate well, as is shown in the following example. A comparison between ART sealants using two types of glass-ionomer in a high caries-risk population was carried out in Brazil[54]. The study showed a high preventive effect (98.5%) for both type of sealants, whilst the retention rates of both types was lower than 50% after 1 year. Obviously, the level of caries risk in an individual and the level of professionalism of the practitioner have an important impact upon the relative contributions of both variables to the effectiveness of a sealant.

High-viscosity glass-ionomers are used in placing ART sealants. In the only comparative clinical trial published so far, they prevented carious lesion development in re-exposed pits and fissures of occlusal surfaces more effectively than resin composite sealants did[5]. Discussion continues as to whether such an effect can be ascribed to the fluoride release from the glass-ionomers used. However, some studies have shown that the fluoride release from glass-ionomers is low and clinically insignificant[55]. Others have demonstrated that glass-ionomer has a remineralising effect and ascribed this to its fluoride release[2,17]. Nevertheless, it appears that the view that their fluoride release is responsible for the preventive effect of glass-ionomer sealants may be based on insufficient evidence. A more plausible reason for its preventive effect over time could be related to the remnants of glass-ionomer left behind in the deeper parts of the pits and fissures, as was recently demonstrated by Frencken and Wolke[29] (2010) (Figure 1). This feature had already been described by Mejare and Mjör[40] (1990) and Williams, et al.[56] (1996) as a possible explanation for the caries preventive effect in deep pits and fissures after the sealant material had clinically disappeared. Obviously, there is a need to further investigate and compare of glass-ionomer and other sealant materials regarding this characteristic. Results of the comparison would assist the dental practitioner to decide which sealant material to use in order to obtain a long-lasting caries preventive effect.

The meta-analysis by Van't Hof, et al.[53] (2006) concluded that although the number of studies reporting on the retention and caries preventive effect of ART sealants was low, the retention of high-viscosity glass-ionomer ART sealants was higher than that of medium-viscosity glass-ionomer ART sealants. Furthermore, the caries preventive effect was high: 99%, 98% and 97% after 1, 2 and 3 years, respectively. This meta-analysis showed that only high-viscosity glass-ionomer should be used for sealing pits and fissures using ART.

USING ART IN MANAGING CAVITATED DENTIN LESIONS

Hand instruments are used for cavity cleaning in accordance with ART. Although hand excavators have been used to clean cavities for more than a century, many dental practitioners resort solely to rotary equipment when "preparing and cleaning" a cavity, thinking that using hand instrumentation alone will lead to insufficient results. In light of this, issues related to the use of the ART approach will be discussed.

HAND EXCAVATION VERSUS OTHER MEANS OF REMOVING CARIOUS TISSUES

Is the cavity clean enough after hand excavation to survive for long? A few *in-vitro* and *in-vivo* studies have provided some results. Bannerjee, et al.[3] (2000) concluded, in an *in-vitro* multiple-caries removal measures comparison study, that using a chemomechanical caries removal gel, manipulated by hand instruments

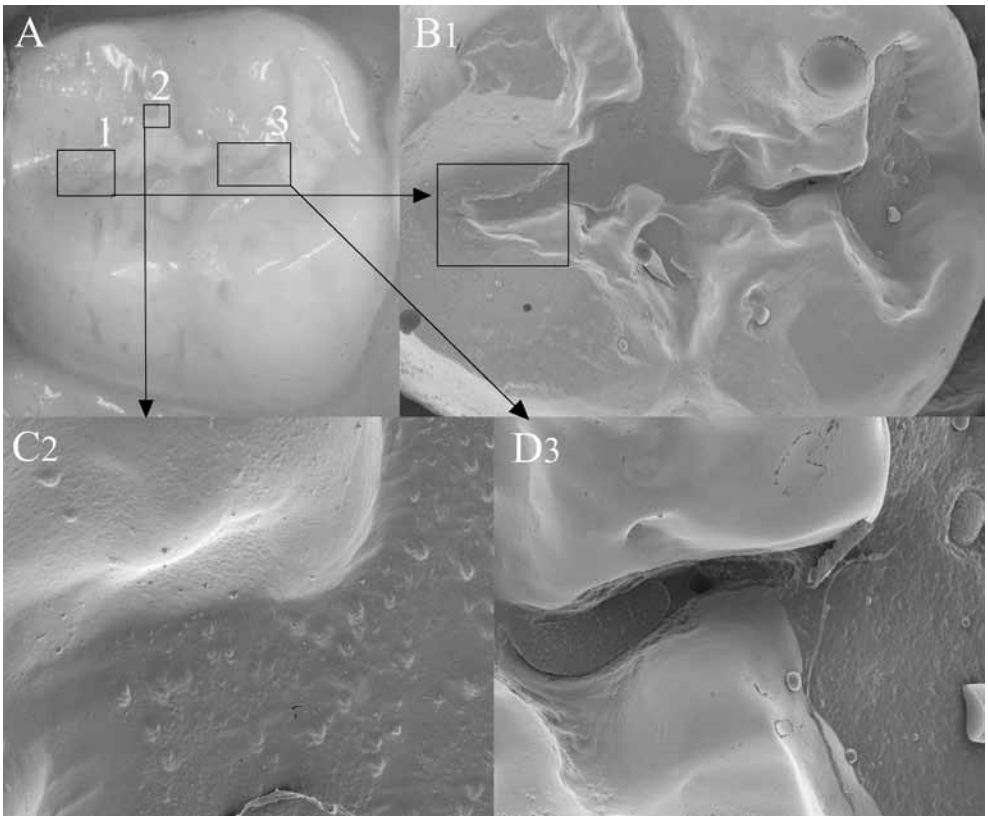

FIGURE-1 A) High-viscosity glass-ionomer (Fuji IX) sealant in tooth 47 after 12 years. The distal fissure appears to be clinically free of glass-ionomer material. B1) On the scanning electron microscopy (SEM) image (12x), glass-ionomer material is clearly visible till end of distal fissure. C2) Good adhesion of high-viscosity glass-ionomer to enamel (SEM: 100x). D3) Glass-ionomer material present in the fissure connecting the central with the mesial pit (SEM: 100x). The glass-ionomer sealant was clinically not visible in the fissure (Copyright: J. Frencken)

especially manufactured to ensure optimum cleaning of the tooth cavities, was the best way of removing carious tissues from an occlusal cavity. However, its disadvantage was the amount of time required to complete the procedure. This study concluded that the use of hand excavators was the most effective method of cleaning cavitated tooth cavities in permanent molars. A similar study, covering primary teeth, also showed hand excavators to be the most effective instruments for cleaning tooth cavities[14]. An *in-vivo* study demonstrated no difference in caries left behind in cavities treated with hand instruments and in those treated with a chemomechanical caries removal gel[42].

Topaloglu-Ak, et al.[51] (2009) compared survival rates of composite restorations performed in class II cavities in primary teeth, cleaned using hand instruments only (ART) and those cleaned with a chemomechanical caries removal gel. The restoration survival results were not significantly different from each other after 2 years. A pilot study, using the same two methods of cavity cleaning, after 12 months showed no significant differences in restoration survival results in permanent teeth restored with a high-viscosity glass-ionomer[4].

On the basis of the available evidence it can be concluded that hand instruments, such as used with ART, are effective for cleaning cavitated dentine lesions. However, the size of the opening of the cavity appears to have an effect on the level of cleanliness of the cavity in occlusal surfaces[43]. The authors concluded that a cavity opening of at least Ø 1.6 mm was necessary for ensuring adequate removal of infected (decomposed) dental tissues.

MICROORGANISMS LEFT IN THE CAVITY

A recently published critical review stated that cariogenic bacteria, once isolated from their source of nutrition by a restoration of sufficient

integrity, either die or remain dormant and thus, pose no risk to the health of the tooth[50]. This implies that, in essence, there is no need to try to remove all microorganisms from within the cavity. If this is attempted, potentially remineralizable and sound dentine is sacrificed, which would inevitably lead to a reduction in the strength of the tooth. This argument is supported by Maltz, et al.[36,37] (2002, 2007), who concluded that incomplete removal of carious affected (demineralised) dentin and subsequent restoration of the cavity with a material that seals the cavity tightly results in the arrest of the lesion. The authors suggested that complete removal of affected (demineralised) dentin is not essential for controlling the progression of dentine carious lesions.

Further support for the finding that microorganisms become inactive after the sealing of small dentine lesions is provided in a systematic review[45]. The review concluded that microorganisms left in small cavities declined in number over time. The authors suggested that sealing over small dentine lesion(s) in pits and fissures is an evidence-based treatment.

This evidence shows that when a cavity is securely restored with a material having a good and long-lasting bond to the cavity walls, micro-organisms unintentionally left behind will not restart the caries process. This does not, however, mean that cavities should be left full of infected (decomposed) dentine and then filled with a restorative material. The intention when using ART is to remove as much infected (decomposed) dentine from the cavity as possible, in order to create the largest possible intra-cavity surface for a secure bonding. Thus production of ART restorations follows the same principles as those of contemporary cariology and restorative dentistry[32].

STEPWISE-EXCAVATION VERSUS ONE-SESSION ART APPROACH

In managing deep carious lesions, the risk of pulp exposure during the removal of infected (decomposed) dentinal tissues led to development of a biological approach intended to preserve tooth tissues and promote the defence of the pulp by a total seal of the cavity and by the stimuli of calcium hydroxide cement. This approach is called "stepwise-excavation"[9]. This approach challenged the belief that the infected (decomposed) dentin had to be removed completely in order to eliminate any potential threat of infection. It demonstrated that it was possible to leave behind a bacterial component controlled by a dental material with healing properties[7,8].

The stepwise excavation technique requires re-entering of the cavity to complete the removal of infected (decomposed) dentine, whereas ART uses only one step. The need for re-entering was investigated in an *in-vivo* study. At baseline and after 3 months, clinical, ultra-structural and chemical analysis was done of cavities in primary molars treated according to ART and filled with a glass-ionomer in one session. The results showed a large reduction in micro organisms, a more densely packed dentine structure and an increase in the calcium content. The authors concluded that a one-session approach creates favourable conditions for the healing process of affected (demineralised) dentine[38]. The application of the ART approach and its success over two decades raises the question as to whether stepwise-excavation is really needed.

Rickets, et al.[48] (2006) conducted a systematic review to test the null hypothesis of no difference in the incidence of damage or disease of the pulp, progression of decay and longevity of restorations, irrespective of whether the removal of decay had been minimal (ultraconservative) or complete. The conclusion was that for reducing the risk of pulp exposure, partial caries removal is preferable to complete caries removal in the deep lesion. However, evidence related to the necessity of re-entering and excavating further was insufficient, although studies where this had not been done did not report adverse consequences. ART studies had not been included in this review. Knowing that particularly in deep carious lesions, infected (decomposed) dentine may be left behind during the ART procedure and considering the absence of reports of abscessed

or extracted ART restorations, many ART studies do not support the need for removal of deep caries infected (decomposed) dentine and thus, for re-entry into the cavity.

BOND STRENGTH OF RESTORATIVE MATERIALS USED WITH ART ON CARIES-AFFECTED DENTIN

From a pathological point of view, it appears that removal of all affected (demineralised) carious tissues from the cavity surfaces is unnecessary. However, to what extent does this situation affect the bonding of restorative materials to the cavity walls? How good is the bonding, of restorative materials used in the ART approach, to the treated dental tissues?

There is evidence which shows that the presence of caries-affected (demineralised) dentine may negatively affect the bonding of glass-ionomers to both enamel and dentin, regardless of the cavity preparation method[15]. The mean values regarding bond strength to caries-affected (demineralised) dentine may vary among different brands of glass-ionomer used. For example; it was reported that the mean bond strength to caries-affected (demineralised) dentine of three conventional glass-ionomers (one medium- and two high-viscosity) tested were lower than that of the resin-modified glass-ionomer used[46].

If resin composite is chosen as the restorative material for ART, the presence of infected (decomposed) dentin may also influence the bond strength of the adhesive systems to dentine and enamel. Two studies comparing micro-tensile bond strength of different resin-based dentin adhesives over sound and caries-affected (demineralised) dentin concluded that values are higher when the remaining dental tissues are not affected by the caries process[12,22]. However, adhesion can be enhanced by means of rinsing solutions like sodium hypochlorite[49] or 2% chlorhexidine digluconate[35].

In conclusion, considering all the biological aspects discussed above, it is important to ensure that as much as possible of the infected, softened (decomposed) dental tissue is removed, in order to obtain adequate adhesion of the restorative material to the cavity walls over a long period, irrespective of the restorative material used.

CASE SELECTION OF CAVITIES TREATABLE WITH ART

It is obvious that the cavity size, selection of restorative material, clinical skills and knowledge of the dental practitioner will determine the success of a restoration, whether conventional, ART or any other cavity cleaning method is used.

The meta-analysis showed that the highest survival rates for ART restorations using high-viscosity glass-ionomers were observed in single-surface cavities in both permanent and primary teeth, while high-viscosity glass-ionomer ART restoration survival rates of multiple-surface cavities in primary teeth needed further improvements[53]. Among the reasons given for clinical failure of ART restorations in multiple-surface cavities in primary teeth are those related to the restorative material used and the operator[28]. As an example of the latter serves a study that was carried out in a high-caries risk child population in the jungle of Surinam. Many (large) cavities were restored, using ART and a high-viscosity glass-ionomer. No reported preventive programme accompanied the restorative care. The survival of ART restorations after 3 years was low. About 34% of multiple-surface cavities were restored but blood and/or saliva had contaminated the cavity[52]. Under such adverse circumstances, good restorations, irrespective of the restorative approach and restorative material used, cannot be achieved. Other treatments like extraction, placing stainless steel crowns or cavity cleaning with a tooth brush and toothpaste would have perhaps been more appropriate[33].

RESTORATIVE MATERIALS USED WITH ART

According to the definition of restorative ART, the cavity should be filled with an adhesive material which seals the adjacent pits and fissures of the cavity in order to prevent carious

lesion development. A number of features such as the sensitivity of the manipulation, the effectiveness of bonding to dental tissues, minimal dimensional changes after hardening and thermo-cycling (heating and cooling in wet conditions), fluoride release/uptake and the remineralisation potential, have to be analyzed to determine which restorative material is suitable for use with ART.

RESIN COMPOSITES

Resin composites have not been used as a first choice for producing ART restorations and ART sealants, despite their good optical and mechanical properties. This is mainly because use of rotary equipment is required for an optimal performance of the material.

However, motivated by low survival rates of multiple-surface ART restorations in primary teeth, Ersin, et al.[23] (2006) carried out a comparative study in class II ART- cleaned cavities, using a high-viscosity glass-ionomer and a resin composite self-etch dentin adhesive system (Xeno III). Although resin composite had higher survival rates, no statistically significant difference was observed between the two types of restoration after 2 years. Resin composite, in combination with the self-etch bonding liquid (Prompt L-Pop), was used to restore class II cavities in primary teeth cleaned according to ART and the results were compared with those of restorations prepared using rotary instrument. This study was carried out to investigate whether the use of resin composite would increase the survival rate of ART restorations using high-viscosity glass-ionomers in class II cavities in primary teeth[20]. After 2 years the survival of both types of restorations were distinctly lower than that reported for ART restorations in class II cavities using high-viscosity glass-ionomers reported in the meta-analysis[53]. In order to test whether the low survival of resin composite class II ART restorations in primary teeth was due to insufficient removal of infected (decomposed) dentine from these cavities, a trial was undertaken, in which ART was used for cleaning class II cavities in primary teeth, with and without the use of a chemomechanical caries removal gel, and restored with a resin composite and the self-etch bonding (Adper Prompt L-Pop)[51]. Results after 2 years showed distinctly lower survival percentages than that reported for ART restorations in class II cavities using high-viscosity glass-ionomers reported in the meta-analysis[53].

The studies covering ART-cleaned class II cavities in primary teeth restored with a resin composite and a self-etch bonding have not led to a superior restoration survival percentage than that obtained for those restored with a high-viscosity glass-ionomer. Failure of the resin composite ART restorations was mainly attributed to the poor performance of the self-etch bondings used. This may not imply that high-viscosity glass-ionomer ART class II restorations in primary teeth are superior to comparable restorations with resin composite bonded with a 3-step system. However, it can be concluded that resin composite restorations can be produced with ART in class II cavities in primary teeth, and that the self-etch bonding systems used were of inferior quality.

GLASS-IONOMER CEMENTS

Because of its biological, physical and chemical properties, the most suitable filling material according to ART definition is the glass ionomer cement. Particularly, its relatively slow setting time makes high-viscosity glass-ionomer the most appropriate material for use with ART. Several authors consider glass-ionomers to be "smart" restorative materials. A smart material is by definition a material possessing properties which may be altered in a controlled fashion by stimuli such as stress, temperature, moisture, pH, electricity or magnetic fields[39].

Cariostatic and remineralising properties, identified in *in-vitro* studies, have frequently been ascribed to glass-ionomers but their clinical relevance appears to be less clear. The antibacterial effect of high-viscosity glass-ionomers frequently used with ART has been reported in *in-vitro*[10,16] and *in-vivo*[27] studies. The antibacterial effect on infected (decomposed)

and affected (demineralised) dentine has been significantly increased when chlorhexidine was added to a high-viscosity glass-ionomer[27]. Such a finding is highlighted by Imazato[31] (2009) as a positive innovation in restorative dentistry. This indicates that incorporation of 1% chlorhexidine diacetate into glass-ionomer used for ART is optimal for reduction of the level of bacteria in infected (decomposed) and affected (demineralised) dentine.

In-vitro studies have clearly shown that fluoride from glass-ionomers is released into enamel, dentine and the oral environment. Donly, et al.[17] (1999) in an *in-situ* study demonstrated the remineralising effect of a glass-ionomer in artificially produced enamel carious lesions. The remineralising effect of high-viscosity glass-ionomer in dentine after 3 months has been evident in the increase of calcium, fluoride and strontium in affected dentine after cavity cleaning using ART[44].

Several studies have demonstrated the antibacterial properties and remineralising effects derived from glass-ionomers used with ART. However, clinical trials are necessary to support the clinical relevance of such features that, applied to the ART concept, may help to control the onset or progression of carious lesions and to achieve a better integration of the restorative material into the cavity.

CONVENTIONAL LOW-VISCOSITY VERSUS HIGH-VISCOSITY GLASS-IONOMERS

Many brands of (medium-) high-viscosity glass-ionomers have been developed and marketed for use with ART, although only a few of them have been tested in clinical trials. The ART meta-analysis[53] concluded that the survival rates of ART restorations using high-viscosity glass-ionomers were superior to those using medium-viscosity glass-ionomers. Therefore, only high-viscosity glass-ionomers that have been field-tested in long-term follow up studies should be used with ART.

The flexural strength values reported in most studies that have compared different commercially available high-viscosity glass-ionomers was low. Such a finding, when extrapolated to a clinical situation, may be the reason for the relatively easy fracture of the material and the subsequent failure of the restoration[11,57]. Compressive strength, often used to measure the ability of the material to withstand masticatory forces, varied according to the brands of glass-ionomer tested, with the well-established high-viscosity glass-ionomer brands (Fuji IX, Ketac Molar, Ketac Molar Easymix) performing well[1,11,47].

HAND-MIXED VERSUS ENCAPSULATED GLASS-IONOMERS

Encapsulated high-viscosity glass-ionomer has been on the market for a decade or so. According to Dowling and Fleming[18,19] (2008,2009), encapsulated anterior and posterior glass-ionomer restoratives outperform their hand-mixed equivalents with regard to the range of powder to liquid mixing ratios routinely encountered clinically. Therefore, if electricity is available, encapsulated high-viscosity glass-ionomers are preferable to hand-mixed glass-ionomers with ART. However, if electricity is not available, it is mandatory for the operator to use the correct liquid to powder ratio, in order to obtain optimal properties from the cement. Being careless and mixing less powder into the drop of liquid, as often happens in practice, will lead to a weak glass-ionomer and consequently, to a poor restoration or sealant.

The only study in which encapsulated high-viscosity glass-ionomer was used with ART showed a cumulative survival rate for single- and multiple-surface ART restorations in permanent teeth of 85% and 77% after 5 years[25].

Dowling and Fleming[18,19] (2008,2009) further conclude that anhydrous glass-ionomer restorative formulations are more susceptible to clinically-induced variability in hand-mixing, in contrast to conventional GI restorative formulations that contain a polyalkenoic acidic liquid. Therefore, if hand-mixed glass-ionomers are used for ART, using those with formulations containing the acid in the liquid is preferable to

using those containing it in the powder. Thus, if encapsulated high-viscosity glass-ionomers can be used, these are to be preferred over hand-mixed high-viscosity glass-ionomers.

RESIN-MODIFIED GLASS-IONOMERS

Incorporation of resin components into glass-ionomers results in better optical properties, control of the setting time by means of light curing, greater early physical strength and less susceptibility to dehydration. Compared to high-viscosity glass-ionomers, resin-modified glass-ionomers have higher values for flexural strength and diametric tensile strength[57], and higher values for strength of tensile bonding to enamel and dentine[46].

Resin-modified glass-ionomers would be suitable for use with the ART approach only when a light-curing device, whether with a cord or cordless, is available. A few clinical studies have investigated the success of resin-modified glass-ionomers with ART. Survival of single-surface ART restorations in primary teeth, using resin-modified glass-ionomers and placed by dental students, showed a success rate of 72% after 25-48 months[24]. The success rate of resin-modified glass-ionomers used for restoring single- and multiple ART-cleaned cavities in permanent teeth appears to be higher than for comparable high-viscosity glass-ionomers after one year[13] and 2 years[21].

The results of these few short-term studies are encouraging. Further research into the use of resin-modified glass-ionomers with ART is therefore warranted.

NEWLY DEVELOPED RESTORATIVE MATERIALS

Physical properties of a newly launched fluorapatite containing glass-ionomer: glass-carbomer, were tested *in-vitro* in large class II ART restorations in permanent teeth. The material was compared with high-viscosity glass-ionomers and a resin composite. Class II ART cavities restored with glass-carbomer were not significantly more fracture resistant than comparable restorations using the conventional hand-mixed high-viscosity glass-ionomers, Fuji IX and Ketac Molar Easymix. Further research is needed to assess the clinical potential of this new cement[34].

Physical and mechanical properties in experimental modifications of a conventional medium-viscosity glass-ionomer were evaluated. Glass-ionomers containing N-vinylpyrrolidone (NVP), nano-hydroxyapatite and fluoroapatite were compared with the original glass-ionomer (Fuji II, GC). The results showed higher values for compressive strengths, diametral tensile strength and biaxial flexural strength and handling properties (working and setting time) for NVP-nanoceramic powder modified cements than for the control group[41]. Considering that this is a self-curing material with enhanced physical properties, this material, if marketed, could be an option for use with ART.

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Transferring ART research into education in Brazil

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ABSTRACT

The aim of this study was to evaluate the teaching of the Atraumatic Restorative Treatment (ART) approach in Brazilian dental schools. Materials and Methods: A questionnaire on this subject was sent to Pediatric Dentistry, Operative Dentistry and Public Health Dentistry professors. The questions approached the followig subjects: the method used to teach ART, the time spent on its teaching, under which discipline it is taught, for how many years ART has been taught and its effect on the DMFT index. Results: A total of 70 out of 202 dental schools returned the questionnaire. The ART approach is taught in the majority of the Brazilian dental schools (96.3%), and in most of these schools it is taught both in theory and in clinical practice (62.9%). The majority (35.3%) of professors teach ART for 8 hours, and most often as part of the Pediatric Dentistry discipline (67.6%). It has been taught for the last 7 to 10 years in 34.3% of dental schools. Most professors did not observe a change in the DMFT index with this approach. There is a diversity in the teaching of ART in Brazil in terms of the number of hours spent, the teaching method (theory and practice), and the disciplines involved in its teaching. Conclusions: It is necessary to address the training of professors in the ART approach for the whole country. An educational model is proposed whereby a standard ART module features as part of other preventive and restorative caries care educational modules. This will facilitate and standardize the introduction and adoption of the ART approach in undergraduate education in Brazil.

Key words: Dental caries. Atraumatic Restorative Treatment (ART). Dental restoration. Dental education. Oral health. Attitude.

INTRODUCTION

Atraumatic Restorative Treatment (ART) takes a special place within the group of minimal intervention approaches for the management of dental caries[4,16]. This treatment approach was recognized and endorsed by the World Health Organization (WHO) for bringing restorative dental treatment to people who would not normally have access to dental care. The ART approach has become available through the combination of a better understanding of the dental caries process, permitting minimal cavity preparations and effective use of adhesive restorative materials[37]. The procedure involves removal of carious tooth tissue using hand instruments only, followed by restoration usually with a glass-ionomer cement[17,33,35].

Critics to the ART approach argue that in spite of the positive results in research carried out into the use of the ART approach in clinical trials[9-11,14,16,20,36,38], many dental institutions in Brazil do not include this approach in their *curricula*. There is, however, no reliable information about the teaching of the ART approach in Brazil with respect to the theory, its laboratory and clinical teaching.

Brazil is currently committed to the implementation of a Family Health Program (FHP) that aims to extend basic health care to the whole population. The FHP is changing from an emergency and restorative treatment model to one of disease prevention and health promotion for individuals as well as families and communities. This will make primary health care the foundation of the Brazilian healthcare system[21]. The main characteristics of the FHP are: a focus on the family, use of a multidisciplinary team, preventive activities, assessment of population needs and intersectoral action to promote health care[6,15]. In addition to the FHP, the Brazilian Government has also started the Programa Brasil Sorridente (Brazil Smiling Program) that has the objective of improving oral health care for the Brazilian population. It is the first time that the Federal Government has developed a national oral health policy with a well established program and not solely based on oral health care. With this program, in addition to basic dental care, the population has access to specialized treatments, such as management of oral cancer, endodontics, orthodontics and surgery[7].

Thus, in Brazil, it is desirable to have, as soon as possible, dental practitioners who are competent theoretically and clinically in the ART approach, to enable them to implement the treatment required by the population under the responsability of each health team.

It was considered that a study regarding the teaching of ART in Brazil, covering all the regions of the country, would provide important information to health managers. This study might also enable the Brazilian authorities to find ways to facilitate the teaching and practice of ART in Brazilian dental institutions. Therefore, the aim of this study was to contact all dental schools in Brazil seeking information, through a questionnaire, from the professors from different disciplines regarding the teaching of ART at the undergraduate level, and to make recommendations based on the outcomes.

MATERIAL AND METHODS

Questionnaire Development

The authors prepared a short and straightforward questionnaire regarding the teaching of the ART approach, in such a way that professors could quickly and easily answer it. The questionnaire consisted of three sections: a) personal and institutional details; b) the method and the time used for teaching ART and the number of years the approach has been taught; and, c) the effects of ART on DMFT (Figure 1).

Selection of the Study Population

According to the Ministry of Education (MEC), at the time of sending the questionnaires there were 202 dental schools in Brazil. Twenty were in the North, 34 in the Northeast, 15 in the Center-

FIGURE 1- Questionnaire on teaching ART in dental institutions in Brazil

1. Professor: _____
2. Institution: _____
3. Address: _____
4. Is ART approach taught in your institution? Yes ( ) No ( )
5. If YES, how has it been taught?
   Theoretically ( ) Laboratory practice ( ) Clinical practice ( )
5a. Time spent with ART teaching
   Less than 8 hours ( ) 8 hours ( ) from 8 to 20 hours ( )
   more than 20 hours ( )
5b. As part of which discipline has ART been taught?
   Pediatric Dentistry ( ) Public Health Dentistry ( ) Operative Dentistry ( )
   Other ( ) Which one? _____
5c. For how long has the ART approach been taught? _____
6. With this approach, the DMFT has been the same ( ) worse ( )

west, 101 in the Southeast and 32 in the South of the country. The target population comprised all dental professors working in Pediatric Dentistry, Public Oral Health, or Operative Dentistry departments from private, regional and district dental institutions in Brazil.

Procedure for Obtaining the Names and Addresses of Dental Professors

The professors' e-mails were obtained from the websites of the universities and individual schools. When an institution did not have a website, or the names of professors were not readily available, the secretaries of the deans of these institutions were contacted by telephone to supply updated information about the professors' names and their electronic addresses. All addresses were entered into a computer database, using Microsoft Excel software.

RESULTS

A total of 70 of the 202 dental schools in Brazil answered the questionnaire, which represents an almost 35% response rate. The question: "Is the ART approach taught in your institution?" was answered by the majority as "yes" (96.3%); the remaining 3.7% answered "no".

According to the respondents, ART is taught both in theory and in clinical practice in the majority of dental schools (62.9%). In 14.3% of the dental schools, ART is taught through a combination of theoretical teaching, laboratory and clinical practice. ART is taught only through theoretical teaching in 13.3% of dental schools, only clinical teaching in 8.6%, and only laboratory practice in 0.9% of schools (Figure 2).

Regarding the time spent with ART teaching, the majority of dental schools answered "8 hours" (35.3%), followed by "from 8 to 20 hours" (29.5%), "more than 20 hours" (27.6%)," less than 8 hours" (3.8%), while 3.8% did not answer (Figure 3).

Figure 4 summarizes the responses to the question "As part of which discipline has ART been taught?". The majority (67.6%) stated that ART is taught in "Pediatric Dentistry", followed by "Public Health Dentistry" (45.7%), "Operative

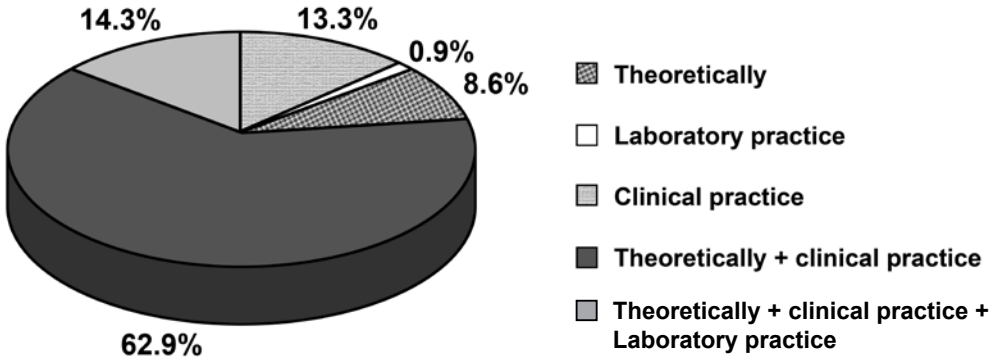

FIGURE 2- Answers given by professors from 70 dental schools in Brazil to the question "How is ART being taught?"

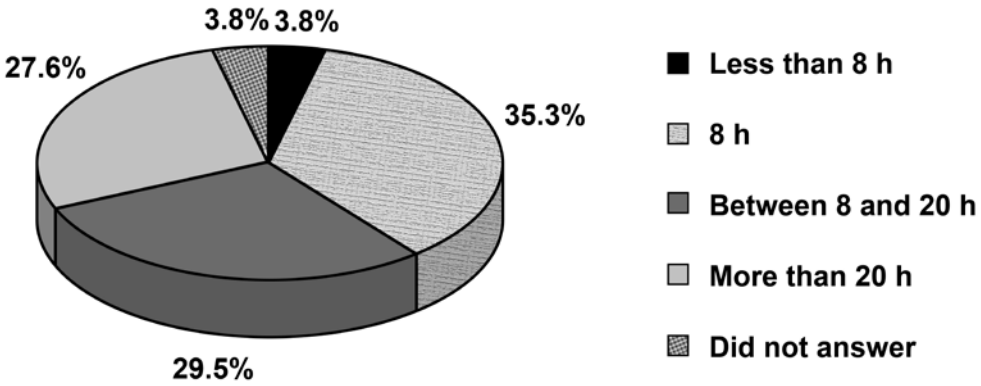

FIGURE 3- Percentage distribution of responses to the question "How much time is spent teaching ART"?

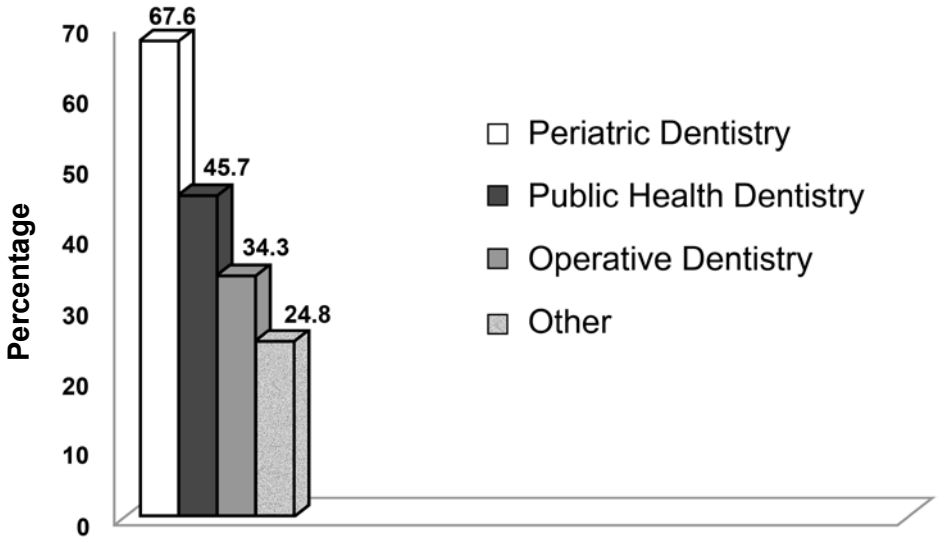

FIGURE 4- Distribution of the responses to the question "As part of which discipline has ART been taught?"

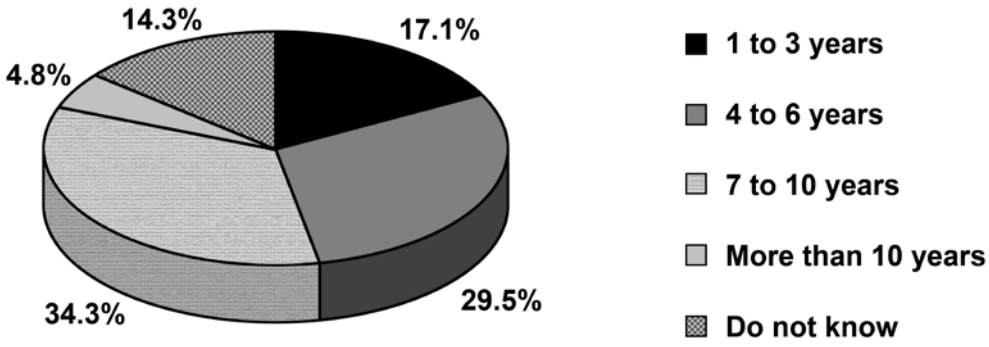

FIGURE 5- Percentage distribution of responses to the question "For how long has the ART approach been taught"?

Dentistry (34.3%), and "Other disciplines" (24.8%).

With respect to the question "For how long has the ART approach been taught?", the majority (34.3%) answered that this approach has been taught for "7 to 10 years", while 29.5% answered "4 to 6 years", 17.1% answered "1 to 3 years", 4.8% stated that ART has been taught for "more than 10 years" and 14.3% did not know (Figure 5).

As regards the DMFT index, none of the respondents stated that the DMFT was worse because of the ART approach. The majority (66.7%) answered that the index had remained the same, and 33.3% did not know.

DISCUSSION

Since its introduction, the ART approach has become a well established caries management option (preventive and restorative), even though it might have some limitations under certain situations. ART is based on a preventive philosophy which includes early interception of the carious process by using different types of fluorides and, when necessary, minimally invasive intervention to conserve sound tooth tissue[27]. Thus, ART must not be used in isolation but should be included with preventive programs and health education to be effective by controlling the etiologic factors of caries. The educational activities and preventive procedures include diet counseling, oral hygiene instruction, plaque removal, and use of remineralizing agents[40].

The ART approach has been incorporated in undergraduate curricula in a number of dental schools around the world. Examples are, Thamarasset Dental School in Thailand and Muhimbili Dental School in Tanzania[23,24]. The approach is taught in dental schools with the aim

of promoting public health to those who do not normally have access to oral health treatment[12].

In this context, many countries have shown dissatisfaction regarding the insignificant contribution of preventive and restorative care to the oral health of their population. Approximately two-thirds of the world population do not have any professional oral care[32]. For example, twenty seven million Brazilians, almost 15% of the total population, have never received any dental treatment, according to a demographic survey performed in 1998[22]. Since then the number of Brazilians who have access to oral health programs of prevention and treatment of oral diseases has increased. For this sector of the population, the Family Health Program (FHP) and the "Brazil Smiling Program" that the Brazilian federal government has established, will take trained medical and dental practitioners to rural and suburban areas where the population does not have access to health treatment. The ART approach was originally developed for this sector of the population so it is necessary to know if dental schools are teaching this approach to their students.

There are many studies that have used questionnaires to evaluate the curricular structure, teaching philosophies, knowledge, the skills of teaching, the status and factors associated with organizational innovation in dental schools[1,25,29]. In the present study, data was collected from nearly 35% of all dental schools in Brazil, which represents 70 schools. Although in our study we used a short questionnaire, with the intention of improving the response rate, other similar studies have had a response rate ranging from 70.5% to 100%[1,25,29]. This difference in response rates may have occurred because Brazilian people are resistant to answering questionnaires for evaluation; for example, some studies have responses as low as 8.4%[34], 35%[13] and 39.5%[3]. Another possible reason is that some of the non-respondent dental schools might not as yet have incorporated ART within their curricula and were reluctant to report on this.

The high percentage (96.3%) of the responding dental schools that teach ART to their students reveal the importance that their professors attach to ART. The majority of the professors (62.9%) teach the ART approach only theoretically and clinically, however laboratory practice is important to teach some of the finer details that the approach requires[27], such as proper cavity cleaning (preparation) and glass ionomer cement manipulation.

Most dental schools claim that they spend between 8 and 20 hours on the teaching of ART. We believe that a minimum of 8 hours for theory and 8 hours for laboratory practice are sufficient to develop good skills with the approach. However, more time should be spent for developing clinical skills since the student can encounter many different situations and difficulties[26] when applying the ART approach, such as different occlusal access[31], consistency and depth of the dentin lesion[5].

The ART approach was developed in Tanzania in the mid-1980's[16,18]. However, it was only in 1994 that the WHO recognized it as a revolutionary technique for caries lesion treatment[37]. The Brazilian dental schools delayed some years before including ART on their undergraduate curricula but even so the majority of dental schools have been teaching the ART approach for between 4 to 10 years. There remains a diversity in terms of hours spent, kind of teaching (theory and practice) and disciplines involved. Ideally, if the school really accepted the ART approach, all the disciplines cited (Pediatric Dentistry, Public Health Dentistry and Operative Dentistry) should teach this approach. This fact points out that it is necessary to address a training of professors covering the whole country.

In 1993, 1996 and 2003, the DMFT (at 12 years of age) reported for Brazil was 4.90, 3.06 and 2.78, respectively, according to the Ministry of Health of Brazil[8]. This shows a clear decrease of the DMFT throughout the years that is associated with many factors, including the use of fluoride in the drinking water, the use of fluoride toothpastes, and the implementation of new government programs focused on oral health. The majority of the professors did not note differences in the DMFT after the introduction of the ART approach because it is part of health

programs. Considering the FHP and "Brazil Smiling Program", it would be very important to motivate professors from target groups, as those from Pediatric Dentistry, Operative Dentistry and Public Health Dentistry, and practitioners already working in these programs to participate in a training covering the whole country using tools such as e-learning with classes addressed by expert professors and books or printed material regarding the ART, aiming to get the best of the ART approach[17,18,30]. In these classes the survival rate of ART restorations in different clinical trials should be stressed[2,19,39].

Based on the current knowledge on the state of the ART approach and on the experiences of dental schools that have introduced ART in the curriculum, an educational model presenting the ART features as part of restorative and preventive caries care modules should be established to facilitate and standardize the introduction and adoption of the ART approach in the undergraduate education in Brazil.

CONCLUSIONS

There is a diversity in the ART teaching in Brazil in terms of hours spent, kind of teaching (theory and practice), and disciplines involved. It is necessary to address a training of professors covering the whole country. An educational model presenting the ART features as part of restorative caries care modules should be established to facilitate and standardize the introduction and adoption of the ART approach in the undergraduate education in Brazil.

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ART integration in oral health care systems in Latin American countries as perceived by directors of oral health

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ABSTRACT

The aim of this study was to carry out a situation analysis of: a) prevalence of ART training courses; b) integration of ART into the oral healthcare systems and; c) strengths and weaknesses of ART integration, in Latin American countries. Materials and Methods: A structured questionnaire, consisting of 18 questions, was emailed to directors of national or regional oral health departments of all Latin American countries and the USA. For two countries that had not responded after 4 weeks, the questionnaire was sent to the Dean of each local Dental School. The questions were related to ART training courses, integration of ART in the dental curriculum and the oral healthcare system, barriers to ART implementation in the public health system and recommendations for ART implementation in the services. Factor analysis was used to construct one factor in the barrier-related question. Means and percentages were calculated. Results: The response rate, covering 55% of all Latin American countries, was 76%. An ART training course had been given in all Latin American countries that responded, with more than 2 having been conducted in 64.7% of the respondent countries. ART was implemented in public oral health services in 94.7 % of the countries, according to the respondents. In 15.8% of the countries, ART was applied throughout the country and in 68.4%, in some areas or regions of a country. ART had been used for more, or less, than three years in 42.1% and 47.4% of the countries, respectively. Evaluation and monitoring activities to determine the effectiveness of ART restorations and ART sealants had been carried out in 42.1% of the countries, while evaluation training courses had taken place in only 3 countries (15.8%). Respondents perceived the "increase in the number of treated patients" as the major benefit of ART implementation in public oral health services. The major perceived barrier factors to ART implementation were "operator opinion" and "high patient load", followed by "lack in supplies of materials and instruments and operators" and "lack of ART training". Respondents recommended that the number of ART courses should be increased. Conclusions: The introduction of ART into the public oral health systems in Latin American countries has taken place but is still in its infancy. More ART training courses need to be organized if the approach is to be adopted in oral health service systems in these countries.

Key words: Atraumatic Restorative Treatment (ART). Science transfer. Latin America. Health care systems. Health policy.

INTRODUCTION

In many developing countries, access to and provision of oral health care is limited[12]. Characteristically, the levels of untreated cavitated lesions are high. As the option of saving a painful tooth by placing a restoration is often not considered, because of a lack of functional dental equipment and materials, and because of the acceptance by patients that toothache can be alleviated only through extraction of a badly decayed tooth, toothache is usually treated by extraction[5]. This situation has arisen as a result of the unconditioned acceptance by governments and professionals in low- and middle-income countries of inappropriate oral healthcare models. These are based on rotary-driven equipment and, although this type of health care has a place in developing countries, their use is more suited to high-income countries having the required infra-structure. In order to improve the situation in developing countries, their authorities need to identify oral care models that suit their health conditions, means and healthcare infra-structure.

One such approach, considered by World Health Organization (WHO) as appropriate for use in low- and middle income countries, is the Atraumatic Restorative Treatment (ART) approach. It was officially adopted by the World Health Organization in 1994 as a technique that could contribute to the control of dental caries, as part of primary oral health programs in developing countries[15]. The restorative component of the ART approach is based on using only hand instruments to eliminate soft, demineralized carious tooth tissues. In the majority of cases, the cleaned cavity is restored with a high-viscosity glass-ionomer[14]. As it does not require electricity or expensive dental equipment, ART offers a pragmatic solution for the problems related to the prevention of carious lesion development and progression and the restoration of untreated cavitated carious lesions[3,8].

Makoni, et al.[6] (1997) showed that ART could be applied in 84% of dentine cavities in an adolescent population with a caries prevalence of 41% and a mean DMFT score of 1.1. The longevity of single-surface ART restorations in primary and permanent tooth has been reported to be good[8]. Mickenautsch, Yengopal and Banerjee[8] (2009) found no difference in survival results, after six years, between single-surface ART restorations and comparable amalgam restorations in the permanent dentition.

The preventive component of ART, that is the sealing of caries-prone pits and fissures with a high-viscosity glass-ionomer, also showed good results, with an annual dentine lesion development of only 1% during the first three years of placement[14].

The cost-effectiveness of amalgam and ART restorations using high-viscosity glass-ionomer was studied in three Latin American countries: Panama, Ecuador and Uruguay. The results showed that single-surface ART restorations in permanent teeth were more cost-effective than comparable amalgam restorations after two years. On the basis of this finding, Pan-American Health Organization (PAHO) recommended the introduction of ART into oral health policies in Latin American countries[10].

The evidence demonstrates that the ART approach produces quality sealants and quality restorations in single-surfaces both primary and permanent teeth. Thus the time has come to extend the structured introduction of ART into the national oral health policies of more low- and middle-income countries than those from which reports regarding its efficacy have been received: South Africa[7], Tanzania[5] and Mexico[4].

Science transfer

One of the most important, but at the same time very difficult, aspects of research is the transfer of results of studies into daily medical/dental practice. The main difficulty is to get practitioners to accept, adopt and apply newly obtained evidence-based results. Educating dental students for life-long learning in dental schools worldwide is only a recent development. Personal experience shows that many dental schools have not adopted the problem-based learning concept. These continue to use the conventional teacher-student one-directional education system. It is not surprising that

professionals educated in this way have great difficulties in accepting new developments in medicine and dentistry. Rindal, et al.[13] (2008) noted that clinical inertia, resistance to accepting newly developed treatments in medicine/dentistry, is a useful paradigm for explaining delays in the incorporation of new knowledge in clinical practice. Introducing the ART approach into oral healthcare systems in a sustainable manner under such prevailing conditions would be difficult.

ART introduction in Latin America

ART has been introduced into oral healthcare systems in Latin American countries. In Peru a basic comprehensive oral health project that included ART was implemented in primary schools in a large number of deprived communities ten years ago[9]. ART is now integrated within the national oral health policy of Peru. In Chile the Ministry of Health has developed an oral health program called: "An Integral Clinical Oral Health Guide for 6 year-old children"[1]. It attempts to manage dental caries development and progression through sealing pits and fissures, the use of additional caries control measures and ART restoration of tooth cavities. As early as 1998, an ART course was organized in Mexico City. This formed the basis for the development of an oral health program for underserved Mexican provinces, covering 25 million people[4].

PAHO has recommended the adoption of ART in oral health services in Latin American countries but no evaluation report to this effect were available in the literature. Therefore the decision was made to carry out a preliminary situation analysis of the: a) prevalence of ART training courses; b) integration of ART into the oral healthcare system and; c) strengths and weaknesses of the ART integration in Latin America.

MATERIALS AND METHODS

Questionnaire

A structured questionnaire, consisting of 18 questions, was sent through the internet to directors of national or regional oral health departments of all Latin American countries and the USA between April and July 2009 (Figure 1). A reminder was sent after four weeks. For the two countries that had not responded, the questionnaire was also sent to deans of dental schools.

Construction of variables

Factor analysis was performed for four items of the barrier question (Q15) to construct one factor, "operator opinion", which had a Cronbach's alpha of 0.62. All other barrier factors were single item statements.

Statistical analysis

Microsoft Excel software was used for entering data onto the computer and checking for accuracy. The data were then transferred into an SAS program for analysis by a statistician. A question that was not answered was considered as "not being in agreement". Mean scores and percentages were calculated.

RESULTS

Disposition of subjects

From the total of 25 questionnaires sent, 19 were returned from 10 Latin American countries and 1 from the USA, covering 55% of all Latin American countries (Table 1). The respondents were directors of national (42.1%) and regional (47.3%) oral health departments, and university lecturers (10.5%). Most of the respondents (52.9%) had graduated before 1990 and 76.5% had held the position of director of oral health for less than 3 years. Only 4 directors (23.5 %) had held that position for 9 or 10 years.

ART education through training courses and dental curricula

An ART training course had been conducted in every country, with the majority of countries (64.7%) having received 2-3, and 23.5% having received 4 or more ART training courses. Whether the ART approach was part of the dental school curriculum, was answered affirmatively by 73.7% of the respondents. ART training was included in pediatric dentistry (21.1%), public oral health

I. General data

1. Country …… 2. Name (optional): …… 3. Year of graduation: ……
4. Current position …… 5. Number in years that you occupy that position ……..

II. ART training in this country

6. Have ART training courses been conducted? Yes /__/ No /__/
7. If yes, how frequent have these courses been conducted?
   1 time /__/ 2-3 times /__/ 4-5 times /__/ > 5 times /__/
8. If no, what is the reason why an ART training course has not been conducted?

III. Integration of ART into the dental education system in this country

9. Is ART being included in the curriculum of the Dental School(s)? Yes /__/ No /__/
10. If yes, is ART part of pediatric dentistry /_/ oral public health /_/ other /_/?
11. Is ART incorporated into the community dentistry programme of dental school(s)? /_/

IV. Integration of ART in the healthcare system in this country

12. Is ART being applied in the oral health services? Yes /__/ No/__ /
13. If ART is being used in the oral health services:
    - Is it being applied throughout the country? Yes /__/ No /__/
    - Is it applied only in some regions or localities? Yes /__/ No /__/
    - Is it applied longer than three years? Yes /__/ No /__/
    - Is it applied less than three years? Yes /__/ No /__/
    - Have monitoring and evaluation exercises been carried out to assess its effectiveness? Yes /__/No /__/
    - Have courses been conducted to train evaluators in evaluating ART restorations and ART sealants? Yes /__/ No /__/
    - Are results of evaluations into the effectiveness of ART available? Yes /__/ No /__/

14. What kind of results, do you think, because of the introduction of ART in the oral health system?

- Increase in number of patients being treated (children or adults) /_/
- Increase in the number of restorations relevant to extractions (REX score) /_/
- Increase l positive opinion of operators (less stress, no invasive treatment, etc.) towards ART /_/
- Increase in positive opinion of the Director Oral Health Department towards ART /_/
- Increase in positive opinion of the patients towards ART /_/
- Other. (Specify) : ……..

IV. Barriers that hinder the introduction of ART in the oral health system in your country

15. Which factors, do you think hinder ART introduction in the oral public health system?

- The offices of directors of health units do not support ART. /_/
- Dental practitioners have to attend too many patients and they do not have time to do ART. /_/
- The patients are not properly informed about the benefits of the ART approach, therefore they do not demand it. /_/
- Operators indicate that the ART restorations take more time than restorations that utilize amalgam or resin composite. /_/
- Operators feel more comfortable using the drill and doing conventional restorations than doing ART. /_/
- Operators think that using ART produces inferior results than achieved using conventional treatments. /_/
- Operators have not received an adequate training ART
- There is not a monitoring or results evaluation of the results /_/
- Dental clinics do not have ART instruments and GIC material /_/
- Dental clinics do not have auxiliary personnel /_/
- Patients prefer extractions rather than any kind of restoration. /_/
- Other (Specify)……

VI. Recommendations

18. What would you recommend in order to facilitate an increase in the use of the ART approach in public oral health programs ? (1= highest and 5= lower priority).

More political support from health authorities in public services /_/
Increase in supply of ART materials and ART instruments /_/
Increase the number of ART training courses /_/
Endowment of auxiliary personnel /_/
Greater dissemination of benefits of the ART approach to the public /_/

Thank you for your cooperation

Figure 1- Questionnaire assessing ART integration into oral health care systems in Latin American countries

(10.5%) and other dental courses (15.8%). Inclusion of ART in the community dentistry program of a dental school was affirmed by 31.6% of the respondents.

Implementation of ART in oral care systems

Almost all recipients (94.7%) responded that ART had been implemented in the nation's public oral health services; 15.8% stated that ART was used throughout their country, while 68.4% commented that it was used in only some areas or regions of their country. Only 2 stated that ART was used in private practices. With regard to the length of period that ART had been in used in these countries, 42.1% of the respondents indicated that it had been applied for more than three years, and 47.4% indicated that it had been applied for less than three years.

Regarding the evaluation and monitoring activities for determining the quality of ART restorations and sealants; 42.1% of respondents answered affirmatively. However, courses for training evaluators in assessing the quality of ART sealants and restorations had been held in only 3 countries (15.8%).

Table 1- Frequency distribution (%) of participating countries

Country	Frequency	Percent
Chile	6	31.6
Ecuador	3	15.8
El Salvador	2	10.5
Honduras	1	5.3
Mexico	1	5.3
Nicaragua	1	5.3
Panama	1	5.3
Paraguay	1	5.3
Peru	1	5.3
Uruguay	1	5.3
USA	1	5.3

Strength and weakness of ART implementation

Table 2 presents the responses to the question regarding the perceived results of the introduction of ART into the public health services. The most important result noted by the respondents was the "increase in number of patients treated".

With respect to identifying barrier factors inhibiting implementation of ART; "operator opinion" and "high patient load", followed by "lack in supplies of materials and instruments" and

Table 2- Mean and standard deviation (SD) of perceived benefits from ART implementation in public oral health services in Latin American countries by directors of oral health

Perceived benefits	Mean	SD
Increase in number of patients treated	0.63	0.49
Increase in positive opinion on ART by operators	0.53	0.51
Increase in positive opinion on ART by patients	0.47	0.51
Increase in positive opinion on ART by Director of Oral Health	0.21	0.49

Table 3- Mean and standard deviation (SD) for perceived barrier factors to ART implementation in public oral health services by directors of oral health in a number of Latin American countries

Barrier factors	Mean	SD
Operator opinion	0.43	0.26
Patient load	0.42	0,51
Lack in supplies of materials and instruments	0.37	0.50
Insufficient skills to carry out ART	0.32	0.48
Absence of chair side assistant	0.26	0.45
No support from management	0.21	0.49

"operators lack of ART training" were perceived by respondents in these countries to be the most important, as shown in Table 3.

Table 4 shows the recommendations, in descending order of importance that would facilitate the implementation of ART in the public oral health services of these countries. Organizing ART training courses in the participating countries was considered to be the most important recommendation.

DISCUSSION

The purpose of the present study was to investigate aspects of the integration of the ART approach into oral health care in Latin America. The response rate was 76%, which implies that some caution should be taken when interpreting the results. Furthermore, a questionnaire like the present one, which relied on information available at the offices of directors of the departments of oral health of the ministries of health, may contain a certain level of bias. The value of the supplied information is dependent upon the organizational structure of each department, which might (or might not) have made available all the requested information about the present situation in its country.

Although the findings of the present study should be considered with some caution, the fact that ART courses have been conducted in all participating countries shows that the directors are aware of ART and that they and others in authority intend to introduce ART into their national healthcare systems. This finding is supported by the knowledge that ART is part of the national oral health programs of countries like Brazil, Chile, Ecuador, Peru, Mexico and Uruguay. Further evidence of ART integration comes from the finding that ART has been included in the *curricula* of dental schools in a number of countries; such as Argentina, Bolivia, Brazil, Ecuador, Mexico, Peru and Venezuela. The inclusion of ART in the dental *curricula*, though not on a massive scale, clearly indicates that the authorities intend to make the ART approach available for use by practitioners in public and private practice. Research monitoring the effects of ART introduction and assessing the quality of ART restorations and ART sealants has been conducted in some Latin American countries, though not on a wide scale. The present study found that ART evaluation courses had been given on relatively few occasions. Therefore, increased implementation of aspects of research methodology appears to be needed in these countries, aimed at monitoring ART integration into their oral health service systems and scientifically reporting the findings. Mexico serves as an example of this suggestion[4]. On the basis of the above findings, the conclusion was reached that implementation of the ART approach in Latin American countries is still in its infancy stage.

Implementation of innovations and new developments has generally been met with resistance and ART has not been immune to this. If the probability of a wider acceptance of ART in oral care is to be increased, reasons for possible resistance need to be elicited. The barrier factors reported most frequently in the present study were: "operator opinion" and "patient load", followed by "absence of sufficient practical skills" to enable dental practitioners to produce quality ART sealants and ART restorations and the "absence of sufficient ART instruments and restorative materials". The "operator opinion" and "absence of sufficient practical skills" barrier factors can be overcome by increasing the number of ART courses given by experienced ART trainers in the countries. Such training could be included in the national oral health programs. Spanish and Portuguese ART manuals are available and professional ART teachers can be trained through adoption of the "Train the Teacher" concept, as done in Mexico[4], with assistance of the Department of Global Oral Health in Nijmegen, the Netherlands.

The absence of the relatively few ART instruments (only 5) and glass-ionomer material have been reported as factors negatively affecting the introduction of ART into the oral health services of South Africa[7] and Tanzania[5]. Coordinated efforts between representatives of the ministries of health, national dental associations and industry could determine

Table 4- Recommendations (mean score and standard deviation; SD) by directors of oral health to facilitate further implementation of ART in public oral health services in Latin American countries

Recommendations	Mean	SD
To organize ART training courses	2.1	1.3
To provide more political support by health authorities	2.4	1.2
To ensure availability of materials and instruments	2.7	1.0
To have auxiliary personnel available	3.6	1.4
To disseminate the benefits of ART to the profession and public	3.7	1.5

1 is the highest and 5 is the lowest priority score

ways of ensuring the availability of quality ART instruments for service providers in Latin American countries. A cautionary point should be noted here. Over the last decades, many different brands of glass-ionomer restorative materials have been marketed all over the world. On the basis of the finding that the use of medium-viscosity glass-ionomers with ART had produced ART restorations in single-surfaces that were inferior to those produced when using high-viscosity glass-ionomers[14], dental practitioners and authorities in charge of purchasing glass-ionomer material should opt for quality and field-tested high-viscosity glass-ionomer restorative material, instead of opting for the cheapest glass-ionomer, which may be far less effective. Using field-tested high-viscosity glass-ionomers in the hands of trained dental practitioners will produce long-lasting ART sealants and ART restorations that will benefit the health of the general public. The production of quality ART restorations has been demonstrated in the study carried out in Ecuador, Panama and Uruguay[10]. The 2-year survival rate of ART high-viscosity glass-ionomer restorations was very high and was equal to that of comparable amalgam restorations. In summary: appropriate training in ART at the under- and postgraduate levels and adequate provision of the tools and quality glass-ionomer would be key factors affecting the adoption and proper implementation of ART in oral health services in Latin American countries.

Because of the high level of dental caries in the youth in many Latin American countries[11], and the insufficient preventive and restorative care available to communities there, health authorities in Latin American countries need to work towards improving the oral health services. They need to make proper use of the existing resources in each health unit; perhaps training dental auxiliaries instead of dentists. This would enable them to address the high patient load barrier factor. They would also need to ensure the availability of adequate materials, instruments and dental equipment. Without these guidelines and specific targets, and without a monitoring system managed by competent suitably trained people, dental practitioners may tend to ignore the need to introduce new and evidence-based health methods into their daily practice and consequently, provide very little information to patients about the benefits.

The World Health Organization (WHO) strongly recommends the implementation of the Basic Package of Oral Care (BPOC) adjusted to the actual conditions of each community[2]. ART, being a part of this package, has been recommended for use in Latin American countries by the Pan American Health Organization. Countries that wish to implement the BPOC or only ART may first have to overcome the barrier factors identified in this study, before starting to introduce BPOC and/or ART into their oral healthcare systems.

ART training courses have been conducted in all participating Latin American countries. ART has been introduced, to varying degrees, into public oral health systems of almost all the participating countries and the main barrier factors for ART implementation are operator opinion, high patient load, insufficient skills for implementing the ART approach, and insufficient availability of restorative materials and ART instruments. The introduction of ART in Latin American countries appears to be still in its

infant stage. The highest recommended priority to consider regarding further introduction of the ART approach is the organization of ART training courses.

Recommendations

In order to facilitate the integration of ART into the national oral healthcare systems of Latin America, the relevant authorities should:

· organize "Training the Trainer" courses in ART, in addition to regular full-level ART courses in countries that have already organized such courses;

· support course participants by ensuring the availability of sufficient ART instruments and a constant supply of quality high-viscosity glass-ionomer restorative material;

· ensure the installation of a system for monitoring treatments provided in public oral health services, which includes assessment of the quality of ART sealants and ART restorations, as well as for caries control measures;

· organize meetings for updating dental practitioners about monitored results;

· promote cooperation of the universities with the ministries of health in developing the ART oral health project.

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The implementation and preliminary evaluation of an ART strategy in Mexico - a country example

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ABSTRACT

The massive use of preventive measures in Mexico including fluoride toothpaste, a national program of salt fluoridation and education on prevention has resulted in a large decline in dental caries over the past two decades. There does however remain a largely unmet need for restorative treatment. This paper describes the steps leading up to the adoption of a strategy, as part of general health policy, to use Atraumatic Restorative Treatment (ART) within the Mexican public health service as a means to address this. This included the development of training materials, the organization of training courses for existing dentists and the incorporation of ART into the undergraduate curriculum. Results: Six years after the introduction of ART in the year 2000, it was estimated that over 2 million ART procedures had been provided. As part of the planning cycle, an evaluation was undertaken in 2008 to determine amongst Mexican dentists what were the perceived problems when implementing the ART approach. Such research identified that the scarcity of appropriate dental materials and the lack of suitable instruments were the major problems. In addition, a preliminary evaluation of ART restorations and sealants placed as part of this National Oral Health Program was undertaken. The survival outcomes after one year compared favorably with one other study conducted in Mexico but were somewhat lower than the results reported from a number of other countries. Conclusion: The ambitious and forward thinking policy for improving the oral health in Mexico is now showing dividends. One example is the ART strategy, which has been successful both in terms of the number of ART procedures provided and generally in terms of clinical outcomes.

Key words: Mexico. Health policy. Dental caries. Atraumatic Restorative Treatment (ART). Glass ionomer cements. Dental restoration. Pit and fissure sealants.

INTRODUCTION

The country of Mexico comprises 32 states, with an estimated total population in 2006 of 107,550,697 living in 2,454 municipalities[10]. Mexico has a relatively young population where about 32 percent are 14 years or younger and a further 19% are aged 15 to 24[22]. It has also a largely urban population where more than 76% of the population lives in urban areas[9].

Mexico has a high prevalence of oral diseases with tooth decay affecting 61% of children over 6 years old[11]. Oral problems constitute the fifth most common reason for visits to the country's health services[16]. In terms of preventive programs for oral health, the Mexican Congress, as part of its 1989-1994 National Health Plan, declared that salt fluoridation should be one of the main priorities[12]. This followed on from the success of salt fluoridation trials initiated

in 1973[6]. In 1991, Mexico became the seventh country in the world to adopt salt fluoridation to prevent dental caries[3]. The massive use of preventive measures including the use of fluoride toothpaste, education on prevention in the schools and the national program of salt fluoridation have resulted in the rapid decline in dental caries over the past two decades from a DMFT in 1989 of 4.4 for 12 year-olds[4,11]. The National Survey of Dental Caries in Mexico, conducted in 2001, reported that the prevalence of dental caries for schoolchildren aged 12 years was 58%, while the DMFT was 1.91. Of this the decayed tooth DT component was 1.54, missing teeth component MT 0.04, and the filled teeth component FT was 0.34[11]. This indicates that although the burden of dental caries in this age group has been substantially reduced through the use of fluoride, there remains a need for restorative treatment which is largely unmet.

Steps leading up to the adoption of the ART approach in Mexico

The General Health Law of Mexico (Ley General de Salud)[12] defines the powers for the establishment of national policies in the area of oral health. Chapter 45 paragraph 1 of the Internal Regulations of the Ministry of Health (Reglamento Interior de la Secretaría de Salud)[18] details the need to propose policies for the prevention, treatment and control of oral disease. According to this regulation, the National Oral Health Program of Mexico defined and published a program of action for the years 2001-2006 (Programa de Acción: Salud Bucal 2001-2006) in which one of the strategies for improving oral health was to strengthen the curative care, expanding coverage to marginalized localities with problems of access and promote alternative curative treatment in the form of a countrywide adoption of the Atraumatic Restorative Treatment (ART) approach[16].

The concept was to implement a plan for the introduction of the ART approach in public clinics in 19 states selected for their degree of marginalization and lack of access to care[11]. A number of barriers were however encountered. First, there was opposition to this approach by the dental association whose concerns included: a fear that caries would be left behind under ART restorations, that this in turn would lead to an irreversible pulpitis, and concerns about the reliability of the restorative material to be used. Other problems that emerged concerned the sourcing of suitable instruments and dental materials, especially high-strength glass ionomer, the availability of information material in Spanish on the ART approach and certain operational problems.

To resolve the latter problem a training manual in Spanish was published for national distribution in 2001[13]. This was followed by a organization of an international master training course on ART held in 2002 and attended by representatives of the Pan American Health Organization, the United States of America Air Force, Cayetano Heredia University of Peru and Caribbean countries, representatives of the 19 priority states, and representatives of the health and academic sector of Mexico.

Since then and up to the year 2006 there have been 27 theoretical and practical training courses where 810 dentists have been trained. In addition, a video on the clinical procedures involved in ART has been developed and is integrated into each ART training course. As a result of these initiatives the number of ART procedures provided has continued to increase from year to year. In 2000, a total of 177.823 ART procedures were reported to have been provided in government clinics rising to 712.869 in 2006. This represented an increase over this period of 400%[19].

The National Development Plan (Plan Nacional de Desarrollo, 2007-2012)[14] and the National Plan for Health 2007-2012 (Programa Nacional de Salud 2007-2012)[17], have a number of strategies. The latter includes five main strategies:

1. To improve the health of the population; 2. To reduce gaps and inequalities in health through interventions targeted at vulnerable groups and marginalized communities; 3. To provide quality health and safety; 4. To prevent the impoverishment of the population for health reasons; and, 5. To ensure that health contributes to poverty reduction and social development of

the country.

This incorporates the "100 Towns 100 Actions" strategy ("100 Municipios 100 Acciones") which applies to the Municipalities which have the lowest Human Development Index (HDI) in the country[7]. It comprises a comprehensive strategy to fast track social development in these marginalized municipalities including increased housing supply, water and drainage, and projects for production.

A Specific Action Program for Oral Health, 2007-2012 (Programa de Acción Específico 2007-2012, Salud Bucal)[15], outlines 13 strategic actions to improve oral health in Mexico. Strategic action number 9 is to extend the coverage of dental care through the use of Atraumatic Restorative Treatment in the 100 municipalities mentioned above. To achieve this goal, 19 additional ART courses were provided in 2008-2009 to a further 570 dentists, rising the total of number of dentists specifically trained in ART to 1380.

In parallel with the activities to train existing dentists about the ART approach, there have also been efforts to train dental students with the aim of improving their attitude to ART as an alternative treatment for carious lesions. This will help the newly trained dental graduate, during their obligatory (six months to one year) working in social service mainly in municipalities with a lower index of human development. Similarly, the Mexican dental associations of the country have also been invited to join this strategy.

The attitudes of Mexican dentists to Atraumatic Restorative Treatment

In order to understand the attitude and views of Mexican dentists concerning the perceived major problems when implementing the ART approach in their practice and to determine where they considered such an approach could be best applied, a survey of 197 dentists was undertaken in 2008 in the states of Chiapas, Michoacan and Sinaloa. This survey found that the major problem for the implementation of ART, perceived by 45 % of the respondents, was the scarcity or unavailability of appropriate dental materials and the lack of suitable instruments; those that were available being of poor quality (Figure 1). It was also noted that the reason that dentists had joined ART training courses was not only to receive information on how to undertake ART correctly but also to facilitate access to appropriate materials and instruments.

This survey also identified that just over 55% of the dentists surveyed strictly followed the correct ART approach using hand instruments alone, while the remaining dentists used either a high- or low-speed handpiece either alone or to compliment the use of hand instruments when preparing a cavity for an "ART" restoration. The use of rotary instruments does not feature as part of the ART approach[2], therefore the number of ART procedures reported from 2000-2006, given above, is most probably an overestimation. Since becoming aware of this reporting problem, the

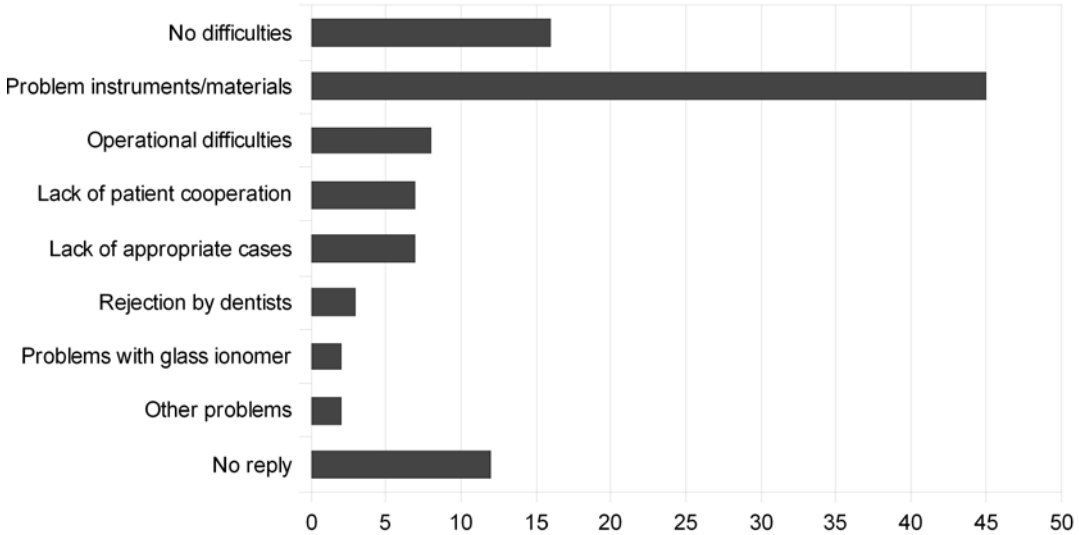

Figure 1- Major perceived difficulties when implementing the ART approach (percentage of responses)

recording system for ART treatment has been corrected. In 2008 there were 241,449 ART treatments provided and from January to August 2009, a total of 172.815[19].

Preliminary evaluation of ART restorations and sealants provided in Mexico

The Specific Action Program for Oral Health, 2007-2012 (Programa de Acción Específico 2007-2012, Salud Bucal)[15] points to the need for surveillance of the oral health program for planning and decision making. This is achieved though the systematized monitoring mechanism that has been instrumental in following, for example, the number of ART procedures provided per year. While the number of procedures performed is one index of the success of the implementation of the ART approach in Mexico it does not provide information on specific outcomes relating to the implementation of the approach.

The National Oral Health Program in Mexico now has some nine years experience in using Atraumatic Restorative Treatment as one of its oral health strategies. Here it is considered to be an important alternative approach to the management of dental caries for marginalized areas of Mexico with problems of access, such as in those municipalities which have the lowest Human Development Index (HDI). It was therefore considered important to make a preliminary evaluation of ART restorations and sealants placed as part of this National Oral Health Program. A study was therefore designed to enable this to be undertaken. The primary objective was therefore to make a pilot evaluation after one year of ART restorations and sealants placed in primary and permanent teeth in schoolchildren aged 6 to 13 years. A secondary objective was to develop a tool for evaluating the effectiveness of the ART strategy in Mexico.

MATERIAL AND METHODS

A prospective cohort study was conducted in 15 primary schools in 13 of the municipalities with the lowest Human Development Index (HDI) in six of the seven states in Mexico with such municipalities. A convenience sample of 304 schoolchildren aged 6 to 13 years was selected based on their need for one or more ART restorations or sealants. Informed consent was sought from the children's parents to participate in the study.

ART restorations were placed following standard ART procedures[1] by 18 dentists who had been trained in the ART approach and who had prior experience with its use. All treatment was performed within the school facilities in areas either inside or outside the classroom. Only single-surface restorations were placed, that is, class I, III and V according to Black's

ART codes and criteria for restorations	ART codes and criteria for sealants
0 - Present. Successful, good condition.	0 - Present in all pits and fissures sealed at baseline
1 - Present. Slight deficiency at cavity margin. (< 0.5 mm in depth).	1 - Any loss of sealant exposing pits and fissures
2 - Present. Deficiency at cavity margin (= 0.5 mm in depth).	
3 - Present. Fracture in the restoration.	
4 - Present. Fracture in the tooth.	
5 - Present. Overextension of approximal margin. (equal to or greater than 0.5mm)	
6 - Not present. Most or all of the restoration is missing.	6 - Not present.
7 - Not present. Other restorative treatment performed (amalgam, resin, etc.).	7 - Not present. Restorative treatment performed.
8 - Not present. Tooth is not present.	8- Not present. Tooth is not present.
9 - Impossible to diagnose.	9 - Impossible to diagnose.

Figure 2- ART codes and criteria for restorations and sealants

classification. The same tooth could have a combination of ART treatment e.g. an ART sealant on the occlusal surface and a Class V restoration on the buccal surface. Ketac Molar Easymix (3M ESPE®) high-strength glass ionomer was used for all ART restorations and sealants.

The one-year evaluations were conducted by 7 examiners who had not been involved in the ART treatment and who had been trained by an external international expert over a four-day course. Evaluations were undertaken using visual criteria alone with a plane mouth mirror and a WHO ball-ended periodontal probe. A specially designed form was used for registration and evaluation of the restorations and sealants. Standard ART criteria (Figure 2) was used to assess the ART restorations and sealants[20]. For this study, ART survival was measured by defining it as a restoration wear or not to submit this is not greater than 0.5mm. Caries was scored at the cavitational level (Figure 3). Furthermore, in two of the six states where the study took place, photographs of the ART treatment were taken for use in subsequent evaluations and for teaching purposes. Standard infection control procedures were observed for all examinations.

The examiner reproducibility was assessed using Kappa to be better than 0.82 for inter-examiner reproducibility and better than 0.92 for intra-examiner reproducibility.

Statistical analysis was undertaken using SPSS Software Version 15, Statistical Package.

RESULTS

Of the 304 children who received ART treatment at baseline only 243 children were available at the one-year follow-up representing 80% of the original sample. In these children, 410 ART restorations were available for evaluation, 314 in primary teeth and 96 in permanent teeth. A total of 390 ART sealants were also evaluated, 182 in primary and 208 in permanent teeth.

The survival of ART restorations and those restorations associated with caries at the one-year evaluation for both primary and permanent teeth is given in Table 1. For this preliminary analysis the association between restoration failure and the finding of caries was not analyzed since this will be part of a subsequent re-evaluation.

The survival of ART sealants at the one-year evaluation and caries associated with part-retained and totally lost sealants is given in Table 2. Since the number of previously sealed teeth with caries was very low, further statistical analysis was unwarranted.

0 - No caries
1 - Caries associated with ART restoration
2 - Caries associated with ART sealant and with loss of sealant extension to ART restoration
3 - Caries on same tooth surface but not associated with ART restoration or ART sealant extension.
4 - Caries on tooth surface not associated with ART restoration or ART sealant
9 - Impossible to diagnose.

Figure 3- Criteria for diagnosing carious lesions in ART studies

Table 1- Survival of ART restorations and those associated with caries at the one-year evaluation

	Number of ART restorations evaluated	Number of successful ART restorations at one year (%)	Number of ART restorations associated with caries (%)
Primary teeth	314	252 (80.2)	31 (9.8)
Permanent teeth	96	84 (87.5)	4 (4.1)
Overall	410	336 (81.9)	35 (8.5)

Table 2- Survival of ART sealants and caries associated with partial or complete loss of sealant at the one-year evaluation

	Number of ART sealants evaluated	Number of fully or part-retained sealants at one-year (%)	Number of teeth with caries located in an area with part loss of sealant (%)	Number of teeth with caries located in an area with total loss of sealant (%)
Primary teeth	182	125 (68.7)	2 (1.6)	2 (3.5)
Permanent teeth	208	148 (71.2)	1 (0.7)	2 (3.3)
Overall	390	273 (70.0)	3 (1.1)	4 (3.4)

DISCUSSION

This paper describes the process involved in introducing the ART approach in Mexico as part of an overall oral health strategy, a strategy which is firmly based on prevention with the emphasis on caries prevention. This has involved policy decisions at all levels of government culminating in the recent Specific Action Program for Oral Health, 2007-2012.

Six years after the introduction of ART as a strategy, in the year 2000, it was estimated that 2,750,899 separate ART procedures had been provided[19]. This is most likely to be an overestimation since the 2008 survey of Mexican dentists' attitudes to ART showed that some professionals had reported ART procedures even when they had used a low- or high-speed drill for cavity preparation. Even when making a safe allowance for this overestimation, it still means that by the year 2006 well over a million ART procedures had been provided over this six-year period. This appoints to the huge success of the adoption of the ART approach strategy in Mexico. The ART strategy has also been progressively scaled up as more and more existing dentists are trained in the approach and as newly qualified dentists join the workforce having been trained during their university studies.

Since the Specific Action Program for Oral Health, 2007-2012[15] ends in just over two years, it is only timely to undertake an evaluation of the outcomes of the strategy of using the ART approach as an important alternative approach to the management of dental caries for marginalized areas of Mexico with problems of access, such as in those municipalities which have the lowest Human Development Index (HDI). The evaluation of the ART program was not easy since it was spread over a number of Mexican states and this necessitated the use of a relatively large number of examiners for purely practical reasons. All the examiners did however follow a short training course with an international expert in an attempt to ensure consistency of results.

The survival results of this preliminary evaluation of ART restorations and sealants provided in the public service compare favorably with one other study conducted in Mexico by López, et al.[5] (2005). In this two-year study, the acceptability and effectiveness of ART restorations and sealants for the prevention and treatment of dental caries were evaluated. A team of dentists and dental students from 2 dental schools and the Ministry of Health placed 370 ART restorations and 193 ART sealants in 118 subjects aged 5 to 18 years. Eighty-five percent of subjects reported no pain and 93% reported being comfortable with their restorations. The subjects were assessed at 1 and 2 years, showing an overall retention of ART restorations in permanent teeth of 81% and 66% respectively. This is poorer than the 87.5% survival reported in this present study at one year for similar restorations. The retention of ART sealants in the Lopez study was also poorer with a one year survival of 51% against the 71.2% found in this present study. It is not clear why this should be the case.

While the results of this present study are encouraging they fall short of the survival

results reported in a meta-analysis of studies published up to 2005 where weighted mean survival for one-surface ART restorations were 97% for permanent teeth and 95% for primary teeth[21]. Similarly, although the number of ART sealant papers is limited in number, weighted mean survival rates in the region of 90% after one year have been reported. The reasons for lower survival rates in the present study will need to be explored but there are a number of possible reasons that might explain this. The outcomes could be due to the dentists failing to select suitable teeth for ART restorations and sealants, or though them failing to rigidly follow the ART treatment protocol. The relatively high percentage of failure due to caries with ART restorations, which hasn't been reported in other ART studies, needs further examination. Here, the photographs which were taken will be very useful in the future to identify whether this could have been the case but also as a teaching tool both in ART courses and in ART calibration training sessions. Moreover, the two-year evaluation will be decisive in shedding light on these matters so firm conclusions on the survival outcomes of ART restorations and sealants placed in the Mexican public health service.

Notwithstanding the survival outcomes, the one-year evaluation can be considered to be a operational success since it has shown that it is possible to evaluate a public program where ART restorations and sealants are being provided even though this might cover a large number of geographical remote areas, in this case a number of Mexican states. Likewise, the specially designed form for recording and monitoring ART treatment was convenient and easy to use, and might be scaled up for monitoring activities on a daily basis within the country's health services.

CONCLUSIONS

Mexico has an ambitious and forward thinking policy for improving the oral health of its population. The results from the evaluation of the ART strategy show that it has been successful both in terms of the number of ART procedures performed since its introduction and generally in terms of clinical outcomes. This evaluation has also been useful in identifying areas where improvements could be made as part of the strategically planning cycle. While in this publication we have concentrated on the ART strategy in Mexico, it is important to reiterate that ART is just one component of Mexico's overall oral health strategy firmly based on prevention and improving access to care countrywide.

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Two decades of ART: improving on success through further research

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ABSTRACT

Since the introduction of the Atraumatic Restorative Treatment (ART) approach over twenty years ago, more than 190 research publications have appeared. The last research agenda defining research priorities for ART was published in 1999. The objective of the present work was to review existing research in the context of future research priorities for ART. Material and Methods: An internet survey was conducted amongst those who had published on ART or were known to be working on the ART approach, to solicit their views as to areas of future ART research. Three broad categories were defined, namely: 1. Basic and laboratory research; 2. Clinical research, and, 3. Community, Public Health, Health Services Research. Results: A 31% response rate was achieved. The study identified a number of new areas of research as well as areas where additional research is required. These are expressed as recommendations for future ART research. Conclusions: The ART approach is based on a robust, reliable and ever-growing evidence base concerning its clinical applications which indicates that it is a reliable and quality treatment approach. In common with all other oral health care procedures, targeted applied research is required to improve the oral health care offered.

Key words: Atraumatic Restorative Treatment (ART). Developing countries. Dental caries. Health services research. Dental education. Cost effectiveness.

INTRODUCTION

The famous quotation of Albert Einstein that "If we knew what it was we were doing, it would not be called research, would it?"[25] holds as true for nuclear physics as it does to oral health and dentistry. In spite of the explosion of dental research over recent decades, the sad fact is that the everyday practice of dentistry has not made the quantum leap to enable effective and affordable oral health care to be brought to the vast majority of the over 6.8 billion people that now inhabit our planet.

Since the mid-1980's, when Frencken pioneered Atraumatic Restorative Treatment (ART)[20], the approach has been subjected to extensive scientific research and evaluation. The highly promising early results of a community field trial of ART in Thailand[24], linked with the increasing realisation of a need for dental caries care to move to more minimal intervention techniques[12,13], led to a symposium being organized to review the scientific rationale for certain minimal intervention techniques, including ART, and to propose an agenda for future research in this field. This symposium was held during the 73rd General Session of the International Association of Dental Research in Singapore in 1995[55]. Following the symposium, the organizers and speakers met to define a preliminary agenda for research on minimal intervention techniques for caries, including ART[30]. Here, five broad areas for research on minimal intervention techniques for caries were identified, namely: their clinical evaluation, caries control, the development of suitable dental

materials, behavioral aspects and educational perspectives of the approach. All the areas defined for minimal intervention also applied to the ART approach, ART being part of minimal intervention. Nonetheless, a research agenda specifically for ART was also defined but at this point in time was limited to an evaluation of its clinical effectiveness.

The symposium and the publication of its proceedings stimulated a number of groups around the world to pursue further research into minimal intervention techniques for caries, including ART, so that three years later, in 1998, a further symposium was organised entitled "The State of ART (Atraumatic Restorative Treatment) - a scientific perspective". This was held as part of the 76th General Session of the International Association of Dental Research in Nice, France[56]. At this symposium, Holmgren and Frencken[28] (1999) reviewed recent research and developments with respect to ART in the context of the 1995 research agenda[30] and outlined future areas for research and development.

Since the 1998 IADR symposium on ART[56], there have been several international symposia devoted specifically to ART, as interest in the approach has grown almost exponentially. Those involved in oral health, from a multitude of countries, have realized the huge potential that such an approach can offer to help combat what has been termed by Edelstein[15] (2006) as "the global pandemic of dental caries". However, none of the symposia have been devoted specifically to ART research and thus the ART Symposium "Two decades of ART – Success through Research" held during the 3rd Latin American Regional Meeting of the IADR, on Isla de Margarita, Venezuela in November 2009 provided a timely opportunity to take stock of what we have learnt about ART through research over the past two decades and identify what future direction ART research should take.

Frencken, et al.[24] (1994) published the results of the first ART research in 1994. Since then, numerous researchers from many countries around the world have undertaken research concerning ART. Tasked with identifying areas of further ART research the authors considered it relevant and useful to solicit the views of those who have or are currently undertaking research on ART, those who have published on the subject and those that have worked with ART and were known to the authors. A survey was therefore conducted to solicit their views as to areas of future ART research.

MATERIAL AND METHODS

To identify those who have published papers on ART, an electronic search of the digital archive of biomedical and life sciences journal literature Pubmed was undertaken in late October 2009 using the term "Atraumatic Restorative Treatment". This search term alone was used since Mickenautsch, et al.[47] (2009) found that the terms "ART", "ART approach", and "ART technique" were not sufficiently specific to select publications relating to Atraumatic Restorative Treatment. It was however realised that such a search strategy might not identify all publications that might be applicable to ART, such as related developments in the dental materials field, or those that were published in languages other than English. This Pubmed search identified a total of 176 publications dating from 1977. Six of these publications, published prior to 1994, were unrelated to the ART approach and therefore excluded.

In the abstract of publications in the Pubmed database it is becoming common practice for the e-mail address of the principal author to be provided. This was the case for 75 publications, giving a total of 66 authors to contact. Personal contacts of people who have worked on ART, known to the authors of this paper, were added to the list, totalling 76 people to contact.

A standard letter was sent to the collected e-mail addresses. The letter explained why they had been contacted and that the purpose of the exercise was to identify areas for future research on ART. It was suggested that they could propose future research, divided into three broad categories, namely: 1. Basic and laboratory research; 2. Clinical research, and, 3. Community, Public Health, Health Services Research. It was also explained that it was

not obligatory to respond to all three areas of research since the person contacted might only have expertise in one of the areas of research. A reasonable deadline was also given for replies.

Of the 76 persons who were sent an e-mail, the addresses used were found to be incorrect in 29 cases since the e-mail was returned by the internet service provider. In such cases the internet Google® search engine was used with the author's name to try to identify a new contact address. Eventually, this resulted in a total of 66 e-mails being successfully sent. One week after the given deadline a total of 21 responses had been received representing a 31% response rate.

The responses from this internet survey were compiled for a presentation given during the symposium "Two Decades of ART – Success through Research" mentioned above. Discussions held subsequent to this symposium added several other important themes for future ART research.

Given below are areas for future ART research proposed, the justifications for the research, and specific recommendations. These are divided into the same categories as defined in the internet survey i.e. Basic and laboratory research, Clinical Research, and, Community, Public Health and Health Services Research. It is inevitable that there is some overlap between the different categories since for instance clinical research might be supported in part by a parallel laboratory investigation and vice versa.

BASIC / LABORATORY RESEARCH

Research to better understand the effects of ART on the dentine / pulp complex

The effect of glass ionomer as used in the ART approach on residual carious dentine has been examined by Smales, et al.[60] (2005) in primary teeth and in permanent teeth by Ngo, et al.[51] (2006). Both studies report penetration of the fluorine and strontium ions into the dentine which is consistent with a remineralization process. The relative effects of the antimicrobial properties of the cavity conditioner and the GIC, as against lesion starvation from sealing the cavity, on remineralisation, is not known. Furthermore, the long term effects of placing an ART restoration on residual carious dentine are unknown.

While it is not the intention to routinely leave significant amounts of infected dentine when placing an ART restoration, sometimes this is the case to avoid a pulpal exposure (see later). In such cases little is known about the effects of this on the dentine/pulp complex. Traditionally this has been examined by extracting the tooth for histological examination of the pulp. Here Kidd[34] (2004) considers that there is a need for a method of monitoring pulpal pathology *in vivo*.

Recommendation: There is a need for further research to understand the effects of ART restorations on the dentine/pulp complex over time, relating to different levels of removal of carious dentine.

Research to improve dental materials used for ART

Part of the recommendations for future research and development in the preliminary research agenda for minimal intervention techniques for caries, including ART[55], concerned the need for improved dental materials[30]. This was answered in part by the development of Fuji IX® (GC Dental), a high-strength glass ionomer specially developed for ART. Other manufacturers closely followed suit with similar materials such as Ketac Molar, Ketac Molar Easymix (3M ESPE) and Chemflex (Dentsply). The effectiveness of a number of these have been validated in clinical trials.

While glass ionomer cement used for ART has inherent antimicrobial properties[10,59], some researchers have attempted to enhance this effect by the use of antimicrobials such as chlorhexidine[6,23], or by the addition of antibiotics[68]. While all the studies have reported that these modified glass ionomers have enhanced antimicrobial action, a danger being that the physical properties of the material might be compromised[61]. For the moment the clinical outcomes of ART restorations using these modified glass ionomer materials have not been studied and thus there is a need to clinically justify the addition of antimicrobials to glass ionomer.

The objective of instrumentation with hand-instruments, as used in the ART approach, is to remove the soft, heavily infected and unremineralisable "infected dentine" leaving behind the harder, minimally infected and remineralisable "affected dentine", thereby conserving sound tooth structure. Studies by Palma-Dibbs, et al.[53] (2003) and Czarnecka, et al.[9] (2007) suggest that the bond strengths of glass ionomer to affected dentine can be less than that to sound dentine. Bond strength is important when restoring cavities with little or no natural retention and therefore attempts should be made to develop systems which specifically improve the bond strength of glass ionomer to affected dentine.

On a more practical issue, the working and setting time of glass ionomers is often optimised for room temperatures which are usually of the order of 20-23°C. At higher temperatures, such as those that might well be encountered in outreach situations, the working time can be significantly decreased. This can make it difficult to pack a cavity and related fissures before the material becomes too hard to use the press finger technique. Clinical experience shows that this can sometimes lead to "high" restorations, which require substantial shaping, particularly with inexperienced operators.

Another potential complication of high temperatures is a reduced shelf life of the material. For countries where high temperatures are encountered, materials which are less sensitive to temperature need to be developed.

Recommendation: Research should continue to develop improve materials for ART which have antibacterial properties, enhanced bond strength to affected dentine and extended working time and shelf life under less than optimal conditions.

CLINICAL RESEARCH

Research on the individual clinical steps involved producing an ART restoration

The clinical step-by-step procedures required to produce an ART restoration have been described in detail by Frencken and Holmgren[21] (1999). Both in this publication and during ART training courses the strict adherence to these step-by-step procedures is emphasised with the objective of obtaining reliable clinical outcomes. However, each step in a clinical procedure takes time and uses material, both of which complicate the procedure and have cost implications. While the ART step-by-step procedure is largely based on an understanding of the carious process, knowledge of the properties of the filling material (glass ionomer) and sound common sense, the necessity of some steps might be re-examined and perhaps others proposed. Here, any modifications to the standard ART step-by-step procedures should be assessed in terms of true clinical outcomes and any gains that might be accrued in terms of savings in time and materials.

In terms of the steps which might be examined or further examined are:

- the need for sharp excavators for cavity cleaning;
- other cavity cleaning approaches such as chemo-mechanical;
- the value of pre-treatment of the cavity, e.g. cavity "sterilisation"[16,18], the use of silver fluoride[36];
- the effect of consistency of glass ionomer[14];
- the effect of different packing techniques;
- the need to apply a varnish or petroleum jelly to protect the restoration[52].

Recommendation: Research should be undertaken to examine the individual clinical steps of the ART approach to determine if each step is obligatory to produce reliable clinical outcomes.

Research on the need to remove all carious dentine and the management of deep caries lesions

In the ART approach the term "cavity cleaning" instead of "cavity preparation" is used to distinguish between the traditional mechanistic approach (cavity preparation) and a biological approach (cavity cleaning). Here, an understanding of the caries process and the extent of the caries lesion determines the size and shape of the final cavity. Thus, with this approach there cannot be a pre-conceived cavity design[21].

As mentioned above, the intention of cavity cleaning as used with the ART approach is to remove the soft, heavily infected and unremineralisable "infected dentine", except in deep caries lesions where there is a risk of pulpal exposure. For such cases soft dentine is deliberately left behind and the cavity filled and sealed with a sealant restoration. In this context Kidd[34] (2004) has asked the question "how clean must a cavity be before restoration?". In her review of this subject she concludes that even this question might be irrelevant since there is little evidence that infected dentine must be removed prior to sealing the tooth with a restoration. A Cochrane review has reported a similar finding[58]. This has implications both for minimally invasive approaches such as ART as well as for the management of deep caries lesions. The question thus turns full circle, since if it is true that infected dentine does not need to be removed for biological reasons, then the only reason to remove it, either in part or in total, would be for mechanical reasons; namely, to assist with the retention of the restoration. Here, Mertz-Fairhurst, et al.[43] (1998), showed that it was possible to maintain very minimally prepared sealed restorations over dentinal lesions for a period of 10 years. The findings from this study need confirmation and it is exciting to learn that a multicenter randomized controlled clinical trial is underway to evaluate the effectiveness of an alternative treatment for deep caries lesions in Brazil[40], where, in one group, carious dentine will be partially removed and a restoration placed in one session, while stepwise excavation[5] will be used in the other group. Since in this study only amalgam or composite resin will be used, there is a need to undertake a similar form of evaluation with glass ionomer, as is used with the ART approach.

Recommendation: Further research is needed to clarify the effects of partial and no removal of "infected" dentine on clinical outcomes in terms of restoration survival and pulpal health. Partial removal should include comparisons of infected dentine removal only at the enamel-dentine junction, as against removal here and towards the pulpal floor of the lesion.

Research on cavity size, shape and location

In order to achieve the most reliable results from the ART approach, careful selection of cases is essential. Here, factors such as cavity size, its shape and location might play an important role in predicting restoration survival. Early studies[38] showed that smaller single-surface ART restorations have a higher survival rate than larger restorations. Kemoli and van Amerongen[32] (2009) have also studied the effect of proximal cavity size in primary molars on survival outcomes. There is however a need to undertake further work in this important area using a standardised and widely accepted method of classifying cavities, to enable this information to be easily applied to daily clinical practice. Mickenautsch and Grossman[45] (2006) propose that the use of the classification system of Mount and Hume[49] (1997) could be useful in this respect.

Recommendation: Further research should be undertaken to clarify the role of cavity size, shape and location on survival outcomes using a standardised and clinically applicable method of classification of cavities.

Research on ART in multi-surface cavities

The growing number of clinical and community studies investigating the survival of ART restorations and sealants has permitted a number of systematic reviews to be undertaken. These have reported on survival rates for single- and multiple-surface ART restorations in primary teeth, single surface restorations in permanent teeth and ART sealants[65] and compared ART versus amalgam restorations[47]. Currently there is a paucity of data on the survival of Class II and multi-surface restorations in permanent teeth and those studies that have reported on these are either of rather short duration, or have rather small sample sizes[8]. The reason for the lack of data is most probably multifactorial, both due to the age groups commonly used for ART survival studies where caries lesions involving multi-surfaces are relatively rare, and also because access to Class II lesions in permanent teeth can be difficult with hand-instruments alone, until the lesion is large and the marginal ridge has been

weakened by the caries process.

For multi-surface ART restorations in primary teeth, the systematic review of van't Hof, et al.[65] (2006) reported that the survival rates of such restorations were low. More recent studies have confirmed this finding, although some studies[33,64] show much lower survival rates than those reported in other studies, the reasons being far from clear.

Recommendation: Research is required to clarify the application of the ART approach for the management of multi-surface and Class II carious lesions in permanent teeth.

Recommendation: Further research is required to improve the success rate of ART restorations in multi-surface and Class II carious lesions in primary teeth.

Research on the use of ART as a fissure sealant

ART sealants are an extension of the ART approach for non-cavitated teeth at risk of caries, where a high-viscosity restorative glass ionomer is used to seal vulnerable pits and fissures, or those with caries only involving the enamel[21]. Even though an evaluation of ART sealants featured in the first field trial of ART in Thailand[24], the systematic review of ART conducted by van't Hof, et al.[65] (2006) reported that the number of studies investigating the retention and caries preventive effect of ART sealants was low. This continues to be the case even though results from existing studies are very encouraging[29]. Moreover, ART sealants offer several advantages over resin-based sealants in terms of the lack of need for strict moisture control and that they can easily be placed in outreach situations e.g. in school populations without recourse to dental clinic facilities. Further studies are therefore warranted.

Frencken and Holmgren[21] (1999) consider that, when evaluating sealants, "biological outcomes should take precedence over mechanical outcomes". In other words, since sealants are usually placed to prevent the onset or to arrest early caries lesions, the true outcome of their success should be expressed in terms of how they have managed to prevent or arrest a lesion from progressing. In a systematic review of the caries-preventive effect of resin-based and glass ionomer sealants, Beiruti, et al.[3] (2006) concluded that there was no evidence that either resin-based or glass ionomer sealant material was superior to the other in preventing dentine lesion development in pits and fissures over time. The decision as to which material to use for sealing might therefore be dependent upon factors such as cost and clinical setting.

Recommendation: Additional long-term studies should be conducted to evaluate both mechanical and biological outcomes of ART sealants in comparison to resin-based sealants in different clinical settings, provided by different levels of oral health personnel, and in populations with different levels of caries risk.

Recommendation: Further research should be undertaken as to the value of using ART sealants to seal sound occlusal surfaces, as against sealing only those surfaces with early enamel lesions, or dentine lesions with small cavity openings e.g. <1 mm.

Recommendation: Studies should be initiated to investigate why, despite the loss of glass ionomer cement from pits and fissures sealed with ART sealants, these surfaces appear to be more caries resistent than pits and fissures previously sealed with resin-based sealants.

Research on the success of repaired ART restorations

An important component of the Minimal Intervention (MI) approach to the management of dental caries is that restorations deemed to have failed should, where technically possible, be repaired rather than replaced in order to conserve sound tooth tissue[62]. In their book on ART, Frencken and Holmgren[21] (1999), discuss the management of defective and failed restorations and their repair. While there have now been many studies documenting the survival of ART restorations, there are no studies on the survival of repaired or replaced ART restorations. Such information would help identify situations where a repair of an ART restoration is likely to result in long term success and where a repair should be avoided and another type of

restoration might be considered.

Recommendation: Research should be initiated on the survival of repaired and replaced restorations taking into account such factors as the initial cavity size, shape and location, and the nature of the primary failure.

Research on patient acceptance, pain and anxiety

Many publications report that subjectively ART is very well accepted by patients since no drill is used, there is almost no noise and rarely is an injection required for local anaesthesia. The few studies which have been published on the subject of patient acceptance, pain and anxiety related to ART have been reviewed by Leal, et al.[37] (2010). In this review, it is pointed out that there is little information available regarding pain and discomfort related to the ART approach for both adults and young children. In those studies that do exist, the results are difficult to interpret because of issues concerning methodology and because confounding factors such as age, gender, operator influence and cultural aspects have not been taken into account[37].

Recommendation: Research on dental fear, pain and anxiety relating to ART and other restorative procedures require further investigation using standard and accepted methodology taking into account possible confounding factors.

COMMUNITY, PUBLIC HEALTH AND HEALTH SERVICES RESEARCH

Research on the use of ART in specific population groups

In most countries the proportion of elderly people is increasing. The United Nations states that population aging is unprecedented, a global phenomenon and is having major consequences and implications on all facets of human life[63]. The aging of populations also imposes new challenges to health care systems, both in terms of the type of care required and access to care for a population which might be medically compromised and where mobility might be severely reduced. The high portability of ART offers an opportunity to care for such patients outside the traditional dental care setting.

To date only two studies have investigated the use of ART in elderly populations, one in Finland[31] and the other in Hong Kong[39]. While both of these studies showed the value of the ART approach in such populations, both studies were of rather short duration with relatively small sample sizes. Additional studies on the use of the ART approach in the elderly are therefore required for this important and ever growing population group.

Another void in the area for ART research concerns its application for people with special needs such as those whose oral health care is compromised by physical, mental, medical or social disability. Because of the difficulties in managing these patients they tend to receive less oral health care than the general population, and when care is delivered the operator might need to resort to the use of sedation or protective stabilization[26]. Since ART is considered to be generally well accepted by patients because of the "no needle, no drill, no noise" characteristic, it might offer a viable alternative to traditional approaches. Currently only one publication on the use of ART in this field has been published[48].

Early childhood caries (ECC) is a serious public health problem in disadvantaged communities in both developing and industrialized countries[11]. To date there is only limited evidence on the use of the ART approach in young infants[17]. Figueredo[19] (2006) has proposed that further research should include both a quantitative and qualitative evaluation of the ART in such infants where there is not only an evaluation of the clinical performance of the ART restorations placed in children with ECC but also an investigation of the mothers' perceptions about the ART approach. To this could be added research on how well young infants tolerate the ART approach, since Ammari[2] (2007) points out general anesthesia is often required when treating very young children, adding to morbidity and introducing the risk of mortality.

Recommendation: Research on ART should be conducted in specific population groups with the emphasis on the elderly, people with special

needs and in young infants with Early Childhood Caries.

Research on science transfer and application

The late Eva Mertz-Fairhurst in a guest editorial for the Journal of Dental Research on "Pit-and-fissure sealants: a global lack of science transfer?" quotes Genco who, on assuming the role of President of the International Association for Dental Research in 1991, stated: "The dental research community has been entrusted with enhancing the oral health of society, and with this trust comes a responsibility to transfer the fruit of our findings to society"[42].

In this editorial Mertz-Fairhurst poses three questions relating to the use of fissure sealants for the prevention of dental caries: 1. Why is there a time lag in the adoption of pit and fissure sealants as a routine caries preventive procedure for children and teenagers? 2. Why are sealants not used by the majority of dentists, and, 3. Can anything be done by the dental research community to facilitate the utilisation of sealants by dental clinicians? In responding to these questions she cites certain barriers, such as the dental education system, attitudes and practices of the dental profession, including that sealants might pose an economic threat and finally reticence of insurance schemes to pay for the provision of sealants.

There are many parallels between the slow uptake of the use of sealants by dentists and the routine use of Atraumatic Restorative Treatment.

Research on the teaching of ART in dental schools

A common observation amongst respondents to the internet survey was that many dental schools were slow to adopt and practice concepts of Minimal Intervention dentistry (MI), including ART, in their curricula. The reasons for this are not clear and are no doubt multifactorial. Currently there is little published information available on the adoption of MI and ART in dental curricula around the world and what barriers might exist. In preparation for the ART symposium during the 3rd Latin American Regional Meeting of the IADR, in Venezuela (2009), this issue was investigated with respect to Brazilian dental schools[50]. This survey suggests that ART is taught in many of the dental schools in Brazil which is very encouraging. However these findings should not be considered to be the norm worldwide, since the ART approach continues to have a very active following in Brazil, which is not the case for many other countries.

It has been said that it is "easier to move a graveyard that to change a dental curriculum"[57] and this epitomises the difficulties in changing curricula to adopt new concepts and approaches, difficulties which are not unique to the dental curriculum[66]. Regrettably, failure to implement teaching of evidence-based minimal intervention approaches such as ART, within a dental curriculum, not only puts dentists at a disadvantage but ultimately their patients and their communities.

Recommendation: Research should be conducted to determine the extent and nature of teaching on minimal intervention for caries and ART within dental curricula and to identify the barriers which might exist in incorporating such approaches.

Research on the use of ART in general dental practice

A recurrent theme from many of the respondents was the need to investigate why oral health care authorities and dentists still hesitate to adopt ART as part of their treatment protocols, even though the results from clinical studies demonstrate its effectiveness for dental caries management. It is inevitable that one reason is that some dentists have neither heard of ART nor practiced it[7], or are not trained and do not feel competent to practice it[41]. However, for those who are cognisant of the approach, it would be useful to identify whether the barriers to using ART are economic, relate to social and peer norms or relate to ingrained beliefs that ART is a substandard and temporary treatment, to be considered only for the poor and disadvantaged. An example of this latter mentality is demonstrated by a policy statement by the American Academy of Pediatric Dentistry[1] (2008), where ART, previously renamed "Alternative

Restorative Treatment" and now referred to as "Interim Restorative Treatment", is considered a "provisional technique in conventional pediatric restorative dentistry" in "...situations in which traditional cavity preparations and/or placement of traditional dental restorations is not feasible"[1].

Frencken and Holmgren[21] (1999) have always stressed the need for training in ART even for existing dental practitioners since although the ART approach might look deceptively simple to the uninitiated, there are many finer details to the approach that need to be observed to ensure consistent and reliable results. As with many dental procedures, the results obtained in a clinical study, even under field conditions, might not always reflect those obtained in day-to-day dental practice, as is evident from the study of Burke, et al[7] (2005). For that reason dental practice-based research networks have an important role to play, not only for traditional treatment, but also to evaluate new and innovative approaches such as ART[4].

Recommendation: Research should be conducted to determine the use of ART within dental practice and possible barriers that exist to its use.

Recommendation: Research should be conducted into the effectiveness of ART provided in dental practice.

Research on the use of ART in public oral health systems

In spite of endorsement of the ART approach by the World Health Organisation in 1994[67], by the FDI World Dental Federation in 2002[62], and by the Pan American Health Organisation in 2006[54], relatively few countries have incorporated ART comprehensively into their national oral health care systems, Mexico being a notable exception[27]. Investigations have been carried out in South Africa[44] and in Tanzania[35] asking government dentists what they consider to be the major barriers that exist to using ART. In both these cases the barriers include: work load, lack of provision of materials and perception of clinical skill. Such research provides valuable information at the individual dentist level, but there remains no information at the health policy decision level concerning the barriers to the use of ART in public oral health systems.

Recommendation: Research should focus on the use of ART in national oral health care systems. This includes investigation of the barriers why oral health care authorities and dentists still hesitate to adopt ART.

Research on the cost effectiveness of ART

Cost effectiveness studies of different oral health treatment approaches are rather rare in the literature, but such studies are important to any publicly funded oral health care scheme to ensure that the maximum benefit is achieved with the resources available. Such studies can be complicated and the results are not always applicable to situations outside those to where the study was conducted. For example, the cost of the treatment must take into account such factors as the cost of the oral health care provider, the equipment and materials required, the time necessary to undertake the treatment and the setting where the treatment is provided. Since these and other factors can differ between countries and regions, data from research conducted in, for instance, a Scandinavian country might not be directly applicable to a Latin American country and *vice verse*.

Some studies on the cost effectiveness of the ART approach have been conducted in South Africa[46] and in Ecuador, Panama and Uruguay as part of the PRAT study of PAHO[54]. However, all these studies are deficient on methodological grounds.

Recommendation: Research should examine the cost effectiveness of ART against other minimally invasive approaches and traditional treatment in different settings, both for the primary and permanent dentition.

Research on the Basic Package of Oral Care (BPOC)

The success of the ART approach in making it possible to provide restorative and preventive care in almost any setting led to the development of a Basic Package of Oral Care (BPOC), work commissioned by the WHO[22]. This model for oral care is based on self care and prevention

involving toothbrushing with an effective and affordable fluoride toothpaste (AFT); Oral Urgent Treatment for the relief of pain, infection and trauma (OUT); and ART. There is a sound evidence base for all the components of the BPOC and the authors of the package have called for demonstration programs to evaluate the tenets of this model of basic oral care. While a few studies on the BPOC are in progress in a number of countries, there remains a need for further research of this and other oral health packages.

Recommendation: Demonstration programs should be established to evaluate the Basic Package of Oral Care in all its aspects including affordability, accessibility, acceptability, sustainability.

CONCLUSIONS

Since its conception, the ART approach has consistently been the subject of research in order to place the approach within a sound evidence base for its application to improve oral health. As a result of this, the approach has evolved and improved as more was known about its strengths and weaknesses. There is now a robust, reliable and ever-growing evidence base concerning the clinical applications of the ART approach. This however should not lead to complacency amongst the research community, since the current exercise seeking opinions about future ART research has identified several further topics for research. Some of these should be considered as "nice to know" rather than "need to know", since research outcomes are unlikely to make significant changes to the way that the ART approach is applied on a day-to-day basis. Other areas are perhaps more important, for instance to identify the barriers that prevent the utilisation of ART and other Minimal Intervention approaches in routine dental practice and public oral health systems. By identifying such barriers action can be taken to reduce or remove them. Such research will need to call on expertise outside the dental research field and involve sociologists, health economists and others to ensure that quality research is achieved.

It is hoped that the definition of a new research agenda, as detailed in this publication, will stimulate researchers in academia, public health administrators and industry to invest time and effort in this essential area of health care. It is also hoped that funding agencies will recognise the need to wholeheartedly support these activities with the objective of improving oral health, not only locally within countries, but globally.

ART has been a remarkable success story in the history of dentistry and oral health and the authors have a firm conviction that it will be possible to improve on this success through further research. In this respect, it is only fitting to conclude by quoting the words of one of the respondents to our internet survey, who wrote: "Your request for input from the clinical and research communities verifies selfless giving and collective problem solving to address needs of the underserved. I think that's what ART has been from the inception." Such a statement makes all our efforts worthwhile.

> The acquisition of knowledge is the mission of research, the transmission of knowledge is the mission of teaching and the application of knowledge is the mission of public service.
>
> James A. Perkins (1911–1998) - Seventh president of Cornell University.

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Conclusions from the symposium. Two decades of ART: success through research

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ABSTRACT

Two decades of ART research has served as the catalyst for a new way of thinking about oral health care. It is now necessary to build on the success of ART research by educating existing and future oral health professionals and health decision makers about the benefits of the ART approach. It is also important to build upon the sound research base that already exists on ART even though enough is known about ART to consider it is a reliable and quality approach to control caries. While oral health promotion through prevention remains the essential foundation of oral health, the ART approach is an important corner stone in the building of global oral health.

Key words: Atraumatic Restorative Treatment (ART). Dental caries. Health services research.

INTRODUCTION

While it might seem only yesterday for those who pioneered the development and research of the Atraumatic Restorative Treatment (ART) approach, two decades have already passed since the start of the first major study on ART in Khonkaen, Thailand[3]. The timing of this present symposium therefore serves not only as a temporal milestone for ART but also marks the principal outcome of two decades of ART research, namely its contribution to successfully improving oral health worldwide.

In organizing this important symposium, reviewing and building upon the two decades of ART research, it was only appropriate that it be held in Latin America, for although ART did not originate there, it is a Region where huge attention has been focused on the ART approach. It is also a Region which has in many ways been at the forefront recently in many fields of ART, both from a research perspective and in its application of ART in community and country programs as is evidenced by the presentations at this symposium.

Over ten years have passed since the last international ART symposium devoted to research during the IADR congress in Nice in 1998[7]. The proposal by Dr. Olga Zambrano (Venezuela) and Dr. Márcia Cançado Figueiredo (Brazil), that this current symposium be held during the 3rd IADR Congress of the Latin American Region in Isla Margarita, Venezuela, November 2009, provided a timely opportunity to take stock of twenty years of research and build on success by acting as a springboard for future ART research. It also provided an opportunity to bring together prominent researchers in the field of ART in Latin America. Here, we were delighted that the symposium speakers, representing different fields of research from four different countries in the Latin American Region were able to participate and provide extremely valuable contributions both to the symposium itself and to a wider audience through the eventual publication of these proceedings. We were also particularly pleased that the President Elect of IADR, Dr Fidela Navarro was able to present at the symposium.

EARLY RESEARCH

In the early 1990's, research into the ART approach was spearheaded by a few dedicated workers who saw the true potential for this approach. This research was neither easy nor straightforward since it was often conducted under difficult conditions in the field on shoe-string budgets. Moreover, such research was often not appreciated or valued by our peers since ART challenged traditional concepts of restorative treatment and caries management. Despite the early resistance by many to the ART approach, some of whom considered ART to be "third-world dentistry" or "dentistry out of Africa" or even "dirty dentistry", time has proven such pundits wrong. This was achieved through a combination of sound research to provide an excellent evidence base for the approach and logical common sense. Through this approach oral health care can readily be transported and used in any setting making care more accessible to the many thousands of millions who do not have ready access to care.

INTERNATIONAL ACCEPTANCE

While research has provided the evidence base, the worldwide awareness of the ART approach can be attributed to the substantial support from other sectors. The extremely encouraging results of the first ART studies led to support of the approach by international health organisations including the World Health Organisation (WHO)[9], the FDI World Dental Federation[8], the IADR[6,7], and later the Pan American Health Organisation (PAHO)[5]. This latter organisation, through funding of the Inter-American Development Bank (IDB), also organised Project PRAT, a study whose main objective was to demonstrate the cost-effectiveness of the ART approach in a variety of settings in the Region in comparison to the cost- effectiveness of the amalgam technique in the same settings[5]. Despite the numerous problems encountered during the study in which we provided considerable input in training, methods and study design, it was an important first-step to further and perhaps better controlled cost-effectiveness studies in the future.

RESEARCH OUTCOMES

As is evidenced by the papers presented during this symposium, over the past twenty years ART has become one of the most researched approaches for the control of dental caries and certainly for minimal intervention (MI) approaches for caries[1,2]. In this respect ART could be considered in many ways to be the spearhead of MI. It certainly helped to build the momentum of the MI movement amongst a traditionally conservative dental profession who are often slow to grasp new approaches, even those that have a significant evidence base, and adopt them as part of their day-to-day practice armamentarium.

While the past two decades of ART can be heralded as a success story, it is necessary to build on this success. One part of this is to educate existing and future oral health professionals and health decision makers about the benefits of the ART approach. The other is to build upon the sound research base that already exists on ART. While we know enough about ART to know it is a reliable and quality approach to control caries, there will always be a call for addition research to improve on success. In particular, in order to make the quantum leap forward to achieve a significant improvement in oral health in all countries of the world there will be a need for resources to be allocated to applied research on approaches such as ART and allied areas. Here such research is hindered by a lack of funding, a lack of motivated and capable researchers often plagued by the publish or perish syndrome[4]. Furthermore, such research sometimes lacks recognition by the research community and in some cases it is difficult to publish such research, the latter because of the lack of understanding of the difficulties involved in conducting applied research under real life circumstances. This having been said, the more than 170 publications dealing with the ART approach bear witness to the motivated and capable researchers who have often put oral health research ethics before personal gain.

CONCLUSIONS

In summing up the last two decades of ART research, ART has served as the catalyst for a new way of thinking about oral health care. While oral health promotion through prevention remains the essential foundation of oral health, the ART approach is an important corner stone in the building of global oral health. We wish to thank all those who have contributed through their research to making the world a healthier and happier place.

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