Atraumatic Restorative Treatment for Tooth Decay

A Global Initiative 1998 - 2000

How to organize and run an ART training course

WHO Collaborating Centre
for Oral Health Care Planning
and Future Scenarios
College of Dental Science
University Medical Centre, Nijmegen

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Material prepared by:

Dr. Jo. E. Frencken
Project Manager, WHO Global Program on ART,
Dental College of Science
University of Nijmegen
The Netherlands

Dr. Christopher Holmgren
WHO Temporary Advisor
Faculty of Dentistry
The University of Hong Kong
Hong Kong

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WHO Collaborating Centre for Oral Health Care Planning
and Future Scenarios,
College of Dental Science,
University Medical Centre,
P.O. Box 9101,
6500 HB Nijmegen,
The Netherlands

Tel: + 31-24-361.4050
Fax:: + 31-24-354.0265

f.mikx@dent.kun.nl
j.frencken@dent.kun.nl
c.holmgren@club-internet.fr

How to organize and run an ART training course

Introduction

The ART approach to the management of caries has been validated in studies from a number of countries around the world. A common finding however is that the treatment outcomes from inexperienced or inadequately trained operators are poorer than for those who have received proper training in the ART approach. This shows that ART training courses are required for operators to achieve optimal treatment outcomes using this approach.

This package of educational material has been prepared to facilitate the task of organizers and trainers involved in giving ART courses. The content and format is based on experience gained from previous ART courses given in more than 30 countries. It is understood that the content and format of the training package might not be totally applicable to all situations. There are naturally many factors that might require some modification to the basic course as described here including:

- Background of trainers and trainees – experience, knowledge, etc.
- Educational facilities available
- Ratio of trainee to trainer

However, the material contained herein forms the basic knowledge that is considered to be necessary for trainees to achieve consistent and reliable outcomes from the application of the ART approach. Subject to preexisting factors, the course can be modified accordingly. It is however recommended that the key elements of the course outline in this package are followed.

Educational objectives for ART training courses

At the end of an ART training course the trainee should

- have a basic understanding of the caries process in the context of its management through minimal intervention approaches
- understand the reasons for the selection and use of specific adhesive materials for minimal intervention approaches
- understand the rationale for ART
- be capable of preparing cavities for ART restorations and be able to place and finish appropriate adhesive materials
- know how to maintain ART instruments
- know how to manage failures of ART restorations when they occur
- understand the applications of the ART approach within a comprehensive package of oral health care and know its limitations

Structure for a basic ART training course

The ART training course is divided into a number of modules some being didactic with others being practical and clinical in nature. The sequence of the course has been so arranged that knowledge gained from one module forms the basis for subsequent modules. For this reason, failure to follow the assigned sequence might compromise the educational outcome.

The first six modules are didactic in nature and comprise:

Module 1 – Dentine caries, its progression and how best to stop it
Module 2 – Adhesive restorative materials for minimal cavity preparations
Module 3 – Equipment and materials required for the ART approach
Module 4 – Selection of cases for ART and a step-by-step guide to the ART approach
Module 5 – Survival of ART restorations and sealants placed as part of the ART approach
Module 6 – Failed ART restorations, their cause and management

The following modules are practical in nature and comprise:

Module 7 – Practical experience in the handling and mixing of adhesive materials for the ART approach e.g. hand-mix glass ionomer
Module 8 – Demonstration and practice of cavity cleaning and restoration placement using the ART approach on extracted teeth
Module 9- Demonstration and practice of isolation, cavity cleaning and restoration placement using the ART approach on patients

The final two modules are free format discussion sessions:

Module 10- ART within the context of a comprehensive package of oral health care
Module 11- Course evaluation

The training materials provided in this package comprise:

These instructions on how to organize and run an ART training course.
Instructional text and diagram sheets that can be made into overhead transparencies locally.
Slide transparencies relevant to the didactic component of the course i.e. Modules 1 to 6.
A teaching guide for modules which rely solely on slide transparencies i.e. Modules 3 and 4.
Post-training course questionnaires for both the trainers and the trainees

Additional training material recommended
J.E. Frencken and C.J. Holmgren: *Atraumatic Restorative Treatment (ART) for dental caries*. This book is available from STI Book b.v., P.O. Box 1191, 6501 BD Nijmegen, the Netherlands; fax: + 31-24-361.4097 or email: info@stibook.nl

General course preparation
In spite of the availability of this training package, ART training courses still need considerable preparation to be successful. DO NOT UNDERESTIMATE THE TIME REQUIRED FOR PREPARATION.

After agreement has been made to conduct an ART training course in a particular location, a tentative timetable with deadlines should be made. This prevents last minute panic situations that might compromise the success of the training course.

Number of trainees
The numbers of trainers, the facilities available and the experience of trainees limit the number of trainees. Practical and clinical demonstrations with more than 8-10 trainees per trainer have proven to be unmanageable. This is because it is often difficult for large numbers of trainees to observe clearly what the trainer is demonstrating. Secondly, during the practical and clinical sessions close supervision and guidance can only be given if the number of trainees is limited.

Pre-course preparation

1. *Participant information*. Obtain a list of participants with details of their relevant background if possible;
2. *Timetable*. Prepare a timetable which allows sufficient time for question and answer sessions and breaks between course modules;
3. *Training areas*. Select suitable areas to conduct didactic and practical components of the course;
4. *Training materials*. Assemble all teaching materials required including those used by the trainer and those to be distributed to the trainees. See checklist of materials required Appendix *;
5. *Patients*. An adequate number of suitable patients should be selected for the clinical component of the course. It is useful if more patients than trainees are selected to compensate for no-shows on the day of the course.
6. *Audiovisual aids*. Ensure that all overhead projectors and slide projectors work efficiently. It is wise to have spare bulbs available for the projectors.
7. *Support staff briefing*. Ensure that any support staff are adequately briefed as to the content of the course, the timetable and their personal responsibilities. A pre-course briefing meeting is usually very helpful, as is a meeting at the end of each day for multi-day training courses.

Example of a timetable

The following is an of a timetable for a 5-days training course. Modifications to its sequence are possible according to local circumstances. For example, part of module 3 (practical) could follow module 1 (theory) in order to interrupt the lecture series (2, 3, and 4). It may be advisable to include a test.

Day 1
1. Opening ceremony, etc.

2. Review of the oral health situation in the country with special emphasis on dental caries

3. Dentine caries, its progression and how best to stop it (module 1)

Afternoon

d. Adhesive restorative materials for minimal cavity preparations (module 2)

e. Practical experience in the handling and mixing of adhesive materials for the ART approach e.g. hand-mix glass-ionomer (module 7)

Day 2

e. Equipment and materials required for the ART approach (module 3)

f. Selection of cases for ART and a step-by-step guide to the ART approach (module 4)

Afternoon

- Demonstration and practice of cavity cleaning and restoration placement using the ART approach on extracted teeth (module 8)

(Test before clinical application??)

Day 3

- Demonstration and practice of isolation, cavity cleaning and restoration placement using the ART approach on patients (module 9). This demonstration is done by the course leader.

- Practice of isolation, cavity cleaning and restoration placement using the ART approach on patients (participants)

Afternoon

Free

Day 4

- Practice of isolation, cavity cleaning and restoration placement with the trainees using the ART approach on patients

- General discussion of subjects covered during the morning following the sequence of performing ART restorations, starting with access to dentine lesions, isolation of the operating area, etc. (round-table discussion, module 9)

Afternoon

1. Survival of ART restorations and sealants placed as part of the ART approach (Module 5)
2. Failed ART restorations, their cause and management (module 6)

Day 5

1. Practice of isolation, cavity cleaning and restoration placement using the ART approach on patients (participants)

2. General discussion of subjects covered during the morning following the sequence of performing ART restorations, starting with access to dentine lesions, isolation of the operating area etc (round table discussion, module 9)

Afternoon

1. ART within the context of a comprehensive package of oral health care

2. Evaluation of course

3. Presentation of certificates

4. Close of training course.

Post-training course questionnaires

All ART training courses should be subject to some form of evaluation. This is most easily and conveniently achieved through the use of standard forms as post-training course questionnaires. A questionnaire has been prepared for trainers to complete to give feedback on the suitability of this ART training package. A second questionnaire to be completed by the trainees is used to provide valuable feedback to the trainer about his/her performance but can also help in the improvement of the basic training package for subsequent courses. The two post-training course questionnaires consisting of a set of basic questions is given in Appendices I and II. Additional questions can be added according to specific or local needs.

Note: A copy of the appendices must be sent to WHO/ORH, Geneva and WHO Collaborating Centre, attn Dr. J. Frencken, P.O. Box 9101, 6500 HB Nijmegen, the Netherlands, so that training course outcomes can be monitored and the training package improved where necessary.

Appendix I

ART Training Course

Post-training course questionnaire for participants

Introduction

The purpose of this questionnaire is to seek your views on certain aspects of the ART training course that you have just attended. The findings from the questionnaire will be used to monitor the quality of ART training course and make improvements where necessary. The questionnaire is entirely anonymous so please feel to state your true feelings on the course.

Educational objectives

Q1. To what extent did the ART training course achieve the following objectives?
(Please place a tick in the box with the most appropriate response)

Objectives	Very well	Well	Satis-factory	Poorly
Provide a basic understanding of the carious process in the context of its management through the ART approach				
Provide a basic understanding of the reasons for the selection and use of specific adhesive materials for the ART approach				
Provide an understanding of the rationale for the ART approach				
Provide the basic competencies required to prepare cavities for ART restorations				
Provide the basic competencies required to place and finish appropriate restorative materials for ART				
Provide the basic competencies required to maintain ART instruments				
Provide the basic competencies required to manage failures of ART restorations when they occur				
Provide a basic understanding of the applications of the ART approach				
Provide a basic understanding of the role of the ART approach within a comprehensive oral health care package				
Provide a basic understanding of the limitations of the ART approach				

Course content

Q2. To what extent did you find the separate modules of the ART training course useful?
(Please place a tick in the box with the most appropriate response)

Modules	Very useful	Useful	Fairly useful	Not useful
Module 1 – Dentine caries, its progression and how best to stop it.				
Module 2 – Adhesive restorative materials for minimal cavity preparations				
Module 3 – Equipment and materials required for the ART approach				
Module 4 – Selection of cases for ART and a step-by-step guide to the ART approach				
Module 5 – Survival of ART restorations and sealants placed as part of the ART approach				
Module 6 – Failed ART restorations, their cause and management				
Module 7 – Practical experience in the handling and mixing of adhesive materials for the ART approach e.g. hand-mix glass-ionomer				
Module 8 – Demonstration and practice of cavity cleaning and restoration placement using the ART approach on extracted teeth				
Module 9 – Demonstration and practice of isolation, cavity cleaning and restoration placement using the ART approach on patients				
Module 10 – ART within the context of a comprehensive package of oral health care				

Course sequence

Q3. Do you think the sequence of training modules could be improved upon?

Yes / No *(Please circle one option)*

If yes, then please indicate what you would consider an ideal sequence

Sequence	1 start	2	3	4	5	6	7	8	9	10 end
Module Number										

Course duration

Q4. To what extent did you find the time used for each of the separate modules of the ART training course appropriate?
(Please place a tick in the box with the most appropriate response)

Modules	**Too long**	**Just long enough**	**Too short**
Overall length of the ART training course			
Module 1 – Dentine caries, its progression and how best to stop it			
Module 2 – Adhesive restorative materials for minimal cavity preparations			
Module 3 – Equipment and materials required for the ART approach			
Module 4 – Selection of cases for ART and a step-by-step guide to the ART approach			
Module 5 – Survival of ART restorations and sealants placed as part of the ART approach			
Module 6 – Failed ART restorations, their cause and management			
Module 7 – Practical experience in the handling and mixing of adhesive materials for the ART approach e.g. hand-mix glass-ionomer			
Module 8 – Demonstration and practice of cavity cleaning and restoration placement using the ART approach on extracted teeth			
Module 9 – Demonstration and practice of isolation, cavity cleaning and restoration placement using the ART approach on patients			
Module 10 – ART within the context of a comprehensive package of oral health care			

Q5. Please give your comments on how you feel the time used on the ART training course could be better used.

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Teaching and teaching aids

Depending on the format of the course, the trainer will have used a variety of teaching aids.

Q6. Please comment on the quality of the teaching and teaching aids used during the course.
(Please place a tick in the box with the most appropriate response)

Teaching aids	Very good	Good	Satis-factory	Poor
Documentation distributed to trainees				
Overhead transparencies				
Slide transparencies				
Extracted teeth for hands-on practice				
Patients for hands-on practice				
Teacher's competence				
Teacher's methods of presentation				
Teacher's willingness to help trainees				

Q7. Please give your comments on how the teaching and teaching aids could be improved.

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Q8. What do you consider to be the <u>most</u> useful components of the ARTtraining course?

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Q9. What do you consider to be the <u>least</u> useful components of the ART training course?

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Q10. Please give your comments on how you feel the ART training course was organized.

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Q11. Please give your comments on how you feel the ART training course could be improved.

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General questions relating to ART

(circle one option)

1. **Had you heard of ART before attending this course?** **Yes / No**
2. **If "Yes" to Q1, from where did you first hear about ART?** ***(Specify)***

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3. **Do you think ART would be useful in your country?** **Yes / No**
4. **If "No" to Q3, why not?** ***(Specify)***

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5. **Do you think ART would be useful in your clinic?** **Yes / No**
6. **If "No" to Q5, why not?** ***(Specify)***

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7. **What materials do you have available in your country that you can use for ART?** ***(Specify)***

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8. **What materials do you have available in your clinic that you can use for ART?** ***(Specify)***

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9. **What do you consider to be the greatest difficulty in adopting ART in your clinic?** ***(Specify)***

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<<<THANK YOU FOR YOUR COOPERATION >>>

APPENDIX II

ART Training Course

Post-training course questionnaire for trainers

Introduction

The purpose of this questionnaire is to seek your views on certain aspects of the ART training course that you have just given. The findings from the questionnaire will be used to monitor the quality of ART training course and make improvements where necessary. This will only be possible if you state your true feelings on the course.

Course statistics

Country_____ Location_____

Dates of course_____

Q1. How many trainees were there on your ART training course according to educational/training level?

Educational/training level	Number
Post-graduate dentist	
Dentist	
Undergraduate dentist	
Dental ancillary 1 (specify)	
Dental ancillary 1 (specify)	
Other (specify)	
Total number of trainees	

Q2. How many trainers were involved with the ART training course?

(Specify) _____

Q3. What would you consider to be the ideal trainer/trainee ration for an ART training course?

(Specify) _____*trainees per trainer*

Educational objectives

Q4. To what extent do you think the ART training course modules helped you achieve the following educational objectives?

(Please place a tick in the box with the most appropriate response)

Objectives	Very well	Well	Satis-factory	Poorly
Provide a basic understanding of the carious process in the context of its management through the ART approach				
Provide a basic understanding of the reasons for the selection and use of specific adhesive materials for the ART approach				
Provide an understanding of the rationale for the ART approach				
Provide the basic competencies required to prepare cavities for ART restorations				
Provide the basic competencies required to place and finish appropriate restorative materials for ART				
Provide the basic competencies required to maintain ART instruments				
Provide the basic competencies required to manage failures of ART restorations when they occur				
Provide a basic understanding of the applications of the ART approach				
Provide a basic understanding of the role of the ART approach within a comprehensive oral health care package				
Provide a basic understanding of the limitations of the ART approach				

Course content

Q5. To what extent did you find the amount of material covered in each of the ART training course modules sufficient?

(Please place a tick in the box with the most appropriate response)

Modules	**Too much**	**Just enough**	**Too little**
Module 1 – Dentine caries, its progression and how best to stop it.			
Module 2 – Adhesive restorative materials for minimal cavity preparations			
Module 3 – Equipment and materials required for the ART approach			
Module 4 – Selection of cases for ART and a step-by-step guide to the ART approach			
Module 5 – Survival of ART restorations and sealants placed as part of the ART approach			
Module 6 – Failed ART restorations, their cause and management			
Module 7 – Practical experience in the handling and mixing of adhesive materials for the ART approach e.g. hand-mix glass-ionomer			
Module 8 – Demonstration and practice of cavity cleaning and restoration placement using the ART approach on extracted teeth			
Module 9 – Demonstration and practice of isolation, cavity cleaning and restoration placement using the ART approach on patients			
Module 10 – ART within the context of a comprehensive package of oral health care			

Q6. Did you omit any components of the ART training course modules?

Yes / No *(Please circle one option)*

If yes, then please indicate what you omitted and the reasons for doing so.

Module number and section (page number)	Reason for omission (specify

Q7. Did you add any components of the ART training course modules?

Yes / No *(Please circle one option)*

If yes, then please indicate what you added and the reasons for doing so.

Subject material added (specify)	Reason for addition (specify)

Course sequence

Q8. What was the sequence you used for the training modules and/or other activities?
(Please list the module numbers according to sequence you used)

Sequence	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Module Number or other activity *(specify)*													

Q9. Do you think the sequence you used was optimal or could it be improved upon?

Yes / No *(Please circle one option)*

If yes, then please indicate what you would consider an ideal sequence

Sequence	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Module Number or other activity *(specify)*													

Course duration

The length of each ART training course may vary due to many factors such as the type of personnel being trained and local constraints. The following questions are designed to determine the ideal length of an ART course according to different circumstances.

Q10. To what extent did you find the time used for each of the separate modules of the ART training course appropriate?

(Please 1. indicate the time spent on each module
2. a tick in the appropriate box concerning the adequacy of time)

Modules	**Time spent (minutes)**	**Too long**	**Just long enough**	**Too short**
Overall length of the ART training course				
Module 1 – Dentine caries, its progression and how best to stop it				
Module 2 – Adhesive restorative materials for minimal cavity preparations				
Module 3 – Equipment and materials required for the ART approach				
Module 4 – Selection of cases for ART and a step-by-step guide to the ART approach				
Module 5 – Survival of ART restorations and sealants placed as part of the ART approach				
Module 6 – Failed ART restorations, their cause and management				
Module 7 – Practical experience in the handling and mixing of adhesive materials for the ART approach e.g. hand-mix glass-ionomer				
Module 8 – Demonstration and practice of cavity cleaning and restoration placement using the ART approach on extracted teeth				
Module 9 – Demonstration and practice of isolation, cavity cleaning and restoration placement using the ART approach on patients				
Module 10 – ART within the context of a comprehensive package of oral health care				
Other activity 1 (specify)				
Other activity 2 (specify)				
Other activity 3 (specify)				

Q11. Please give your comments on how you feel the time used on the ART training course could be better used.

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Teaching and teaching aids

Q12. Please comment on the quality of the teaching aids provided for the course.
(Please place a tick in the box with the most appropriate response)

Teaching aids	Very good	Good	Satis-factory	Poor
Guidance on how to organize and run an ART training course				
Documentation distributed to trainers				
Overhead transparencies				
Slide transparencies				
Questionnaires for participants				

Q13. Please give your comments on how the teaching aids could be improved.

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Q14. What do you consider to be the most useful components of the ART training course?

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Q15. What do you consider to be the least useful components of the ART training course?

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Q16. Please give your comments on how you could have better organized the ART training course was organized.

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Q17. Please give your comments on how you feel the ART training course could be improved.

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<<<THANK YOU FOR YOUR COOPERATION >>>

Acknowledgements

The authors would like to thank those that have assisted in the production of the teaching modules. These include Heleen Brulot and Harry Hoogenboom (the Netherlands) who contributed the drawings and Anja Prischman (the Netherlands) who took many of the photographes.

During the construction of the teaching modules the authors consulted experts who gave freely of their time and advice. We would like to express our sincere gratitude to Dr. Evert van Amerongen (University of Amsterdam, the Netherlands), Prof Prathip Phantumvanit (Thammasat University, Thailand) and Prof Martin Tyas (University of Melbourne, Australia).

P

Trainers guide for ART training courses

Module 1 - Dentine caries, its progression and how best to stop it

This module comprises a series of overhead transparencies, numbered 1-41. The module describes the progression of dental caries and discusses which tooth tissues need to be removed to halt the carious process and which should be retained to maximally conserve tooth tissue. The efficacy of the traditional approach in treating dentinal lesions is shown and the results are related to the concept of modern approaches. The importance of the appropriate instrumentation in this matter is highlighted.

Time requirement for this module

1 hour

General introductory statements to the module:

Essential reading for the trainer is Chapter 1 in the book by J.E. Frencken and C.J. Holmgren entitled: *Atraumatic Restorative Treatment (ART) for dental caries*. It provides the necessary background information needed to teach this module. Additional literature is provided in the references chapter.

ART COURSE

DENTINE CARIES

ITS PROGRESSION AND

HOW BEST TO STOP IT

Caries is a dynamic process (remineralization - demineralization) and has been defined in many ways. Ultimately, it can be considered to be:

' a bacterial process that results in gradual loss of the minerals that make up the tooth structures'

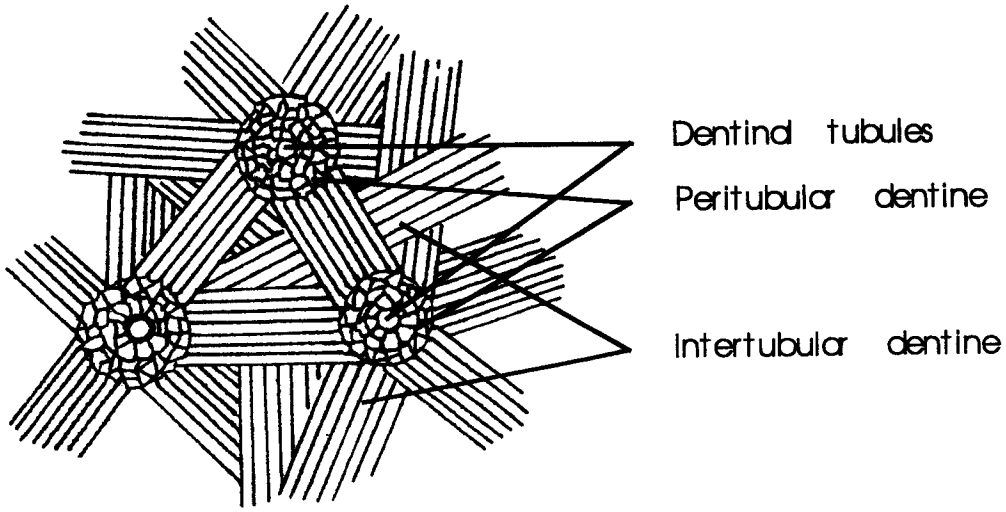
This applies to both enamel and dentine caries.

STRUCTURE OF DENTINE

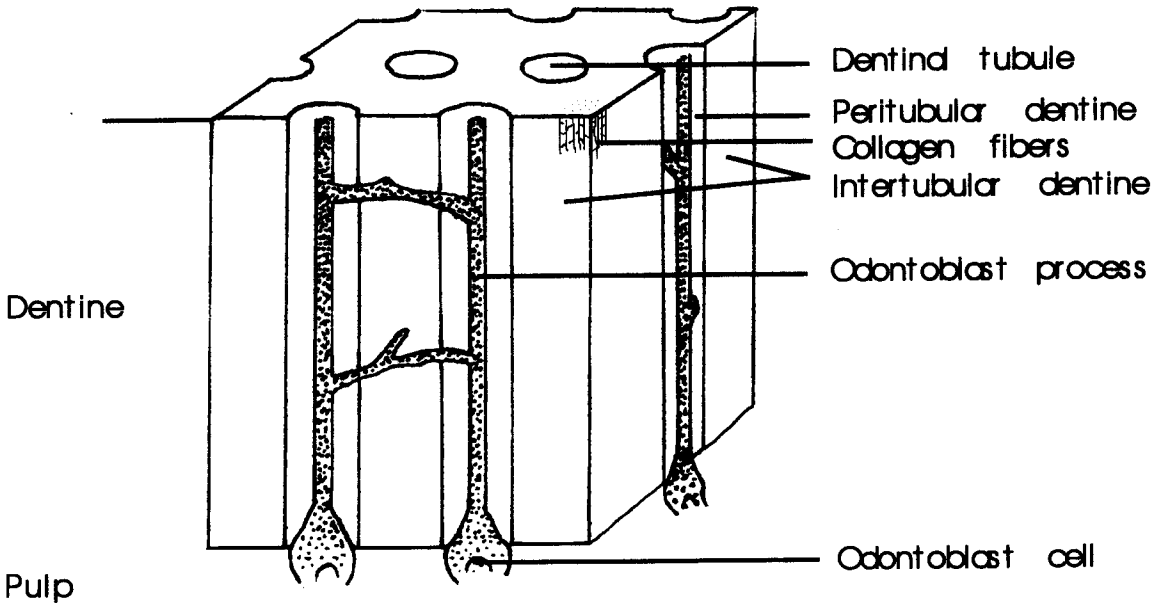
Important points to note:

- Dentine tubules are surrounded by peritubular dentine.
- Intertubular dentine connects peritubular dentine.
- Apatite crystals are embedded in a dentine matrix that contains collagen fibres.
- These collagen fibres are connected to each other through intermolecular cross-linking.

Cross-section through the dentine matrix



Dentine structure

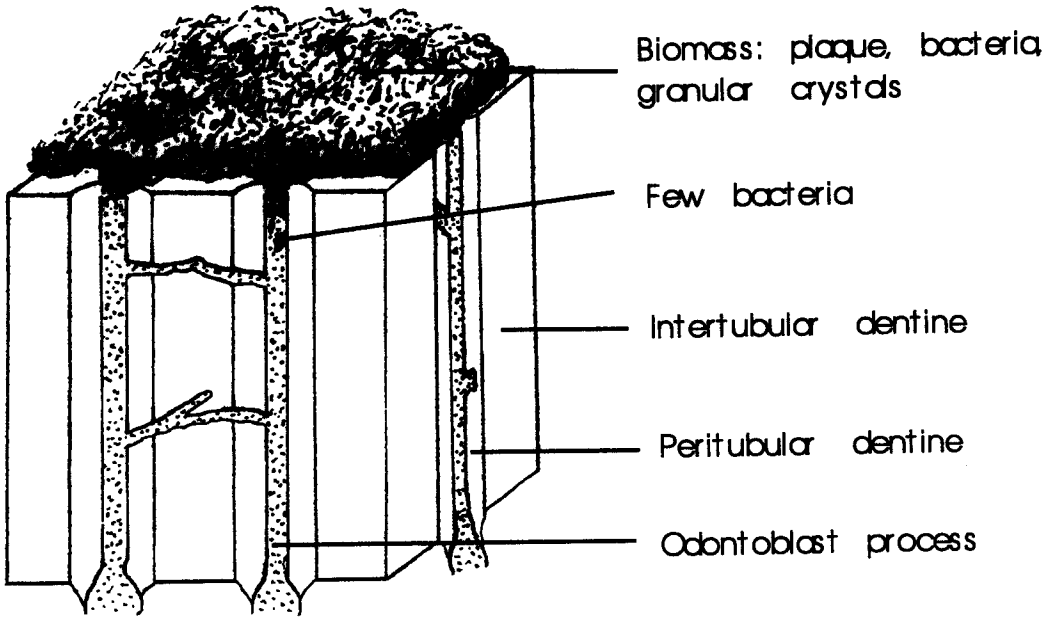


PROGRESSION OF DENTINE CARIES

BACTERIAL INVASION

- Bacteria need to have a source of nutrients, i.e. from the oral environment.
- Bacteria are found mostly in the biomass with few being found in the dentine tubules.

Biomass and dentine

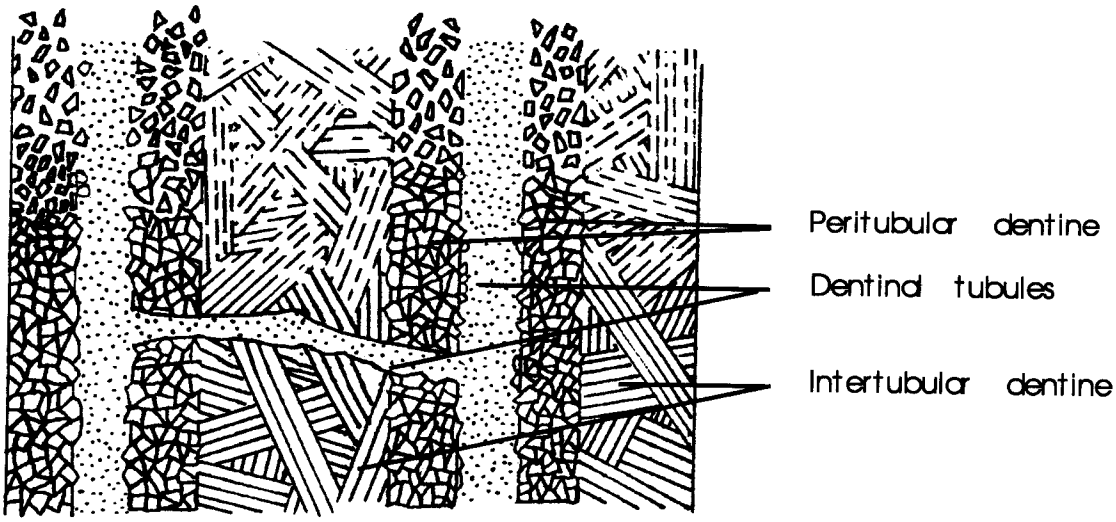


CRYSTAL REMOVAL PROCESS

This follows a sequence:

- Acid from fermentation process penetrates the dentine tubules ahead of bacterial invasion.
- This softens the dentine matrix.
- The collagen fibres are reversibly damaged in the dissolution process.
- Continuation of acid production dissolves crystals in the peritubular and intertubular dentine.
- Further continuation of acid production breaks the intermolecular crosslinks of collagen fibres irreversibly.

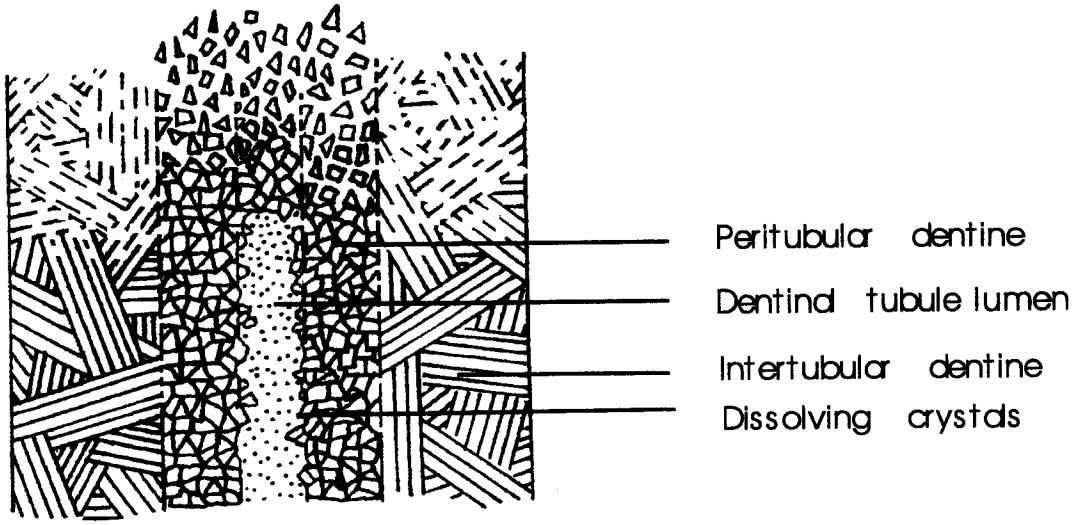
Loose dissolving crystals at top of dentine



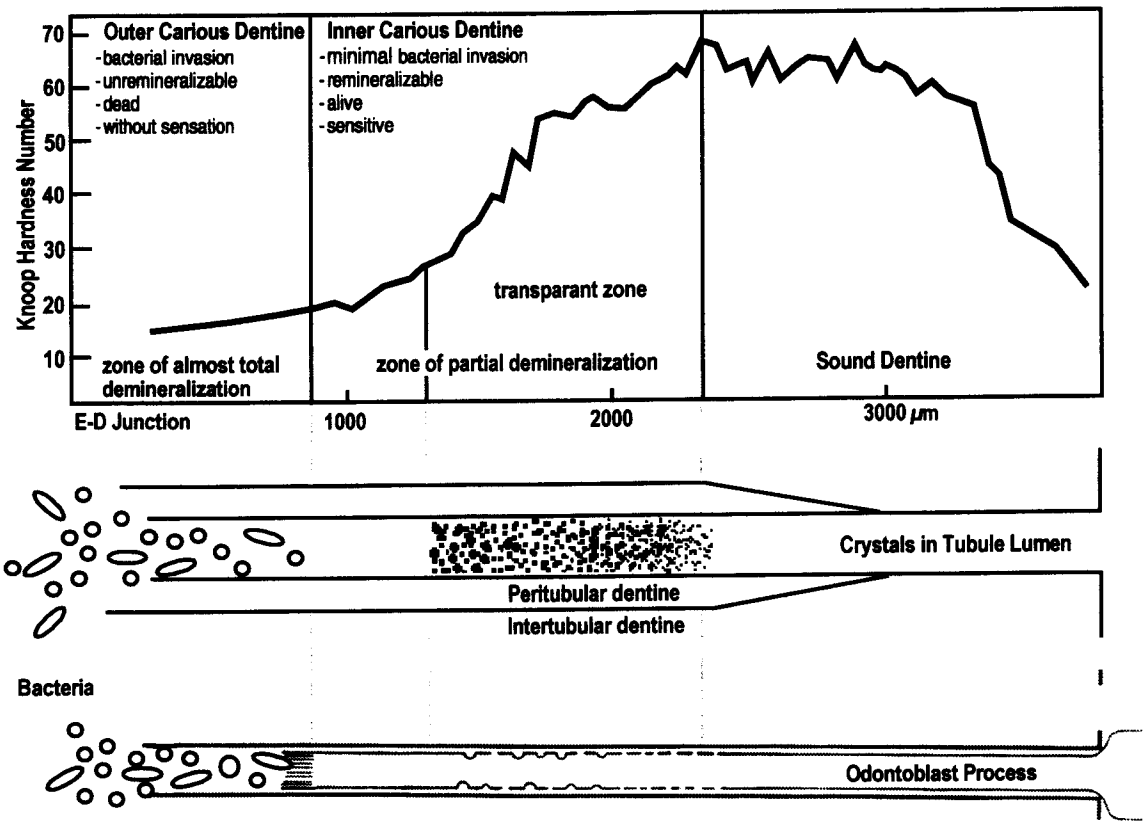
DEFENCE REACTION IN DENTINE

- A defence reaction takes place in the dentine.
- Dissolution alters the hydroxyapatite crystals.
- Crystals with a lower hardness and a lower calcium density (= whitelockite) remain.
- The dentine tubules are blocked by precipitated intratubular whitelockite crystals.
- These crystals originate from the peritubular and intertubular dentine.
- This process is known as **TUBULAR SCLEROSIS.**
- It is seen clinically as yellow-brownish discoloration of the dentine.

Precipitated crystals block entrance to tubular lumen



A cross-section of a carious lesion in dentine in relation to mineral content



(Modified from Fusayama T, A simple pain-free adhesive restorative system by minimal reduction and total etching 1993. Published with permission from the author)

TWO LAYERS OF CARIOUS DENTINE

Outer ***('infected')***	**Inner** ***('affected')***
• Bacterial invasion	Minimal bacterial invasion
• Unremineralizable	Remineralizable
• Dead	Alive
• Without sensation	Sensitive

(From: Fusayama T, Int Dent J 1997)

Remineralization of Inner Carious Dentine

Two prerequisites are needed for *physiological remineralization*:

1. Presence of collagen fibres with an intact structure - for reattachment of crystals.
2. Presence of living odontoblastic process - for supply of calcium phosphate from the vital pulp.

Both situations occur in the inner carious dentine.

External sources for remineralization

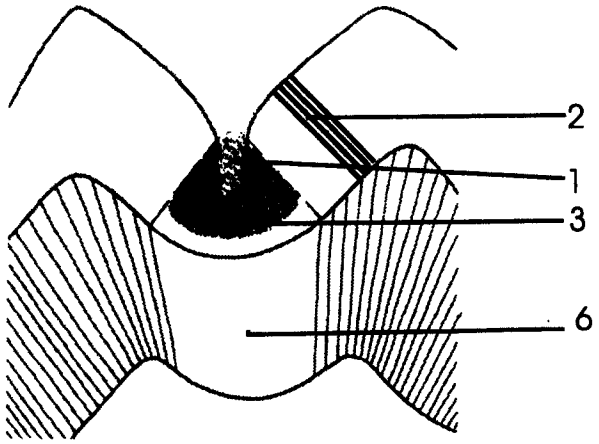
1. Exposure to saliva
2. Exposure to bioactive agents

(From: Fusayama T, Int Dent J 1997)

CHARACTERISTICS OF OCCLUSAL CARIES - 1

Progressive stages of dentine lesion formation in an occlusal fossa

A. Reaction in enamel to caries-stimulating factors in plaque

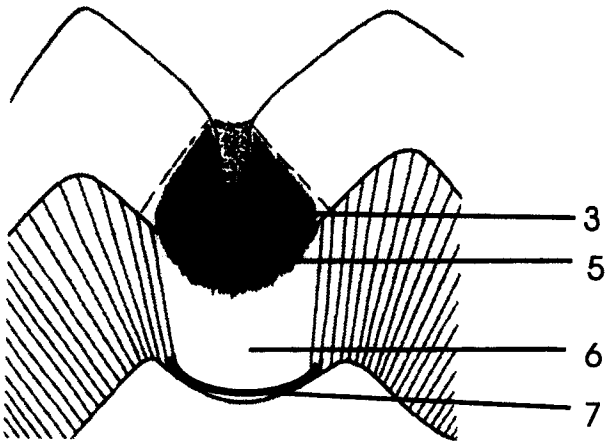


1: Dental plaque; 2: Enamel rod direction; 3: Demineralized enamel;
6: Transparent zone in dentine

(Modified from Thylstrup A and Fejerskov O (eds.). Textbook of Clinical Cariology, 1996. Reprinted with permission from Munksgaard)

CHARACTERISTICS OF OCCLUSAL CARIES - 2

B. Further demineralization follow the enamel rods creating a reaction in the dentine directly underneath these lesions.

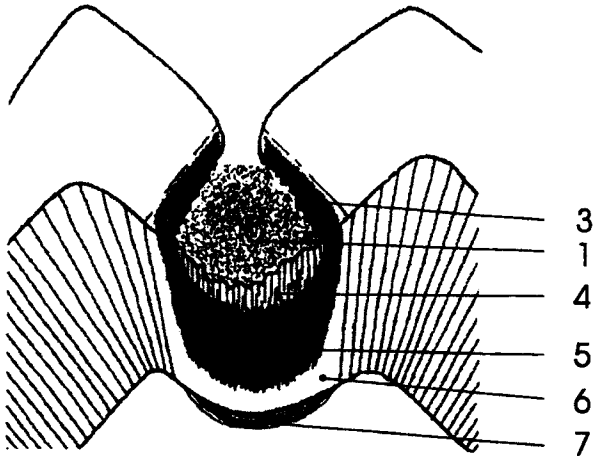


3: Demineralized enamel; 5: Zone of partial demineralization in dentine;
6: Transparent zone in dentine; 7: Reactive or reparative dentine

(Modified from Thylstrup A and Fejerskov O (eds.). Textbook of Clinical Cariology, 1996. Reprinted with permission from Munksgaard)

CHARACTERISTICS OF OCCLUSAL CARIES- 3

C. After caries has reached the EDJ, it first follows the direction of the dentine tubules.

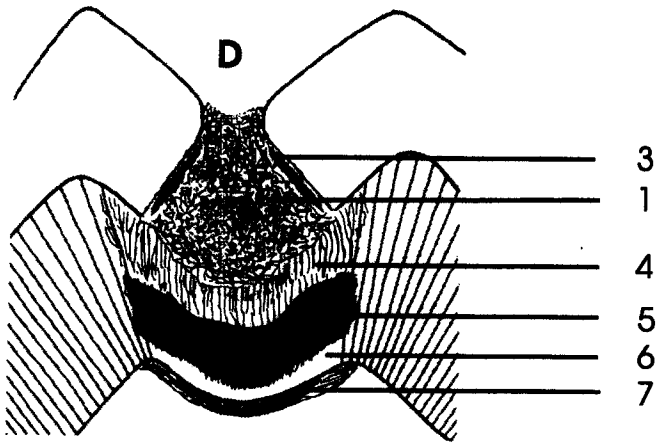


1: Dental plaque; 3: Demineralized enamel; 4: Zone of bacterial invasion and complete demineralization (destruction) in dentine; 5: Zone of partial demineralization in dentine; 6: Transparent zone in dentine; 7: Reactive or reparative dentine

(Modified from Thylstrup A and Fejerskov O (eds.). Textbook of Clinical Cariology, 1996. Reprinted with permission from Munksgaard)

CHARACTERISTICS OF OCCLUSAL CARIES- 4

D. Lateral spread of dentine caries occurs mainly in cavitated lesions



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Summary of stages of dentine lesion formation and progression in an occlusal fossa

- Reaction in enamel to caries - stimulating factors in plaque.
- Enamel demineralization follows the rods.
- Initial dentine demineralization does not spread along the Enamel Dentine Junction (EDJ) beyond the periphery of the lesion in the enamel.
- This leads to a cone shape lesion with the base at the EDJ.
- In any pit and fissure system there can be multiple lesions in different stages of progression.

(Stages A, B and C.)

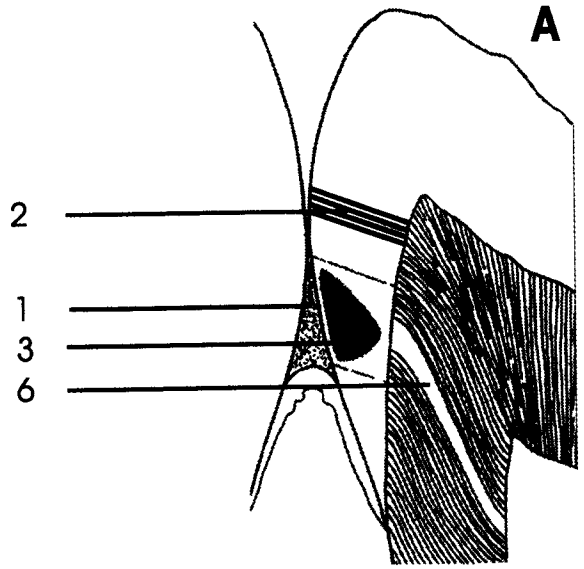
- Only when there is frank cavitation and a cariogenic environment, will dentine demineralization spread in a lateral direction.

(Stage D)

CHARACTERISTICS OF APPROXIMAL CARIES - 1

Progressive stages of dentine lesion formation in an approximal surface

A. Reaction in enamel to caries-stimulating factors in plaque

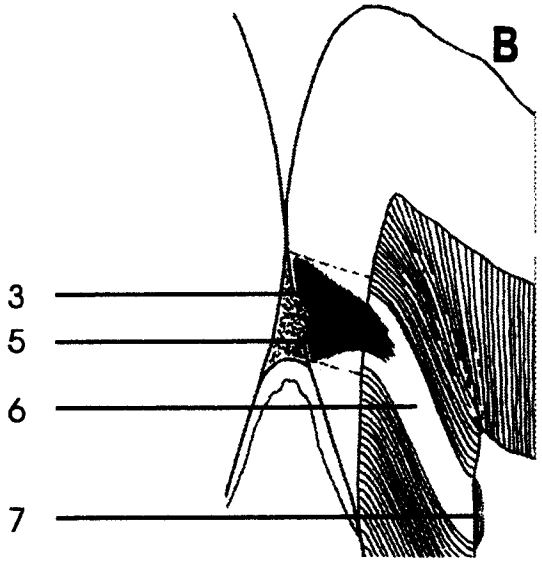


1: Dental Plaque; 2: Enamel rod direction; 3: Demineralized enamel;
4: Transparent zone in dentine.

(Modified from Thylstrup A and Fejerskov O (eds.). Textbook of Clinical Cariology, 1996. Reprinted with permission from Munksgaard)

CHARACTERISTICS OF APPROXIMAL CARIES - 2

B. Further demineralization follow the enamel rods creating a reaction in the dentine directly underneath these lesions.



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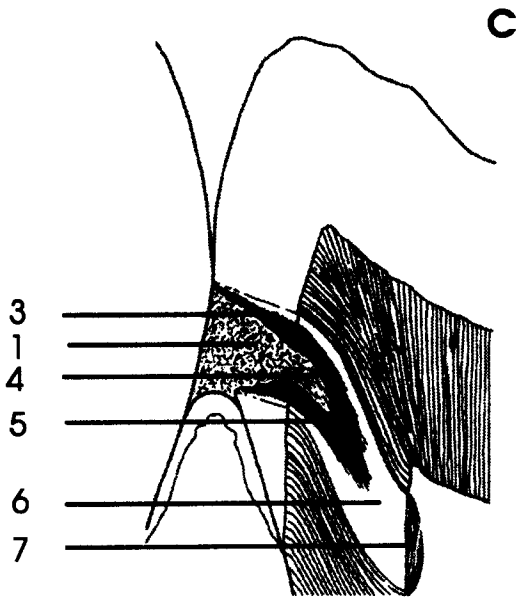

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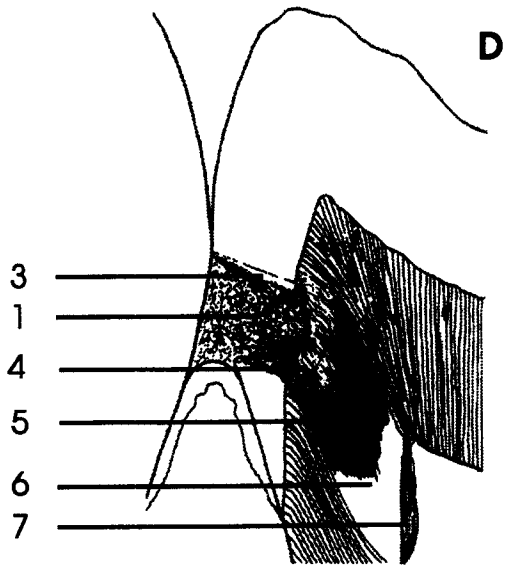

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Summary of characteristics of progression of approximal caries

- Progression of approximal caries follows the same principles as for occlusal caries.

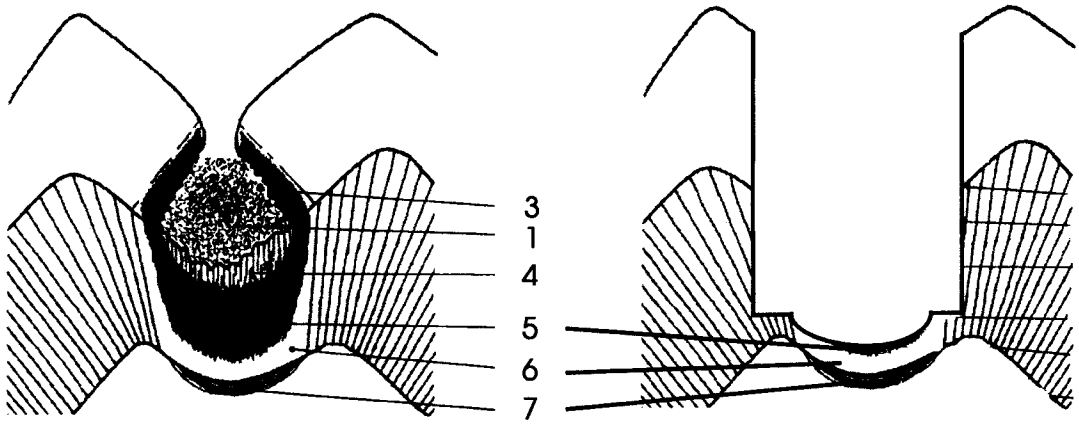
- It follows the enamel rods, but because of the curved shape of the approximal tooth surface, the lesion does not lead to a cone shape at the EDJ as present in an occlusal fossa.

TRADITIONAL CONCEPTS OF CAVITY DESIGN

- GV Black's cavity preparations followed designs that were largely dictated by the physical properties of the filling materials used at that time, e.g., amalgam and silicate cement.

- These materials needed mechanical retention, hence cavity preparations had:
  - flat floors
  - vertical walls
  - triangular retention niches
  - undercut areas.

Cavity preparation for the treatment of occlusal caries with amalgam



Dentinal lesion in an occlusal surface

Mechanical cavity preparation for treatment of occlusal caries with amalgam

1: Dental plaque; 3: Demineralized enamel; 4: Zone of bacterial invasion and complete demineralization (destruction) in dentine; 5: Zone of partial demineralization in dentine; 6: Transparent zone in dentine; 7: Reactive or reparative dentine.

⇒ ***Is this the way a dentine lesion progresses?***

⇒ ***Is the shape of the prepared cavity limited to the tooth destruction caused by caries?***

HOW MUCH SOUND TOOTH TISSUE IS REMOVED ?

Longevity of amalgam restorations in general dental practice

Mean survival time of amalgam restorations placed in general practice

	Average life of restoration in years	
	Mjör 1992*	Mjör et al, 1997**
Amalgam - Single surface - Multiple surfaces	 10 8	 8 6

* *Mjör IA. Problems and benefits associated with restorative materials: side-effects and long-term cost. Adv Dent Res 1992; 6: 7-16*

** *Mjör IA, Burke FJT. Wilson NHF. The relative cost of different restorations in the UK. Br Dent J 1997; 182: 286-89*

A review of survival studies showed:

- Amalgam and composite resin restorations survive on average between 6 and 10 years (*Downer et al., 1999*)

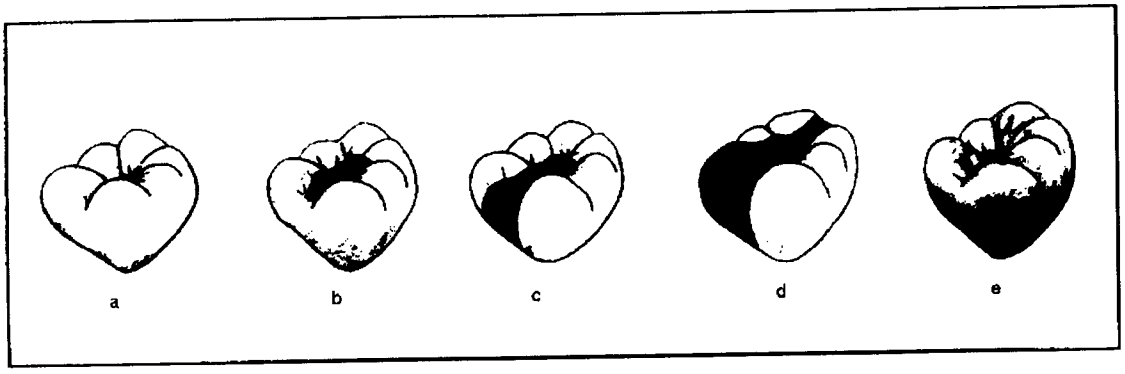
Reasons for failures

- secondary caries (predominantly)
- marginal breakdown

Thus, Black's principles could be considered as:

'the application of a mechanical design on a biological process'

Repeat restoration cycle for amalgam restorations - 1



a: occlusal lesion; b: occlusal restoration based on the principle of 'extension for prevention'; c: 2-surface restoration; d: extended restoration including a cusp; e: crown or f: extracted

a) Except with respect to overt carious lesions, caries 'diagnoses' are uncertain, with considerable variation occurring between dentists. Furthermore, in general, dentists have an urge to place restorations - to do something.

b) Extensive cavity preparations (Black) in the name of outline form and extension for prevention result in restorations with weak margins, leading to marginal breakdown and 'ditching'.

Repeat restoration cycle for amalgam restorations - 2

c. Dentists have an urge to replace restorations as if this were a panacea solution to overcome whatever 'problems' may exist. Reasons why restorations fail are not usually identified correctly.

The cavities increase in size because there is a perceived (but erroneous) requirement to 'freshen up' the cavity walls and margins.

d. The teeth inevitably become weaker, thereby reducing their prognosis.

e. The complexity of the restorations increases or

f. Tooth needs to be extracted.

(From: Elderton RJ. Principles of decision-making to achieve oral health. In: Professional Prevention in Dentistry, 1994. Reprinted with permission from the author)

OUTCOMES OF TRADITIONAL TREATMENT APPROACH

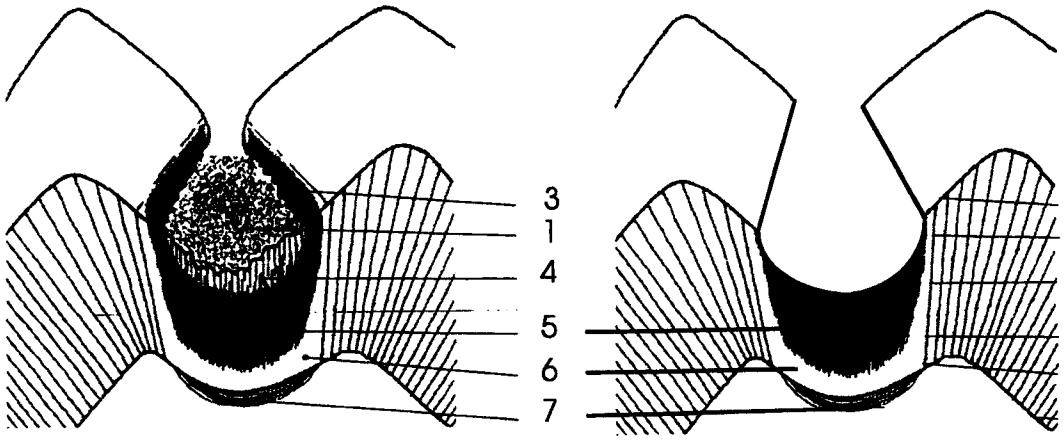
Summary:

- Much sound tooth tissue needs to be removed.
- Applied in the dental practice, the traditionally placed restorations, on average, do not last long.
- The replacement restorations are, in many cases, prepared using the same obsolete principles of cavity design and last for less time.
- The end result is a tooth that became weaker and weaker each time a replacement was made.
- The weaker the tooth becomes, the more likely the restoration will fail, resulting in a vicious cycle and termed the 'repeat restoration cycle'.

BIOLOGICAL PRINCIPLES OF CAVITY PREPARATION - 1

- This should be restricted to cavity cleaning.
- It only involves:
  - obtaining adequate access and
  - remove dead, non-remineralizable dentine and enamel.

Biological approach to cavity cleaning



Dentinal lesion in an occlusal surface

Biological cavity preparation

1: Dental plaque; 3: Demineralized enamel; 4: Zone of bacterial invasion and complete demineralization (destruction) in dentine; 5: Zone of partial demineralization in dentine; 6: Transparent zone in dentine; 7: Reactive or reparative dentine.

BIOLOGICAL PRINCIPLES OF CAVITY PREPARATION -2

Thus, the shape of the cavity is determined by

' the anatomy of the carious lesion as it presents at the time of cavity preparation '

Therefore, there is no preconceived cavity design.

Thus, Black's principles of cavity design are redundant.

WHAT KIND OF INSTRUMENTATION IS REQUIRED TO REMOVE DEMINERALIZED TOOTH TISSUES?

- GV Black initially used hand instruments but these did not provide sufficient retention for the filling materials in use at that time; the fillings fell out.
- Later Black proposed the use of a rotary handpiece. This was done because of the need to cut hard sound tooth tissue to produce a mechanically retentive shape.

Nowadays adhesive restorative filling materials exist.

- There is little or no need for mechanical retention as these filling materials bond to tooth tissues.

Most appropriate instrumentation - 2

This raises the question:

'If mechanical retention is no longer needed, is there a need to use a rotary instrument for removing soft, demineralized tooth tissues?'

In other words, can the soft, demineralized tissues be removed in a different way?

The answer is YES !

If the shape of the cavity is determined by the anatomy of the lesion surely, a rotary instrument is not the best instrument for:

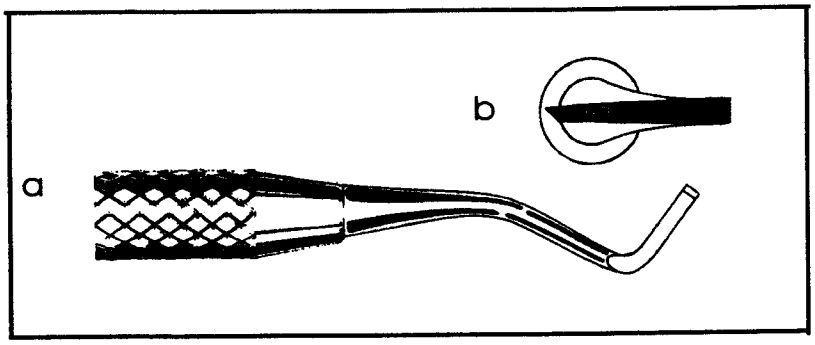
- removing only soft, completely demineralized tooth tissue and
- preserving as much remineralizable enamel and dentine as possible.

Most appropriate instrumentation -3

The best instruments for cleaning the cavity are:

1. Hand instruments,
    - *dental hatchet or similar instrument* to gain access and
    - *excavators* for the removal of dead tissues

Dental hatchet (e.g., 10-6-12)

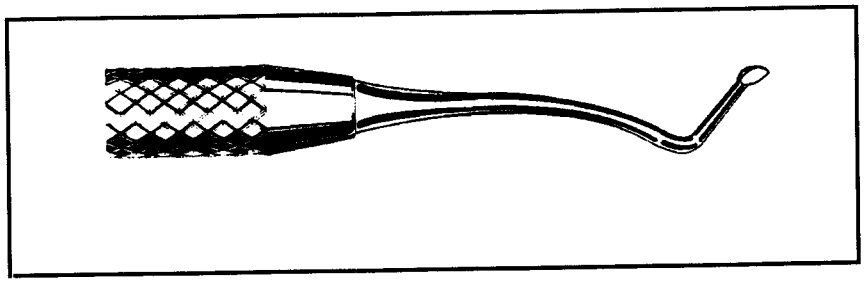


(a) Binangle dental hatchet. (b) End view of dental hatchet.

(Reprinted from 'Fundamentals of Operative Dentistry. A contemporary approach'. Schwartz RS et al, 1996, p 78, by permission of Quintessence Publishing Co, Inc.)

Most appropriate instrumentation -4

Excavator (e.g., 153-154 and 131-132)



Binangle discoid spoon excavator

(Reprinted from 'Fundamentals of Operative Dentistry. A contemporary approach'. Schwartz RS et al, 1996, p 79, by permission of Quintessence Publishing Co, Inc.)

Why hand instruments?

- creates the most ideal (conservative) cavity shape
- gives the operator improved tactile sense
- does not damage surfaces adjacent to the lesion, in the case of approximal lesions and
- therefore, does not promote caries development.

Most appropriate instrumentation - 4

2. Chemo-mechanical gel

Mechanism:

- to chemically disturb denaturated collagen in the partially demineralized dentine and remove the unsupported minerals by gently scraping.
- This approach is currently under investigation.

3. Rotary instruments

These might be considered under certain circumstances.

Slow speed drill

- *with straight bur* for further opening of dentinal lesions that have a very small entrance
- *with round bur* for gentle removal of dead tissue.

High speed drill

- only for opening cavities that are inaccessible
- removal of failed restorations.

WHY DOES THE CLEANED CAVITY NEED TO BE RESTORED?

- to stop the caries process
- to facilitate easy plaque removal
- to encourage remineralization of inner carious dentine
- to restore function
- to restore aesthetics.

HOW IS THIS BEST ACHIEVED?

Application of a material that:

- produces a seal against bacterial invasion
- encourages remineralization
- is sufficiently durable
- maintains function.

What material best offers this?

1. Adhesive restorative materials
   - composite resins and polyacid-modified composite resins ('compomers')
   - glass-ionomers and resin-modified glass-ionomers.

2. Non-adhesive restorative materials
   - amalgam

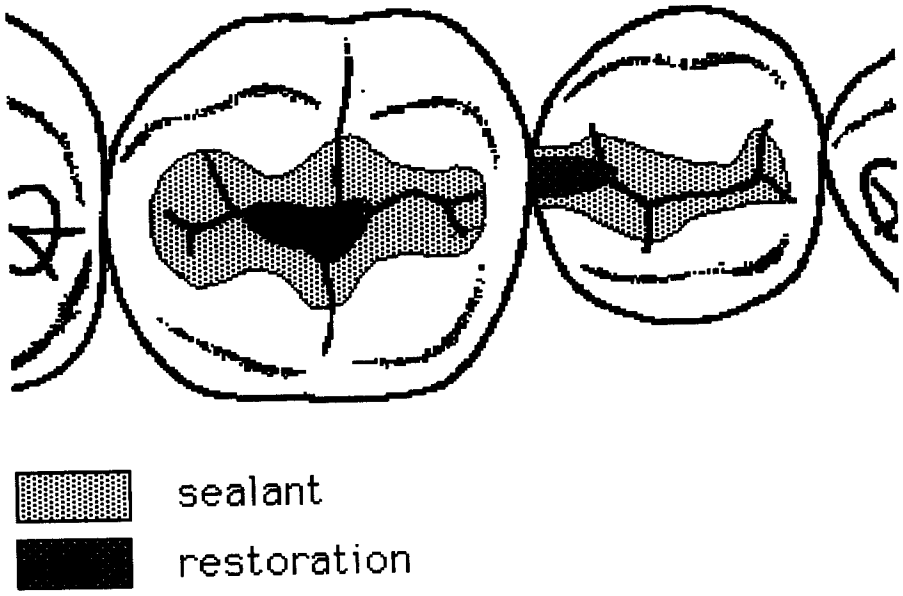
TOOTH PRESERVATION VERSUS CAVITY PREPARATION - 1

Preservation not only refers to a restoration, it also refers to prevention.

For a dentine lesion in an occlusal surface, preservation includes:

- restoring the cavity
- sealing the adjacent pits and fissures.

This is called a **"sealant restoration"**



Occlusal sealant restoration in molar and disto-occlusal sealant restoration in premolar

TOOTH PRESERVATION VERSUS CAVITY PREPARATION- 2

Examples are:

For carious lesions in occlusal, buccal and lingual surfaces of posterior teeth:

- Preventive resin restoration (outcome: excellent - good).
- Preventive glass-ionomer restoration (outcome: unknown).
- Atraumatic Restorative Treatment (ART) (outcome: good, short-term).

For carious lesions in approximal surfaces of posterior teeth

- Box-type restorations (outcome: good).
- Tunnel preparation (outcome: dubious).
- ART (outcome: unknown yet).

EFFECT OF SEALED VERSUS NON-SEALED RESTORATIONS

Clinical trial in the USA.

After 10 years, the study revealed that, in comparison to conventional restorations, sealant restorations resulted in:

- more sound tooth structure was conserved
- restoration margins were better protected
- recurrent caries was less frequent
- clinical survival of restorations was prolonged.

(Mertz-Fairhurst et al., J Am Dent Ass 1998)

SUMMARY

- The biological principle to the management of a dentine lesion is to only remove soft, completely demineralized tooth tissue. This is best achieved through using hand instruments and/or a slowly rotating drill rather than a high-speed drill. In doing so, less sound tooth tissues are removed and damage to surfaces of other teeth is minimized. The use of a gel for chemically and mechanically removal of demineralized tooth tissue is under investigation.

- Since only soft, completely demineralized tissue is removed, there can be no preconceived cavity design; the anatomy of the carious lesion dictates the size and shape of the cavity preparation.

SUMMARY - 2

- The treatment is completed by placing an adhesive filling material into the cleaned cavity preparation, over its margin, and over the adjacent pits and fissures. This sealant restoration will arrest caries activity that is present in dentine and enamel, provided that the bonding of the material to these tooth tissues is adequately established.

- This treatment modality has the potential to:
  - control dentine caries
  - increase survival of the restoration
  - save tooth tissues and thus
  - increase tooth life expectancy.

IMPORTANT:

DO NOT FORGET TO APPLY PREVENTIVE MEASURES AND TO ENCOURAGE ORAL HYGIENE AS NEEDED

Trainers guide to ART training courses

Module 2 - Adhesive restorative materials for minimal intervention approaches for caries management

This module comprises a series of overhead transparencies, numbered 1-36. It describes the adhesive restorative materials that are used in connection with minimal intervention approaches for caries management. To date the ART approach has mainly used glass-ionomers. This material is most likely to be the material of choice in outreach situations. For these reasons, glass-ionomers have been explained in much more detail than other adhesive restorative materials.

Time requirement for this module

1 hour

General introductory statements to the module:

Read chapter 2 in the book by J.E. Frencken and C.J. Holmgren entitled: *Atraumatic Restorative Treatment (ART) for dental caries*. It provides the necessary background information needed to teach this module. Additional literature is provided in the references.

ART COURSE

ADHESIVE MATERIALS FOR

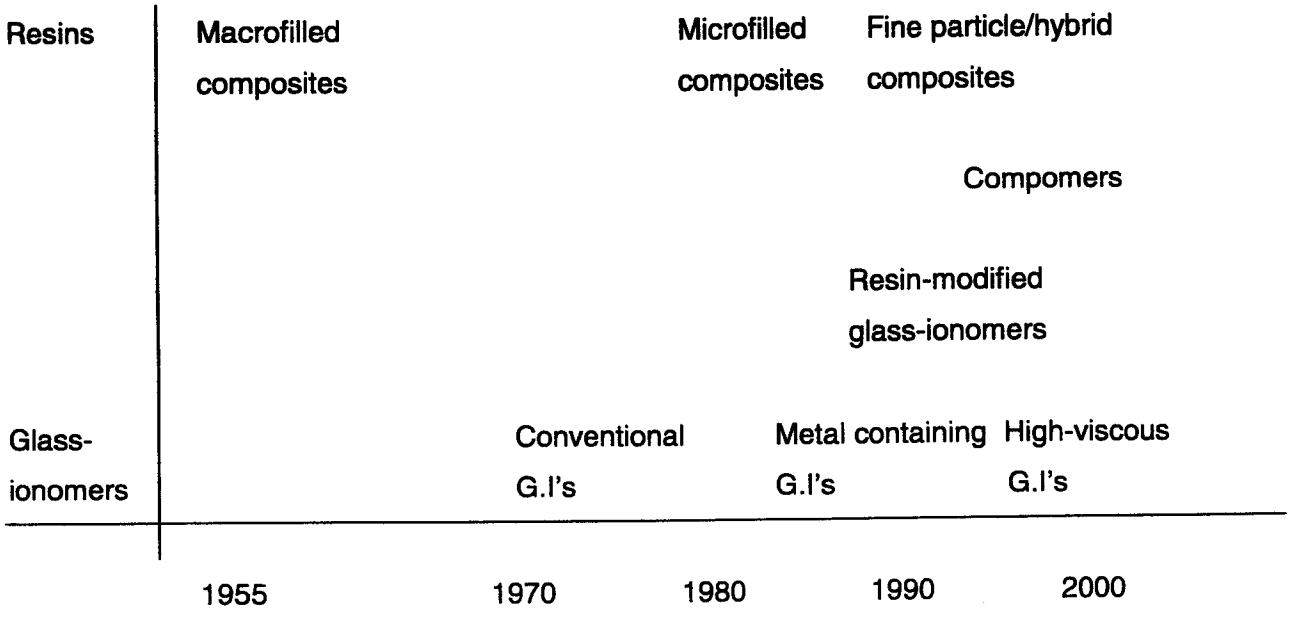
MINIMAL CAVITY PREPARATIONS

ADHESIVE RESTORATIVE MATERIALS FOR MINIMAL CAVITY PREPARATIONS

- The arrival of adhesive restorative materials meant that mechanical retention was no longer necessary. Thus it was possible to develop intervention techniques for caries management that were more conservative of tooth tissue.

- The historical development of adhesive restorative materials is presented below:

Historical development of adhesive restorative materials



ADHESIVE RESTORATIVE MATERIALS FOR MINIMAL CAVITY PREPARATIONS

Glass - ionomer (self - cure)

A dental glass-ionomer is supplied as

- a powder and liquid in separate bottles (hand-mix version)

  or

- in an encapsulated form.

Powder

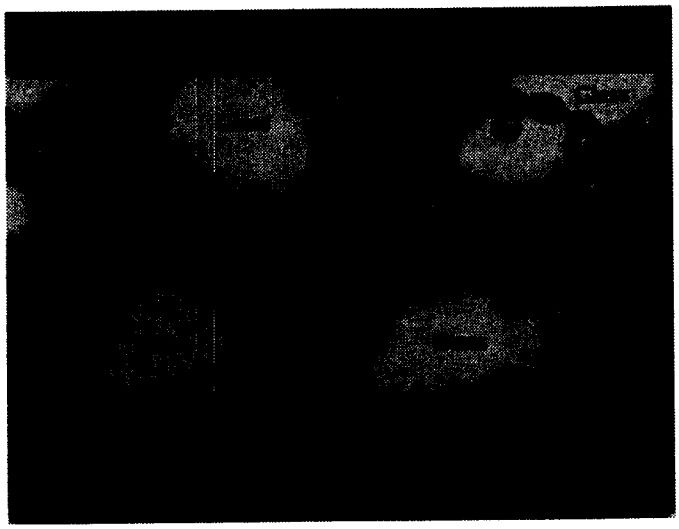
The powder comprises a fluoride glass that is made up of a number of minerals, the most important being SiO_2 and Al_2O_3.

Liquid

- The liquid is usually a water-soluble organic (polyakenoic) acid, mostly polyacrylic acid.
- Some glass - ionomers are supplied with the acid component added to the powder in freeze-dried form. In this case, the liquid comprises deionized water.

How does glass-ionomer harden?

The setting reaction



(Reprinted from 'Preservation and Restoration of Tooth Structures', GJ Mount and RW Hume. Glass-ionomer materials, p 74 , 1999, by permission of the publisher Mosby).

- The acidic liquid decomposes the outer layer of the ionomer glass particles.
- Ions, such as calcium and aluminium, are freed and react with the polyacrylic molecules.
- Chains of calcium-polyacrylate and aluminium-polyacrylate are formed.
- Other freed ions attach to this network of metal-polyacrylate chains.
- The mixture hardens.
- The initial setting takes place within 5 minutes.

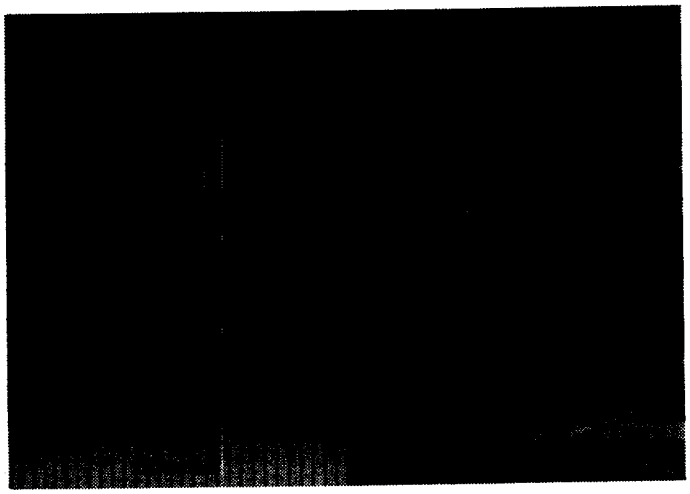
What are the main characteristics of glass-ionomers?

Glass-ionomers:

- bond to enamel and dentine without acid etching
- leach fluoride into the tooth tissues and oral environment
- are pulp - friendly.

How does glass-ionomer bond to tooth tissues?

Adhesion between glass-ionomer and tooth structures



(Reprinted from 'Preservation and Restoration of Tooth Structures', GJ Mount and RW Hume. Glass-ionomer materials, p 79, 1999, by permission of the publisher Mosby).

- Adhesion occurs chemically through ion exchange.
- The polyacrylic acid attacks the dentine and the enamel and displaces phosphate and calcium ions.
- Adhesion of glass-ionomer to enamel is stronger than to dentine.

What about micro-leakage of glass-ionomers?

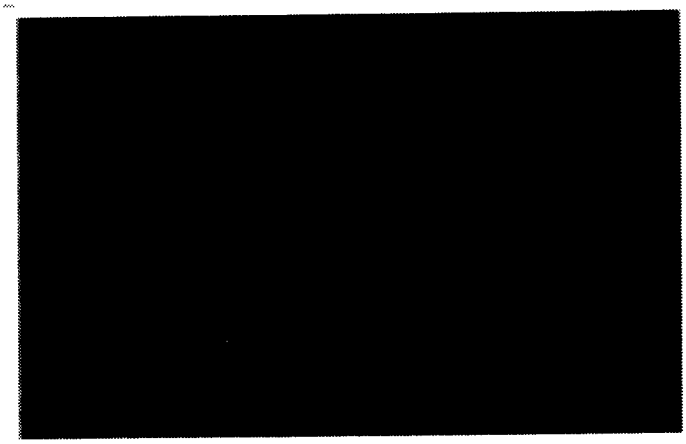
- Usually less often seen with glass-ionomers than for composite resin restorations, particularly at dentine margins.
- Polymerisation shrinkage and shrinkage stress are low for glass-ionomers.
- High adhesion values, necessary for resin containing materials, are therefore not so relevant.

What does the tooth tissue - glass-ionomer inferface look like?

Interaction zone between glass-ionomer and enamel.
Original magnification x 1,936.
(From Ngo et al, 1997. Reprinted with permission from Quintessence international)

- A distinct zone exists at the interface of glass-ionomer and tooth tissues.
- This zone is more resistant to acid attack than the surrounding glass-ionomer material and tooth tissues.
- This is an indication of hypermineralization of the interface.

What if glass-ionomers fracture?



Cohesive failure of glass-ionomer (white arrow) adjacent to the interface.
Original magnification x 2,215
(Reprinted from Ngo et al., 1997, with permission from Quintessence International)

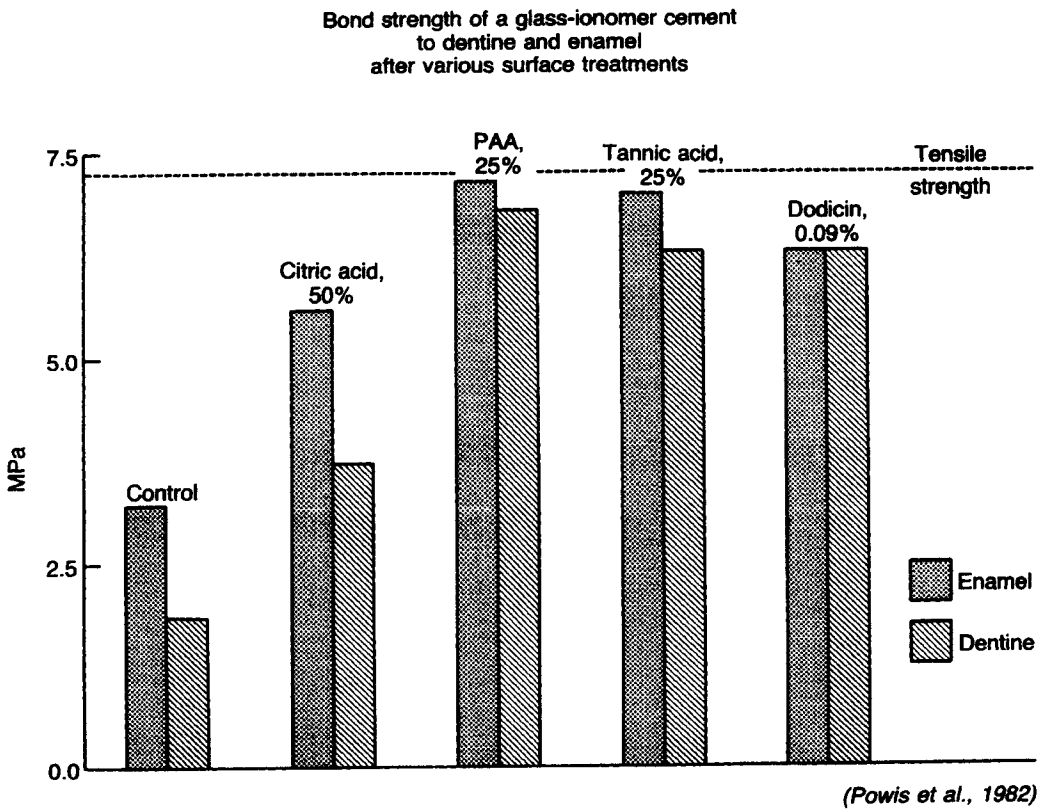
- Fractures occur within the material (cohesively).
- Glass-ionomer, therefore remains in contact with both dentine and enamel at the interface.

When used as a sealant, and if the sealant is eventually lost, the glass-ionomer that is left behind in the deeper parts of pits and fissures may act as a caries inhibiting agent.

What is the function of a surface conditioner?

- A surface conditioner is a weak organic acid, usually a polyacrylic acid.
- The removal of outer carious dentine with either a hand instrument or a drill results in the production of a smear layer.
- This smear layer prevents adequate bonding of glass-ionomer to the tooth tissues and should therefore be removed.
- In order to achieve this, a surface conditioner must be used.

Bond strength of glass-ionomers to enamel and dentine with and without dentine conditioners



(From Glass-ionomer Cement, Wilson AD and McLean JW,1988. Reprinted with permission from Quintessence Publishing Co., Inc.)

- Surface conditioning doubles the bond strength.
- A surface conditioner differs from a liquid used for acid etching of tooth tissues and they are not interchangeable.
- Acid etching is restricted for use with resin based materials.

What is the role of water in glass-ionomer - 1?

- Glass-ionomers are water-based materials.
- Water is the reaction medium into which glass-ionomer forming metal ions leach at the beginning of the setting reaction.

- This setting process is very fast during the first 5 minutes or so. It continues over time and it may take a year before the glass-ionomer is completely mature.

- Both during the initial set and during this so-called 'slow maturation phase', the material is vulnerable to water uptake and water loss.

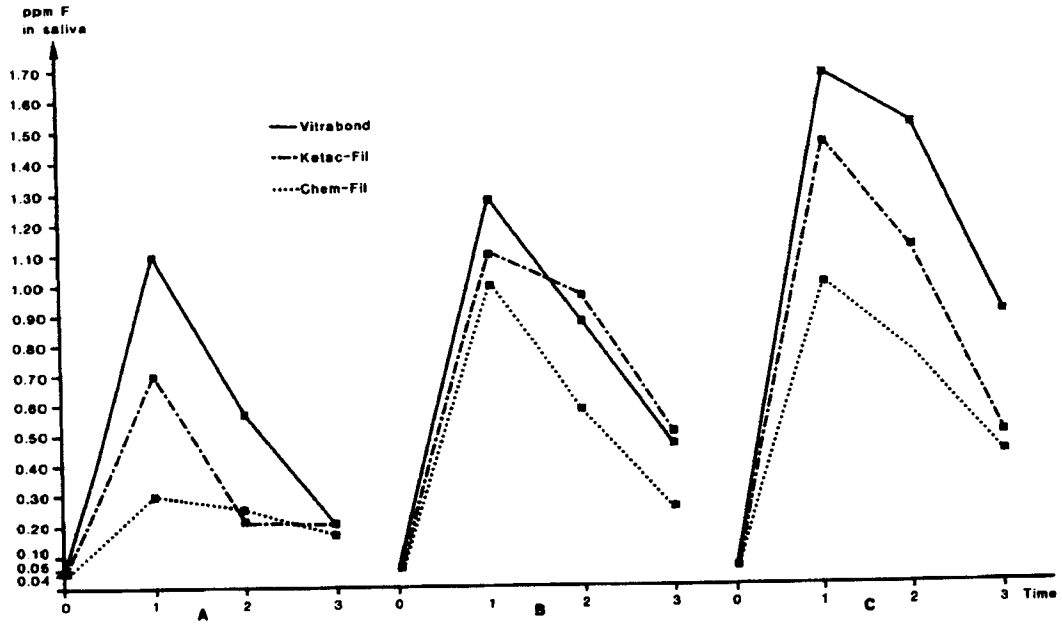
- Therefore, ilt is recommended that the surface of the restoration or sealant should be protected during the initial set by application of an impermeable layer of varnish, petroleum jelly or unfilled resin.

- Desiccation of the cavity preparation prior to placing glass-ionomer material leads to poor adhesion and to gaps between restoration material and tooth tissues. This should thus be avoided.

What does fluoride do in glass-ionomer?

- Fluoride originates from the aluminosilicate glasses that can contain up to 28% fluoride.
- Glass-ionomer restoration and sealants can take up fluoride (e.g., from topical application) and subsequently release it.
- Leaching of fluoride does not affect the properties of glass-ionomer because it does not contribute to its matrix.
- Fluoride continues to be released from glass-ionomer for a long period, up to 8 years in-vitro.

Pattern of fluoride release from glass-ionomers

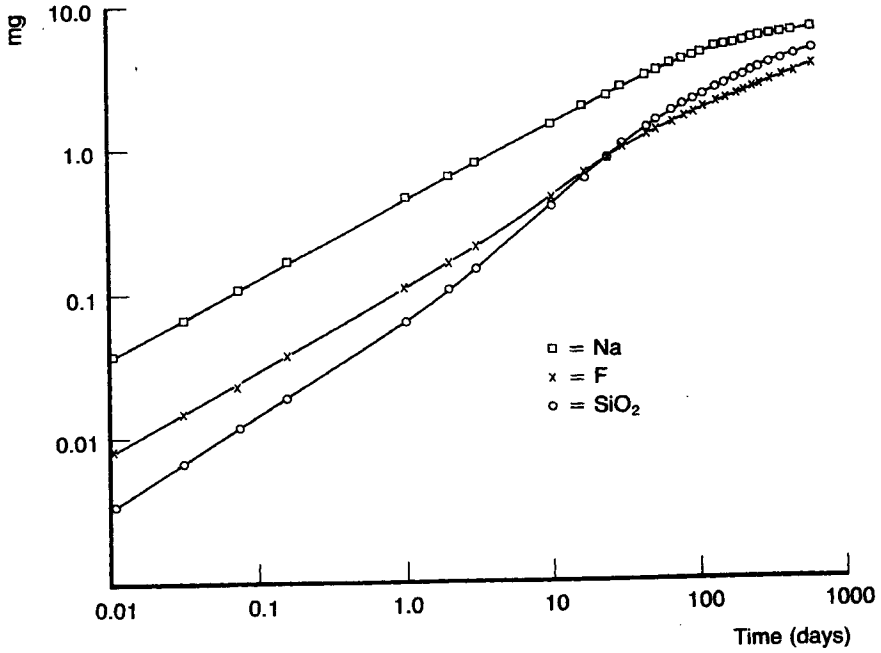


Fluoride in saliva after placement of (A) one, (B) two, (C) three restorations of different glass-ionomers. 0 = before placement, 1 = immediately, 2 = three weeks and 3 = 6 weeks after placement. (From Koch G and Hatibovic-Kofman S, 1990. Reprinted with permission from the Swedish Dental Journal).

- The pattern of fluoride release is characterised by an initial burst of fluoride up to a week. This is followed by a gradual decrease that levels off after some months.
- The amount of fluoride increases with increase in number of restorations placed.
- As an indication, two restored surfaces provided 0.4 ppm fluoride in saliva after 10 weeks.

What happens to the fluoride that is released from the glass-ionomers?

Cummulative release of fluoride, sodium and SiO_2 from glass-ionomers by time.



(From Glass-ionomer Cement, Wilson AD and McLean JW,1988. Reprinted with permission from Quintessence Publishing Co., Inc.)

- Release of fluoride takes place in two directions; into:
  - surrounding enamel, dentine and cementum,
  - saliva and plaque.

Fluoride concentration and its penetration depth into enamel increases with the time that glass-ionomer is in contact with it.

What is known about fluoride in plaque?

- Fluoride levels in plaque grown on glass-ionomer restorations are much higher than in plaque grown on composite resin restorations.
- The metabolic activity of the resident micro-flora is reduced.

- A low number of Strep. mutans is found in plaque samples from margins of glass-ionomer restorations in permanent dentitions after 4 weeks. These numbers are much lower than those from comparable amalgam and composite resin restorations.
- The same trend has been observed in the primary dentition.

Has glass-ionomer the potential to remineralize carious lesions in adjacent tooth surfaces - 1?

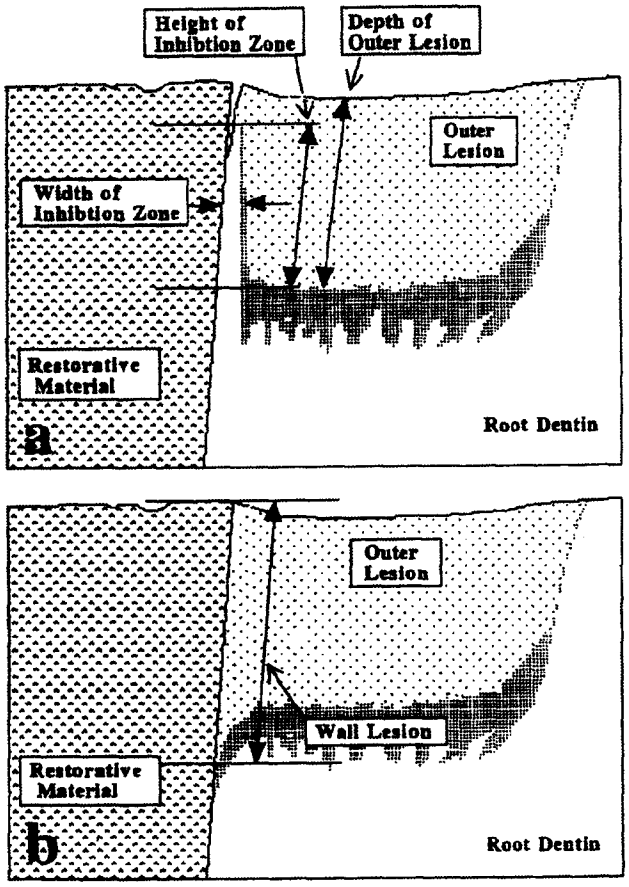
From a biological point of view, the fact that a restorative material may have remineralizing potential, is most appealing.

- In vitro, in-situ and in-vivo studies have been carried out in which glass-ionomer restorations have been compared to amalgam, composite resin and fluoride-containing composite resin restorations.

- The conclusion is that there is a reduction in progression of carious lesions in dentine and enamel surfaces that are in contact with glass-ionomer restorations compared to carious lesions that were in contact with other restorative materials.
- Reduction in progression of carious lesions one study was measured as 20% in enamel and 24% in dentine lesion depth.

Has glass-ionomer the potential to remineralize carious lesions in adjacent tooth surfaces? - 2

Overview of caries inhibition zone adjacent to glass-ionomer and composite resin material

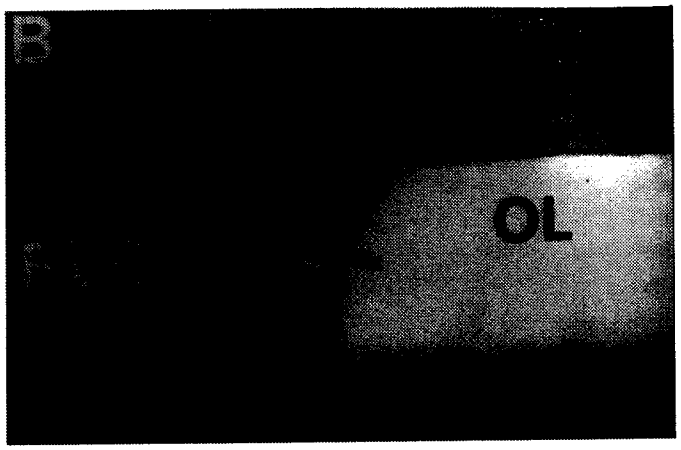


Schematic presentation of a caries-like lesion and the inhibition zone around:
a) the conventional or resin-modified glass-ionomer restoration,
b) the fluoride-releasing adhesive composite restoration.

(Reprinted from the Journal of Dentistry, vol 26, 1998, pp 505-510, Pereira et al., with permission from Elsevier Science)

Has glass-ionomer the potential to remineralize carious lesions in adjacent tooth surfaces? - 3

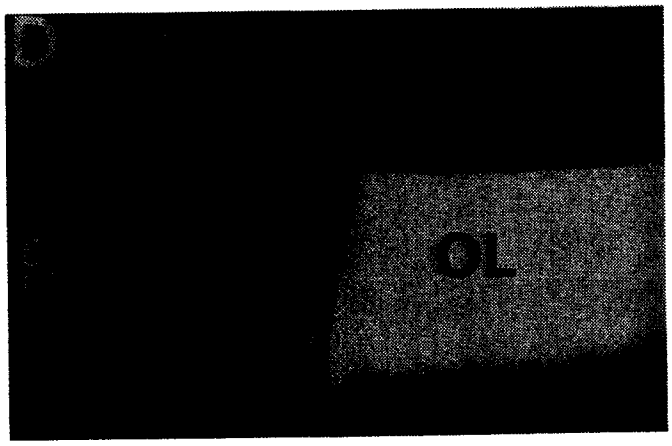
Overview of caries inhibition adjacent to resin-modified glass-ionomer and composite resin restoration



(B) Photomicrograph of a caries-like lesion depicting the outer lesion (OL) and the inhibition zone (arrows) formed adjacent to Fuji II LC (FLC).
(Reprinted from the Journal of Dentistry, vol 26, 1998, pp 505-510, Pereira et al., with permission from Elsevier Science)

Has glass-ionomer the potential to remineralize carious lesions in adjacent tooth surfaces? - 4

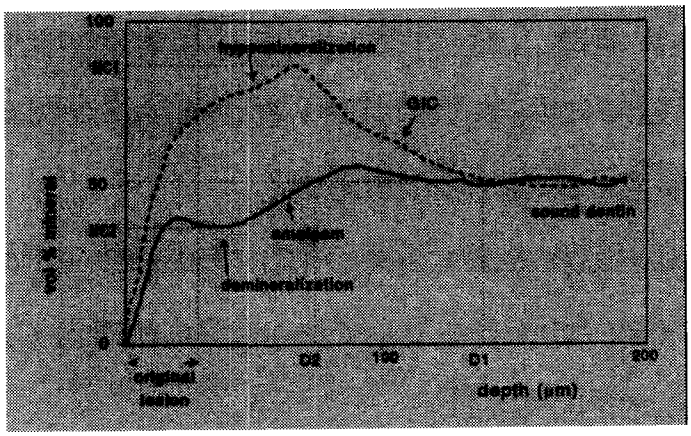
Overview of caries inhibition adjacent to resin-modified glass-ionomer and composite resin restoration



(D). Photomicrograph of a caries-like lesion and wall lesion (black arrow) adjacent to the fluoride releasing adhesive resin composite (RC) (Clearfil AP-X). **Note** that demineralization along the cavity wall extends beyond the length of the outer lesion (OL) despite the absence of a gap at the cavity margin. Asterisk indicates bonding resin and white long arrow indicates Protect Liner F.
(Reprinted from the Journal of Dentistry, vol 26, 1998, pp 505-510, Pereira et al., with permission from Elsevier Science)

Has glass-ionomer the potential to remineralize carious lesions in adjacent tooth surfaces? - 5

Hypermineralization of carious lesions adjacent to glass-ionomer compared to amalgam restorations in situ



Mineral profiles from the experiment showing demineralization and hypermineralization in the dentine specimens with amalgam and glass-ionomer (GIC) restorations, respectively. MC1 = maximum mineral content in hypermineralized layer of GIC specimens, MC2 = minimum mineral content in body lesion of control group,
D1 = depth over which hypermineralization had occurred in the GIC specimens, and
D2 = lesion depth in the control group.

(Reprinted from Ten Cate and Van Duinen, 1995, with permission from the Journal of Dental Research)

- The study reported that caries-like lesions in tooth surfaces adjacent to glass-ionomers became hypermineralized.
- Further demineralization occurred in caries-like lesion adjacent to both composite resin and amalgam restorations.

How pulpal-friendly is glass-ionomer?

- Acid released from glass-ionomers has been identified as a possible factor contributing to pulpal irritation.
- A thin mixture of glass-ionomer may contain more unreacted acid. This makes the powder/liquid ratio important.

- Glass-ionomers are the most pulpal-friendly restorative material but there exists variation in the biocompatibility of the various makes of glass-ionomers.
- In case of pulpal exposure, the placement of a hard-setting calcium hydroxide material over the area of the exposure is sometimes recommended.
- This leaves sufficient dentine on the floor of the cavity available for adhesion and subsequently, for prevention of bacterial invasion.

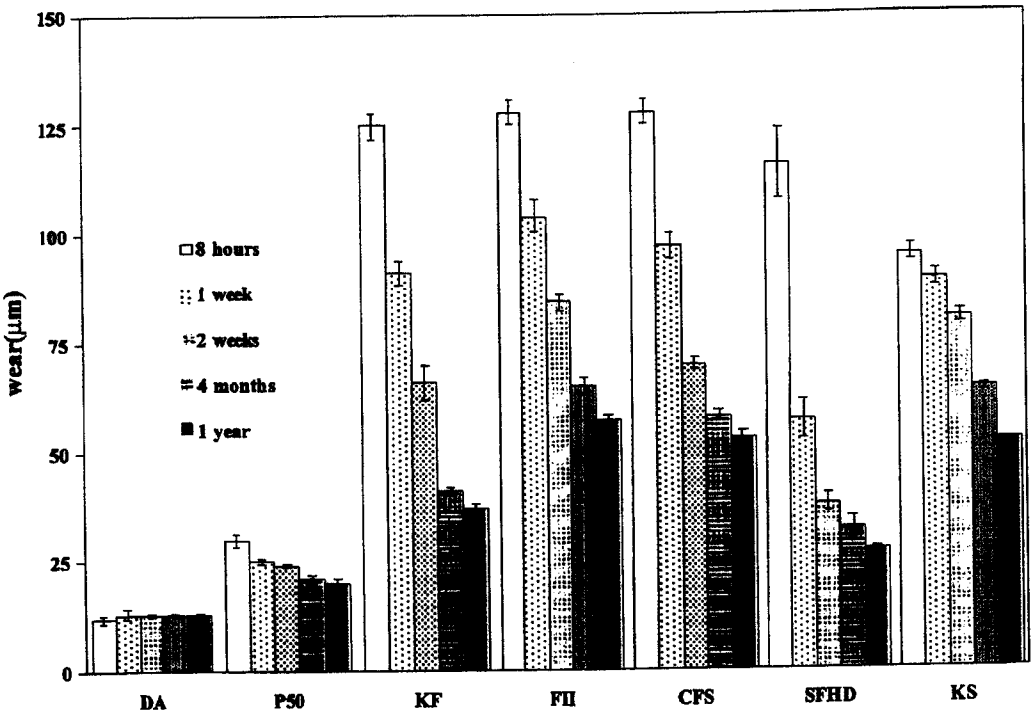
What can be said about the physical characteristics of glass-ionomers - 1?

Early glass-ionomers were difficult to handle and were very water sensitive. Much has changed since then and improved glass-ionomers have been marketed in recent years. One of the improvements is related to **wear resistance**.

- Recent in-vitro studies have shown that wear of glass-ionomers decrease as the material matures. Wear was greater when the pH was low, such as after consuming acidic beverages and during application of an APF gel.
- Long-term wear (one year) of the newer glass-ionomers approached that of early wear of composite resin materials. This result is obviously related to the process of maturation of glass-ionomer.

Physical characteristics of glass-ionomers - 2

Pattern of wear in vitro



Bar graph showing the effect of maturation on occlusal contact-free wear for conventional and metal-reinforced glass-ionomers in comparison with amalgam and composite using the ACTA wear machine.
DA = Amalgam; P50 = Composite; KF = Ketac-Fil Aplicap; FII = Fuji Cap II; CFS = ChemFil Superior; SFHD = Shofu High Dense; KS = Ketac-Silver.
(Reprinted from De Gee et al, 1996, with permission from the Journal of Dental Research)

- Early wear of conventional glass-ionomers is high.
- Long term wear of some glass-ionomers compare favourably with the composite resin material tested.

Physical characteristics of glass-ionomers - 3

- Resistance to wear is still lower than that of composite resin or amalgam.
- The compressive strength of matured glass-ionomer is higher than that of newly set glass-ionomer.

- The human factor for achieving good physical characteristics is important. A study showed that chairside assistants routinely used a lower powder to liquid ratio than recommended. This resulted in a mixture that had half the normal compressive strength.
- Other characteristics that need improvement are fracture toughness, flexural strength and tensile strength.
- The physical characteristics of glass-ionomers restrict its use to certain applications in preservative oral health care.

Conclusions - 1

- Glass-ionomers adhere chemically to enamel and dentine but need a dentine conditioner to remove the smear layer and thus improve adhesion.

- It is very important to reduce exposure of a freshly placed glass-ionomer restoration or sealant to saliva and water for at least one hour. This is achieved by placing a varnish, unfilled resin or petroleum jelly over the restoration or sealant.

- Fluoride is released from the material into the tooth tissues and into plaque and saliva.

- There is growing evidence that the progression of carious lesions is reduced in tooth surfaces adjacent to glass-ionomer.

Conclusions - 2

- The compressive strength and wear resistance of glass-ionomer restorative material are substantial but fracture toughness and flexural strength need further improvement.

- The optimal mechanical characteristics are achieved if the specified powder/liquid ratio is closely followed. A thinner mixture may also irritate the pulp during the early setting phase.

- The use of glass-ionomers in preservative oral health care is restricted to certain appplications.

Resin-modified glass-ionomer - 1

This type of adhesive restorative material was developed to improve the mechanical properties of conventional glass-ionomer.

- It is a combination of a glass-ionomer and a resin in the ratio of about 80% to 20%.
- Resin-modified glass-ionomer sets by an acid-base and a polymerisation reaction.

Because of the high proportion of acid-based reaction, resin modified glass-ionomers closely resemble the behavioural characteristics of conventional glass-ionomers with respect to the:

- pattern of fluoride release
- antibacterial effect
- susceptibility to dehydration.

Resin-modified glass-ionomer - 2

The differences between the two materials include:

- The mechanism of adhesion that is both mechanical and chemical for resin-modified glass-ionomers.
- Bonding to enamel and dentine requires mostly acid conditioning. Setting is activated by light curing.

- Greater mechanical strength for resin-modified glass-ionomers which is attributed to the polymerization setting reaction of the resin component.
- However, resin-modified glass-ionomers seem to wear more than conventional glass-ionomers, particularly under acidic conditions.

Composite resin - 1

This adhesive restorative material exists in many forms. Without an adhesive technique and chemicals, such as bonding and primer materials, a composite resin does not bond to tooth tissues.

- The material is available in two systems:
  - a two-component that cures chemically and
  - a one-component that requires light curing.

- For restorative purposes, a high filler load and small particle size material is required.
- In an attempt to match the caries reducing effect of glass-ionomers, caries inhibiting agents such as fluoride have been incorporated in composite resins.

- Studies have shown that caries is not reduced in the presence of composite resin material. On the contrary, caries progresses in dentine alongside composite resin material under circumstances of continuous cariogenic ecology without plaque removal.

Composite resin - 2

- The biocompatibility of composite resin is lower than that of conventional and resin-modified glass-ionomers.
- In general, the physical properties of composite resin materials are the best of the adhesive restorative materials.

- Despite the high values for adhesion to enamel, polymerisation shrinkage and shrinkage stress remain a problem.
- This can result in micro-leakage at the tooth-filling interface and cracks in the enamel.
- The level of micro-leakage is dependent on the technique used to insert the material, quality of light curing source and skill of the operator.

Polyacid modified composite resin ('Compomer')

A compomer is to a composite resin as a resin-modified glass-ionomer is to glass-ionomer.

- The main difference between a compomer and a resin-modified glass-ionomer is the ratio of resin to glass-ionomer filler which is in the order of 80 to 20 per cent, respectively.
- Therefore, the behaviour of compomers is essentially that of composite resin materials.

- As compomers do not contain water, the acid based setting reaction that characterizes glass-ionomers, does not take place.
- The setting is completed after the light curing the material.

- The physical properties are somewhat lower than for normal composite resins but are generally higher than for resin-modified glass-ionomers and conventional glass-ionomers.
- Despite the presence of fluoride - containing glass particles, compomers do not leach enough fluoride to reduce caries progression.
- As with normal composite resins, polymerization shrinkage and shrinkage stress are a problem.

Strengths and weaknesses of four adhesive dental restorative materials according to requirements

Requirements	Glass-ionomers	Resin-modified glass-ionomers	Polyacid - modified composite resins ('Compomers')	Composite resins
Biological				
• biocompatible	+++	++	++	++
• encourage remineralization	+++	+++	+	-
• reduces demineralization	+++	+++	+	-
Physical				
• adhesion to enamel	++	++	+++	+++
• adhesion to dentine	++	++	+	+
• micro-leakage	++	++	++	++
• occlusal wear	+	-	++	+++
• fracture resistant	+	++	+++	+++
• thermal expansion	+++	++	+	+
• aesthetics	+	+	++	+++
• moisture tolerant	+++	++	-	-
General				
• hand-mix	+++	n/a	n/a	+
• self curing	+++	n/a	n/a	+
• user tolerant	++	++	+	+
• cost	?	?	?	?
• shelf-life	++	++	++	++

+++ very good, ++ satisfactory, + could be better, - poor.
n/a not available

Comment

- Conventional and resin-modified glass-ionomers score high on the biological but lower on the physical requirements.

- The opposite is applicable for composite resin and polyacid-modified composite resins ('compomers') materials. They score low on the biological and high on the physical requirements.

- Conventional glass-ionomers and chemically cured composite resins are available in hand-mix form and can therefore be used without electricity.

- The cost and availability of materials vary according to country.

SUMMARY

- Glass-ionomers have been explained in more details than the other adhesive restorative materials for the reason that this material has been used in the ART studies.

- Each material has its strengths and weaknesses.

- An ideal biological restorative material has not been manufactured.

- The selection of material for caries preventive and tooth restorative purposes is dependent on a number of factors such as:
    - the size of the caries lesion
    - its site in the mouth
    - patient's oral health promoting or harmful behaviour
    - knowledge and skills of the operator.

Trainers guide to ART training courses

Module 3 – Equipment and materials required for the ART approach

This module comprises a series of slide transparencies numbered 3.1 to 3.16. A detailed description of the content of each slide and the important points which should be covered are given below:

Time requirement for this module

1 hour (including demonstration of sharpening of instruments)

General introductory statements to the module:

Point out that before applying the ART approach, it will be necessary to assemble all the equipment and materials required. This includes:

- appropriate supports for the patient and for the operator;
- dental instruments;
- restorative materials;
- miscellaneous consumable materials; and,
- a light source.

The selection of these depends upon the working environments where ART is to be applied. These can loosely be divided into the use of ART in the well-equipped dental clinic environment and ART placed in outreach situations e.g. where conventional dental equipment is not available such as in schools or homes.

Read chapter 3 in the book by J.E. Frencken and C.J. Holmgren entitled: *Atraumatic Restorative Treatment (ART) for dental caries*. It provides the necessary background information needed to teach this module. Additional literature is provided in the references.

1. Appropriate support for the patient and the operator

Slide 3.1 Appropriate support for the patient and operator (dental clinic)

Points to be noted:

- Both the operator and the patient should be comfortable.
- Because the operator is likely to be working for extended periods at any one time, it is best for him/her to be seated.
- The patient should be in a supine position so that the operator can achieve maximum visibility of the oral cavity.
- With the patient so positioned there is no need for the operator to bend or twist from an upright seated position since the correct positioning of the patient's head enables all parts of the oral cavity to be seen.
- In this position saliva collects at the back of the oral cavity thereby facilitating saliva control.

Slide 3.2 Appropriate support for the patient and operator (outreach situation 1)

Point to be noted:

- The patient can be positioned on a portable dental "bed" which are available commercially or can be locally made.

Slide 3.3 Appropriate support for the patient and operator (outreach situation 2)

Point to be noted:

- A suitably sized table can be adapted by the use of cushioning e.g. foam rubber. The addition of a support for the patient's head made of firm foam or a rubber ring with a cover, stabilizes the patient's head in the desired position for maximum visibility by the operator and improves the comfort of the patient.
- Whatever support is used it must be stable and secure to ensure the safety of the patient.

2. *Dental instrument requirements for ART*

Slide 3.4 Basic ART instruments overview

Points to be noted:

- The number of instruments is kept to the minimum required to undertake the procedure safely and effectively.
- This reduces the cost and effort required for maintenance and sterilization.
- The instruments used are based on the stages involved in placing an ART restoration and are almost all commonly found in dental surgeries.

Mouth mirror

Point to be noted:

- The mouth mirror is used for viewing tooth surfaces indirectly, for reflecting light into the field of operation and for retracting the soft tissues of the mouth e.g. tongue or cheek.

Explorer (probe)

Points to be noted:

- The explorer is used to determine the softness of dentine caries prior and during cavity preparation.
- It is also used for scraping plaque from fissures prior to conditioning for restorations or sealants.
- The probe must NOT BE USED for probing into small carious lesions since these often have the ability to remineralize.
- In addition, the probe must not be used on the floor of deep cavities where there is a danger of exposing the pulp.

Tweezers

Points to be noted:

- Used for placing and removing the cotton wool rolls used for isolation of the tooth being restored.
- They are also used to hold cotton wool pellets used for cleaning, conditioning and drying the tooth surface and for articulating paper used to check the occlusion after placement of a restoration or sealant.

Slide 3.5 Excavators

Points to be noted:

- The spoon shape excavators has been found to be the most useful for ART restorations. They are used for removing soft carious dentine. A set of two or three double-ended excavators is recommended.
- A small excavator is used for excavating small cavities and for removing caries under the enamel-dentine junction. The diameter of the spoon should be approximately 1mm across. This is a delicate instrument and must not be used with excess force. (An example is the 153-154).
- A medium size excavator is used for removal of caries from larger cavities and at the pulpal floor of cavities. The convex surface of the head of the instrument can be used to place filling material into small cavities. The diameter of the spoon should be approximately 1.5mm across (An example is the 131-132).
- A large size excavator is used for caries removal in large cavities and at the pulpal floor of cavities. It can also be used for the removal of excess filling material from the restoration. The diameter of the spoon should be approximately 2mm across (An example is the 127-128).

Slide 3.6 Dental hatchet

Points to be noted:

- This double-ended instrument has a chisel-like working end.
- The hatchet is used when there is a need to open the entrance into a cavity or to break off very weak unsupported enamel.
- In order to permit access to cavities with the smallest excavator the width of the blade should be a minimum of 1mm in width. (An example is the 53/54 10-6-12).

Slide 3.7 Applier/carver

Points to be noted:

- This double-ended instrument that fulfils two functions.
- The round end is principally used as for placing the filling material into the cavity and fissures.
- The square end which has a sharp edge is used for removing excess restorative material and shaping the restoration.

Slide 3.8 Mixing spatula and pad

Point to be noted:

- If hand-mixed restorative material is used, then a mixing spatula and pad are required. Many materials designed for ART are supplied with a plastic spatula and disposable paper mixing pad. The latter saves time since there is no need to clean the pad between fillings and also helps with respect to infection control.

Slide 3.9 plastic strip

Points to be noted:

- For multiple-surface a matrix band necessitating a holder or a plastic strip is required.
- This prevents the formation of overhangs and prevents the restoration from bonding to the adjacent tooth.

Tumbler/cup

Points to be noted:

- This should either be disposable e.g. plastic, or stainless steel to permit sterilization. The tumbler is used to hold water used for rinsing the operating site (see slide 3.11).

Miscellaneous equipment 1 (rotary instruments)

Points to be noted:

- When ART restorations and sealants are being placed in a well-equipped dental surgery some minor modifications to the basic approach are possible.
- In some situations where there might be difficulty in obtaining access to underlying carious dentine, the careful use of a slowly rotating bur in a handpiece might be considered. This is only to achieve access since once gained, the remaining excavation of caries should be undertaken with hand excavators. This will ensure that only soft carious dentine is removed while retaining the maximal amount of sound tooth tissue.

Miscellaneous equipment 2 (light curing machine)

Points to be noted:

- Light curing units permit the option of using light cured restorative materials.
- While there is currently no data on how materials such as light cured glass ionomers, compomers or composites perform in the context of ART, it is likely that they will perform in a similar manner to the self-curing glass ionomers currently in use.

3. Restorative materials required for ART

Slide 3.10 A selection of self-curing hand-mixed glass ionomers used for ART

Points to be noted:

- The restorative material used is dependent upon many factors. These include the conditions under which the ART restorations are going to be placed, the availability and cost of materials.
- For practical reasons, in outreach situations (schools, villages) a hand-mix, self-curing material is advisable. In a well-equipped dental clinic where light curing machines and efficient aspiration is available, other materials might be considered.
- To date, almost all studies evaluating the ART approach have used glass ionomer restorative material. Materials shown are GC Fuji IX, ESPE Ketac Molar, Dentsply ChemFlex.

4. Miscellaneous consumable materials required for ART

Slide 3.11 Miscellaneous consumable materials required for ART

Points to be noted:

- **Cotton wool rolls** are used for moisture control so that the operating site is kept dry. This is not only important for visibility but also to ensure that the optimal properties of the restorative material are achieved. The size of the cotton wool roll used is dependent upon the size of the mouth of the patient. A large cotton wool roll used in a child will hinder visibility and access. A small cotton wool roll in an adult will be less effective in moisture control.
- **Cotton wool pellets** are used for cleaning and drying cavities as well as for applying conditioner and varnish if a glass ionomer is used as the restorative material. They are available in a number of sizes with size 4 being the smallest. Even this is often too large for the smaller cavities produced by the ART approach and they therefore need to be cut in half with scissors.
- **Petroleum jelly** is used both as a lubricant to prevent gloves from sticking to the restorative material and later for protecting the surface of the restorative material if self-curing glass ionomer is used.
- **Wooden wedges** are used both to hold matrix bands and strips in place when placing approximal restorations and to prevent overhanging margins at the portion of the restoration closest to the gingival margin.

5. The operating light

Slide 3.12 Portable light source in field setting (headlamp)

Points to be noted:

- Good illumination of the operating site is essential for good vision.
- In the dental clinic situation operating lights are always available.
- In outreach (field, community) situations the light source can be the sun (natural) or artificial.
- Artificial light is more reliable and constant than natural light and can also be focused on a particular spot.
- In a field setting a portable light source is recommended.
- This can take the form of a headlamp, glasses with a light source attached as shown here.
- I can also be a light attached to the mouth mirror or a light on a portable stand.
- Electrical power can either be provided by mains electricity or by a rechargeable portable battery.

6. Sterilisation of instruments

Sterilization of hand instruments is a straightforward procedure. It is essential that cross-infection be prevented.

Slide 3.13 Washing of instruments prior to sterilization

Points to be noted:

- After use the instruments should be washed in soapy water to remove all debris.
- The wearing of heavy-duty rubber gloves is recommended to protect the hands.

Use of an autoclave to sterilize ART instruments

Points to be noted:

- In a dental clinic where an autoclave is usually available follow the manufacturer's instructions.
- In outreach situations it is usually possible to carry sufficient instruments for a day's work.
- The instruments can then be returned to a facility where they can be properly sterilised before the next treatment session.

Use of a pressure cooker to sterilize ART instruments

Points to be noted:

- In outreach situations a pressure cooker can be used for sterilization.
- The clean instruments are placed in a pressure cooker and clean water is added to a depth of 2-3 cm from the bottom. The instruments should be evenly distributed around the cooker. (Read instructions supplied with the pressure cooker).
- The pressure cooker is placed on the stove and brought to a boil. When the steam comes out from the vent, the weight should be put in place. If available, a timer should be set for 15 minutes.
- The pressure cooker is heated continuously on low heat for a minimum of 15 minutes. The steam must continue to be released from the pressure cooker during this time. If this stops, there may be no water left in the pressure cooker anymore.
- If this happens, the pressure cooker must be removed from the heat, allowed to cool, and the cycle repeated. (Read the instructions supplied with the pressure cooker).
- **CARE MUST BE TAKEN WHEN OPENING THE PRESSURE COOKER. THE PRESSURE MUST BE RELEASED FIRST.**
- The pressure cooker is removed from the stove after 15 minutes, and left to cool.
- The instruments are taken out of the pressure cooker with instrument forceps and dried with a clean towel.
- They are then stored in a covered, preferably metal box

7. Sharpening of ART instruments

Note: Sharpening is an essential component in the maintenance of the ART instruments. The instruments that will need sharpening are those used for cavity preparation, i.e. the hatchet and excavators, and the carver used for finishing the restoration. These should be kept sharp to be effective since when blunt they will require excessive force to function. This is not only tiring for the operator but can be hazardous since the instrument can easily slip and damage adjacent tissues. In addition, the time required to prepare a cavity might take longer with blunt instruments.

During use an experienced operator will be able to detect when the cutting edge of an instrument has become blunt since its effectiveness is reduced.

Testing the sharpness of an instrument on the thumbnail

Points to be noted:

- If the cutting edge digs in during an attempt to slide the instrument over the thumbnail, the instrument is sharp. If it slides, the instrument is blunt.
- Only light pressure is exerted in testing for sharpness.
- The instrument should be sterilised again afterwards.

Slide 3.14 Sharpening the dental hatchet and carver 1

Points to be noted:

- A flat sharpening stone with a fine grain is used such as an 'Arkansas' stone as shown. Coarse grained sharpening stone should be avoided since their use results in rapid wear of the instrument.
- The approach adopted in sharpening the instrument varies with the design of the instrument but the objective should be to produce a sharp cutting edge while maintaining the original shape of the instrument.
- The hatchet and carver are sharpened in a similar manner since they both have a bevel that forms a straight cutting edge.

Slide 3.15 Sharpening the dental hatchet and carver 2

Points to be noted:

- The sharpening stone is stabilized on a flat surface such as a table. A drop of oil is placed on the stone (this prevents the fine stone from clogging). The stone is held firmly with one hand and the middle finger of the other hand is rested on the stone as a guide.

The beveled surface of the instrument is placed flat on the stone. Particular attention is taken to ensure the bevel is parallel to the surface of the stone.

Slide 3.16 Sharpening the dental hatchet and carver 3

Points to be noted:

- The instrument is slide back and forth over the oil covered stone several times for maximum sharpness.
- Care must be taken to ensure the surface to be sharpened stays parallel to the stone surface.
- The intruments are re-sterilised after they have been sharpened.

Sharpening the spoon excavator

Points to be noted:

- The cutting edge of a spoon excavator that needs sharpening extends around the rounded outer edge of the spoon.
- To sharpen, the sharpening stone is stabilized on a flat surface such as a table.
- A drop of oil is placed on the stone.
- The stone is held firmly with one hand. The round surface of the excavator is placed in the oil and small strokes are made from the center of the round surface to the edge of the spoon.
- This in done all directions so that the entire cutting edge is sharpened
- The instruments are sterilized after they have been sharpened.

Trainers guide to ART training courses

Module 4 – Selection of cases for ART and Step-by-step guide to the ART approach

This module comprises a series of slide transparencies numbered 4.1 to 4.46. A detailed description of the content of each slide and the important points which should be covered are given below:

Time requirements for this model

1-1.5 hours

General introductory statements to the module:

Before describing the ART approach in detail it is important to point out that the choice of restorative procedure and materials used to treat caries depends upon many factors. This includes aesthetics, cost, ease of placement, patient's wishes and longevity of the restoration in the situation where it has been applied. It must be emphasized that research has only validated the ART approach for single-surface restorations using glass-ionomers. Its use for multiple-surface restorations should, for the time being, be carefully considered. In order to ensure consistent and reliable results with ART, careful selection of cases and restorative materials is required.

The ART approach as given in the slide sequence for this module details the steps taken when using a hand-mix posterior glass-ionomer. In situations where another adhesive restorative material is being used, the steps should be modified accordingly.

Read chapter 4 in the book by J.E. Frencken and C.J. Holmgren entitled: *Atraumatic Restorative Treatment (ART) for dental caries*. It provides the necessary background information needed to teach this module. Additional literature is provided in the references.

1. Selection of cases for ART

In general, ART can be applied when:
- there is a cavity involving the dentine, and
- that cavity is accessible to hand instruments.

There are no other special limitations to the use of the ART approach in the management of dental caries other then applicable to conventional treatment concepts such as pulp exposure.

It is known from studies that access to approximal dentine lesions in anterior teeth with hand instruments is difficult. Such a type of cavity is not treatable with ART.

2. Step-by-step guide to the ART approach

Slide 4.1 Preparation of the ART instruments and materials

Points to be noted:

- All the instruments and materials that are likely to be required for an ART restoration are laid out in a logical and ordered manner in the sequence that they will be used.
- This simple step will save time and mean that the operator can concentrate on the preparation and restoration of the cavity instead of searching for instruments or materials.

Slide 4.2 Isolation of the operating site 1

Points to be noted:

- Isolation of the operating site is an essential component in the placement of ART restorations for reasons of saliva control.
- Failure to control saliva adequately will compromise visibility of the operating site, effect bonding of the glass ionomer to the tooth surface and prevent the glass ionomer from setting optimally.
- Isolation is usually achieved by means of cotton wool rolls. When ART is being placed in a well-equipped dental clinic, saliva control can be supplemented by the use of suction.
- Cotton wool rolls must be changed regularly as soon as they are saturated with saliva. It is usually a good idea to change the cotton wool rolls at key steps of the preparation and placement procedure e.g. after cavity preparation and before conditioning.
- For lower teeth cotton wool rolls are placed at either side of the tooth to be restored.

Slide 4.3 Examining the cavitated tooth 1

Points to be noted:

- Once isolated, the tooth and the extent of caries can be examined more easily.
- Any plaque or food debris is removed from the pits and fissures with a caries probe.

Slide 4.4 Examining the cavitated tooth 2

Points to be noted:

- Clean the tooth surface by rubbing with a wet cotton wool pellet. This is then followed by drying the surface with a dry pellet.

Slide 4.5 Gaining access to the carious lesion 1

Points to be noted:

- IMPORTANT; A local anesthetic is usually not required since only dead tooth tissue is being removed during cavity preparation.
- In small carious lesions where the opening to the cavity is small, it is necessary to widen the entrance for access.
- A dental hatchet is use for this task.
- The corner of the hatchet is placed in the opening that is usually the deepest part of the pit or fissure.

Slide 4.6 Gaining access to the carious lesion 2

Points to be noted:

- The hatchet is rotated backwards and forwards whilst maintaining slight pressure.
- This breaks off unsupported and demineralized enamel.

Slide 4.7 Gaining access to the carious lesion 3

Point to be noted:

- The cavity entrance is thereby increased to at least 1 mm which permits access for the smallest excavator.

Slide 4.8 Removal of soft, completely demineralized, dentine 1

Points to be noted:

- Soft dentine is removed with excavators.
- This is achieved by making circular scooping movements around the axis of the instrument.
- It is important that the soft dentine from the enamel-dentine junction is removed first by use of a small excavator

Slide 4.9 Removal of thin, overhanging enamel

Points to be noted:

- The removal of soft dentine from the enamel-dentine junction often results in thin overhanging enamel. When thin, it is best removed. Its removal improves visibility and access to the deeper parts of the cavity.
- The blade of the hatchet is used to fracture off this thin overhanging enamel along the plane of the rods.
- The hatchet is placed at the edge of the enamel and slight pressure applied. The thin enamel should break off.
- The enamel-dentine junction should be checked once again to ensure that all the soft dentine has been removed.
- IMPORTANT: It is not always necessary or possible to remove all overhanging enamel. Only that enamel which is weak and thin or that hinders access for removal of soft dentine should be removed.

Slide 4.10 Removal of soft, completely demineralized dentine 2

Points to be noted:

- Soft dentine is now removed from the floor of the cavity. Use as large an excavator as access permits.
- Care must be taken in deep cavities where there is danger of exposing the pulp.
- Do not exert excessive pressure on the pulpal floor with small excavators since this increases the likelihood of exposure.
- Clean the cavity with a wet cotton wool pellet followed by a dry pellet.

Slide 4.11 Soft, completely demineralized dentine removed

Points to be noted:

- After excavation of soft, completed demineralized dentine, the floor of the cavity is often stained or discoloured.
- This dentine which is hard should be retained.

Slide 4.12 Conditioning the cavity 1

Point to be noted:

- The use of hand-instruments on the dentine surface results in a smear layer. This is shown here in a scanning electron micrograph.

Slide 4.13 Conditioning the cavity 2

Points to be noted

- In order to improve the chemical bonding of the glass-ionomer to the tooth tissues this smear layer must be removed by the use of a conditioner. . This is shown here in a scanning electron micrograph.
- This can be achieved either by the use of a dentine conditioner specially developed for this purpose or the liquid component of the glass-ionomer itself.
- The latter usually contain a solution of between 25-40% polyacrylic, tartaric and/or maleic acid.
- If a conditioner supplied by a manufacturer is used then follow the instructions provided carefully.
- The glass-ionomer liquid for conditioning can only be used if it contains the acid component of the glass-ionomer.
- The liquid component of some brands of glass ionomer contains only demineralized water, the acid being in freeze-dried form in the powder. This cannot be used for conditioning.
- When ever in any doubt, follow the manufacturer's instructions.

Slide 4.14 Dispensing the glass-ionomer liquid and powder 1

Points to be noted:

- The liquid bottle is carefully tipped upside down to avoid the formation of air bubbles.
- One drop of the liquid is allowed to drop at one corner of the mixing pad or slab.
- This drop usually contains air bubbles and is used for conditioning.

Slide 4.15 Dispensing the glass-ionomer liquid and powder 2

Points to be noted:

- Without releasing the pressure, the bottle is moved vertically towards the centre of the pad or slab.
- A second drop of liquid is dropped on the pad. That is usually bubble-free.
- Drops with bubbles must not be used for mixing the glass-ionomer since it will result in a mix being over-dry thereby compromising chemical bonding.
- The top of the liquid bottle is replaced.

Slide 4.16 Conditioning the cavity 3

Points to be noted:

- THe conditioner is applied to the cavity and pits and fissures using a cotton wool pellet for a minimum of 15 seconds or for the period of time specified by the manufacturers.
- Bond strength is affected if insufficient time is allowed for conditioning.
- The cavity and pits and fissures are then washed with pellets dipped in clean water and then carefully dried.
- Compressed air should not be used if glass ionomer is the restorative material since this can over-dry the tooth and reduce the chemical bonding of the glass ionomer.
- At this stage proper isolation is essential. Contamination of the conditioned tooth surface with saliva or blood will have a severe effect on the chemical bonding of the glass-ionomer. Therefore, if the conditioned tooth surface becomes contaminated then it is essential to wash, clean and condition it again.

Slide 4.17 Mixing the glass-ionomer 1

Points to be noted:

- Glass-ionomer for ART restorations is available from some manufacturers in both hand-mix and encapsulated forms.
- Encapsulated glass-ionomers are the easiest to use but are more expensive than hand-mix versions. They also require use of additional equipment that might not be available.
- The manufacturer's instructions concerning the mixing of glass-ionomer should always be followed to ensure a consistent mix.
- The hand-mix posterior glass-ionomers used with ART have a high powder to liquid ratio. This makes them a little more difficult to mix than conventional glass-ionomers.
- The amount of glass-ionomer required to fill the cavity and seal the fissures is estimated. Larger cavities often require double quantities of powder and liquid.

Slide 4.18 Mixing the glass-ionomer 2

Points to be noted:

- The powder bottle is shaken to ensure an even powder consistency.
- The measuring scoop provided by the manufacturer is used to take a full scoop of the powder. Excess powder is removed from the scoop by scraping the top surface against the lip of the bottle.
- The measured powder is then checked for any voids that would result in too little powder being used.

Slide 4.19 Mixing the glass-ionomer 3

Points to be noted:

- The powder is placed on the mixing pad or slab to one side of the centre.
- The top of the powder bottle is immediately replaced to prevent the powder from taking up water from the atmosphere.

Slide 4.20 Mixing the glass-ionomer 4

Points to be noted:

- The powder and liquid are spatulated until a consistent mix has been achieved. This must be completed within the mixing time advised by the manufacturer. The working time of glass-ionomers is temperature dependent. It sets more slowly in cold temperatures and faster in high temperatures.
- With experience the operator or assistant will be able to judge whether the consistency of the final mix is correct or not. Overly dry or thin mixes should not be used since they will compromise the success of the restoration. The consistency of the final mix does however vary between different manufacturers.
- It is helpful to have a trained assistant to mix the glass-ionomer. This allows the operator to concentrate on moisture control.

Slide 4.21 Restoring the cavity and filling the pits and fissures 1

Points to be noted:

- The mixed glass-ionomer must be used promptly since any delay will compromise chemical bonding to the tooth surface.
- The glass-ionomer is inserted into the cavity in small increments using the rounded end of the applier/carver instrument.
- Where possible, the glass ionomer should be packed around the margins of the cavity particularly under any overhanging enamel before filling the central portion of the cavity. This helps to prevent air bubbles from being incorporated into the restoration.

Slide 4.22 Restoring the cavity and filling the pits and fissures 2

Point to be noted:

The cavity is overfilled and then additional glass-ionomer is placed into any pits and fissures adjoining the cavity.

- A small amount of petroleum jelly is rubbed onto the gloved index finger.

Slide 4.23 Restoring the cavity and filling the pits and fissures 3

Points to be noted:

- The gloved index finger is then used to press the glass- ionomer firmly into the cavity, pit and fissures.
- The ball of the index finger is rolled slightly bucco-lingually and then mesio-distally so that material is spread over the whole occlusal surface. This is called "the press-finger technique".
- After a few seconds, the index finger is moved sideways to prevent the restorative material from lifting out of the cavity or pits and fissures.

Slide 4.24 Restoring the cavity and filling the pits and fissures 4

Points to be noted:

- The press-finger technique results in excess glass-ionomer being displaced to the outer margins of the occlusal surface.
- This excess should be quickly removed with either the carver instrument or the large excavator. Make sure that the ART restoration is not dislodged.

Slide 4.25 Adjusting the bite 1

Points to be noted:

- When the glass-ionomer has semi-hardened it is important to check the bite.
- The bite is checked by asking the patient to bite from side to side on articulating paper placed on the surface of the restoration.
- Care should be taken to ensure that the patient does not bite on the cotton wool rolls isolating the teeth.

Slide 4.26 Adjusting the bite 2

Points to be noted:

- Any parts of the restoration that are too high are identified by coloured marks on the restoration.
- These areas are then be adjusted using the carver instrument and the bite is then rechecked and further adjusted as necessary.
- The restoration is then painted with varnish or with petroleum jelly.
- The cotton wool rolls are removed.

Slide 4.27 Restorative procedure is completed

Point to be noted

- The restoration procedure is now finished and the patient is asked to refrain from eating for at least an hour.

Slide 4.28 Caution in restoring the cavity 1

Point to be noted:

- Placing larger parts of glass-ionomer material into the cavity and or insufficient condensing may cause voids in the restoration.

Slide 4.29 Caution in restoring the cavity 2

Point to be noted:

- Insufficient condensing and insufficient care in placing glass-ionomer under overhangs may cause voids at the dentine - glass-ionomer interface. There will be no adhesion at that spot.

Slide 4.30 Properly restored cavity using ART

Points to be noted:

- Good adaptation of glass-ionomer to the cavity walls.
- Good packing of glass-ionomer in the cavity.

3. Restoring multiple-surface cavities

Slide 4.31 *Restoring Multiple-Surface Cavities Using ART*

Points to be noted:

- The ART approach has only been validated for one-surface restorations using glass-ionomers.
- Since studies evaluating multiple-surface ART restorations with various adhesive materials are currently in progress, the clinical outcomes cannot be stated precisely.
- There are many situations however where there is no alternative to placing a multi-surface ART restoration i.e. the only alternative is often to do nothing.
- The approach to preparing multiple-surface ART restorations closely follows that for single-surface restorations such as the use of a dental hatchet to open de cavity. Specific points to be observed are as follows:

Slide 4.32 Removal of carious tissue with excavators

Point to be noted:

- Removal of carious tissue follow the same principles as that for one-surface restorations.

Slide 4.33 Use of a matrix band

Points to be noted:

- Where a multiple-surface restoration is adjacent to another tooth, such as one involving a proximal surface in posterior teeth, a matrix band held in place with a wedge should be used interproximally.
- This prevents the adhesive restorative material from adhering to the adjacent tooth, it gives the restoration shape, and avoids the production of an overhang.

Note also:

- Multiple-surface restorations often require more restorative material than single-surface restorations. A careful assessment of the amount required should be made before mixing up the restorative material.
- In the event of an underestimation of material required, the existing material should be pressed into the proximal part of the cavity as much as possible. A second mix of glass ionomer is then made to complete the restoration. It is important to avoid contaminating the first mix with saliva while the second mix is being prepared since this will prevent adhesion between the mixes.

(On this slide the occlusal cavity preparations has been filled.)

Slide 4.34 Adjusting the marginal ridge

Points to be noted:

- If glass-ionomer is being used as the restorative material, it is advisable to avoid excessive occlusal loading of the restoration in the region of the marginal ridge.
- This area should be carved so as to be just out of contact with the opposing tooth.

4. ART based fissure sealants

Slide 4.35 *ART based fissure sealants*

Points to be noted:

- The ART approach to the treatment of cavitated carious lesions involves both the filling of the cavity and the sealing of the adjacent caries-susceptible pits and fissures with an adhesive restorative material. In doing so, ART combines both a preventive and restorative procedure.
- The objective of sealing the fissures is to prevent and/or arrest fissure caries.

Slide 4.36 Indications for sealants 1

Points to be noted:

- A sealant is indicated where there is caries of the fissures restricted to the enamel.
- Sealants are indicated in caries-free teeth with a deep pit and fissure morphology, or in patients who are assessed to be at high risk to caries.
- The indiscriminant use of sealants in individuals and in teeth at low risk of caries is not recommended on the basis of overtreatment and cost.

Type of sealant

Points to be noted:

- In the dental practice environment where moisture control is usually optimal, resin based sealants have been shown to be a highly effective.
- These currently remain the sealant of choice.
- But, any contamination of the tooth surface with moisture will affect the retention of a resin-based sealant.
- Since glass ionomer sealants are tolerant of moisture they can be used in situations where moisture control might be less than optimal such as in young children, when caries susceptible teeth have just erupted, or in outreach situations.

Type of glass ionomer sealant

Points to be noted:

- Glass ionomers specifically marketed as sealants usually have a thin consistency so the material can be flowed into pits and fissures in a manner akin to resin based sealants.
- The ART approach for pits and fissure sealants uses the same 'putty-like' glass-ionomers as used for restorations.
- The retention of glass-ionomer sealants is greatest in the deeper pits and fissures which are also those that are most at risk for decay.
- In contrast, glass-ionomer sealants may be lost rather quickly in shallow pits and fissures.

For ART sealants the procedure closely follows that used for ART except that cavity preparation is not undertaken. Thus, techniques of isolation, cleaning, conditioning and filling of the pits and fissures remain identical as follows:

Slide 4.37 Isolation

Slide 4.38 Removal of plaque and food debris from the deepest parts of the pits and fissures with an caries probe

Slide 4.39 Conditioning for the specified time

Slide 4.40 Wash the pits and fissures using wet cotton wool pellets and then drying

Slide 4.41 Application of glass ionomer to all pits and fissures

Slide 4.42 Pressing the glass-ionomer mixture into the pits and fissures with the press-finder technique

Slide 4.43 Excess of mixture after use of 'press-finger' technique

Slide 4.44 Removal of visible excess of mixture

Slide 4.45 Adjusting the bite until comfortable

Slide 4.46 Application of a layer of petroleum jelly or varnish

Trainers guide to ART training courses

Module 5 - Survival of single-surface ART restorations and sealants placed as part of the ART approach

This module comprises a series of overhead transparencies, numbered 1-30. The module describes the criteria used to assess ART restorations and sealants placed as part of the ART approach and short-term survival results. This is an important module for those who wish to research the efficacy of ART restorations in his or her country or region. Comparisons with results of conventional restorations made in the traditional way are provided.

Time requirements for this module:

- one hour

General introductory statements to the module:

Read chapter 5 in the book by J.E. Frencken and C.J. Holmgren entitled: *Atraumatic Restorative Treatment (ART) for dental caries.* It provides the necessary background information needed to teach this module. Additional literature is provided in the references chapter.

ART COURSE

SURVIVAL OF ART RESTORATIONS AND SEALANTS PLACED AS PART OF THE ART APPROACH

SURVIVAL OF SINGLE-SURFACE ART RESTORATIONS

Which criteria have been used to evaluate ART restorations?

From the outset, it was considered important to design specific criteria. These would be able to:

- detect potential weaknesses in the approach
- be pragmatic, easy to use and reproducible
- identify problems associated with the glass-ionomers used.

Evaluation criteria for ART

- Wear at the margin of restorations and marginal breakdown is measured with a CPI probe that has a ball-end of 0.5 mm.
- The cut-off point of success and failure is set at 0.5 mm.

Table 1. Evaluation criteria for ART restorations

Score	Criterion
0	Present, good
1	Present, slight marginal defect for whatever reason, at any one place which is less than 0.5 mm. in depth. *No repair is needed.*
2	Present, marginal defect for whatever reason, at any one place which is deeper than 0.5 mm. *Repair is needed.*
4	Not present, restoration has (almost) completely disappeared. *Replacement is needed.*
5	Not present, other restorative treatment has been performed.
6	Not present, tooth has been extracted.
7	Present, wear and tear gradually over larger parts of the restoration but is less than 0.5 mm. at the deepest point. *No repair is needed.*
8	Present, wear and tear gradually over larger parts of the restoration which is deeper than 0.5 mm. *Repair is needed.*
9	Unable to diagnose

Restorations that have survived are scored by codes: 0,1,7;
those that have failed are scored by codes: 2,4,8;
those that are unrelated to survival and failure are codes:
5,6.

How well do ART restorations perform?

ART restorations in the permanent dentition

Table 2. Overview of survival of single-surface ART restorations in the permanent dentition

Country	Period	Operator	Material	Age (yrs)	N. at last evaluation	Survival (%) years		
						1	2	3
Thailand	1991-94	D, DT	ChemFil	7-58	144	93	83	71
Cambodia	1993-96	DTstud	Fuji II	12-17	39	78	-	59
Zimbabwe	1993-96	D, DT	ChemFil Superior	13-16	197	93	89	85
Zimbabwe	1994-97	D, DT	Fuji IX	13-16	206	99	94	88
Poland	1994-97	D	Fuji IX			-	-	94
Zimbabwe	1995-97	D, DT, DT stud	Fuji IX	13-16	156	95	92	-
Pakistan	1995-97	D	Fuji IX	6-16	234	98	94	
China	1996-99	DT	Ketac Molar	12	253	97	93	89
Hong Kong	1995-97	D	ChemFil Superior / Fuji IX	17-49	92	98	93	
South Africa	1997-98	D, DT	Fuji IX / Ketac Molar	6-11	108	94		
China	1997-98	D	ChemFlex / Fuji IX	6-14	110	96		
Latvia	1998-99	D	ChemFlex	8-14	28	100		
Tanzania	1998-99	D	Fuji IX	8-15	238	96		

D Dentist
DT Dental Therapist
DTstud Dental Therapy student

ART restorations in the permanent dentition - 1

Outcomes of ART studies are to some extent dependent upon the *material used* and *operator experience*.

What are these material considerations?

- The early ART studies made use of glass-ionomers that were manufactured for use in non-stress bearing situations such as cervical cavities.
- Dental materials manufacturers produced glass-ionomers specially formulated for ART. These were reported to be stronger and more wear resistant. They have been used in the more recent ART studies and most probably play a role in the improved survival rates seen in these studies.
- Wear of more than 0.5 mm. was unexpectedly low (1.2 - 2.5% of restorations assessed).

ART restorations in the permanent dentition - 2

What are these operator considerations?

Studies of the outcomes of traditional dental treatment often report an operator effect on the success of treatment: ART is no exception.

- **Cambodia**: a combination of factors contributed to the results achieved
  - ART treatment was performed by *dental therapy trainees* who had little experience in performing any type of oral care.
  - The materials used (Fuji II) belonged to the group of earlier glass-ionomers. They were not good in stress-bearing situations
  - The treatment protocol did not included conditioning of cavities.
- **Zimbabwe**: senior dentists performed better than junior dental therapists.
- **Pakistan**: one dentist had lower success rates compared to the other four dentists.

- **China and Thailand**: no operator effect observed

Applicability of ART

How effective are existing hand instruments?

Dental hatchet in widening the opening of dentine lesions.

- **Zimbabwe**: it was possible to treat 84% of the dentine lesions that were judged to be in need of treatment. Access was difficult to dentine lesions that were present in approximal surfaces of anterior teeth. This study was carried out in a low-caries prevalance population (41% and a mean DMFT score of 1.1).

- **Syria**: Of the total number of carious surfaces in deciduous dentitions of 6-7 year olds that were in need of a restoration, 90% were diagnosed as being treatable through ART. In 50% of carious surfaces diagnosed as requiring a restoration in the permanent dentition of these children, the examiners had indicated that ART could be applied.

How well are hand instruments accepted by care receivers?

Hand instruments versus rotary instruments

- **Pakistan**: hand instruments used in ART with glass-ionomer were better accepted than rotary instruments and amalgam.

Applicability of ART

How does the size of cavity preparation made with hand instruments compare with rotary instruments?

Pakistan:

- Using cylindrical insets, the size of preparations were measured in mm^3. The mean size of restorations produced by hand (ART) and rotary (drill) instrumentation was 5.1 and 6.1 mm^3, respectively.

What can be said about discomfort felt during treatment with ART?

Pakistan:

- Restorations placed using ART were compared to those placed using conventional procedures.
- Patients aged 6-16 years were asked whether or not the treatment they received was painful.
- Operative sensitivity was less (19%) in restorations placed with ART than in those placed using the drill and amalgam (36%).
- Discomfort was higher in large than in small size preparations.

China:

- On average 12-year-old children were asked whether the ART treatment was painful.
- More than half of them indicated that they did not feel any pain or discomfort during treatment.
- A little discomfort had been experienced by 40% of the children.

Applicability of ART

What can be said about post-operative sensitivity?

Zimbabwe:

- Observed in 5-6% of the ART restorations placed. This information was collected 2-4 weeks after placement. At that time, sensitivity had disappeared for all but one of 197 restoration.

China:

- Observed in 5% of the ART restorations placed

How well is ART accepted by care receivers?

Zimbabwe:

- 95% of secondary school students were satisfied with the ART procedure and with the restoration(s) obtained
- 95% of secondary school students said that they would not hesitate to undergo the same treatment again if needed and would recommend it to their best friend.

China:

- Over 90% of on average 12-year olds were willing to receive ART restorations again should a need arise.

Have changes in treatment patterns occured due to the introduction of ART?

South Africa:

- Staff members had difficulties in treating rural primary schoolchildren since many were fearful of the dental treatment delivered through the mobile system.
- A year after the introduction of ART, the percentage of extractions was reduced by 17% for permanent and by 36% for primary posterior teeth compared to the year prior to ART.
- Also the percentage of amalgam restorations was reduced: by 16% in permanent and 1% in primary teeth.
- Conversely, restorative care increased by 33% in permanent and by 37% in primary posterior teeth.
- This positive change was ascribed to the patient-friendly nature of ART which had reduced fear, mainly because of the absence of injections, and thus had increased children's acceptance of restorative care.
- Another advantage was the simplified infection control, very relevant in an area with a high prevalence of HIV and hepatitis.

How do ART restorations compare to conventional restorations in the permanent dentition?

- As discussed, the quality of a restoration is dependent on a number of factors that are material, operator and patient related.

- Longevity of amalgam and composite resin restoration varies tremendously and ranges from 3 to more than 20 years.

Mean survival of amalgam and composite resin restorations in general practice

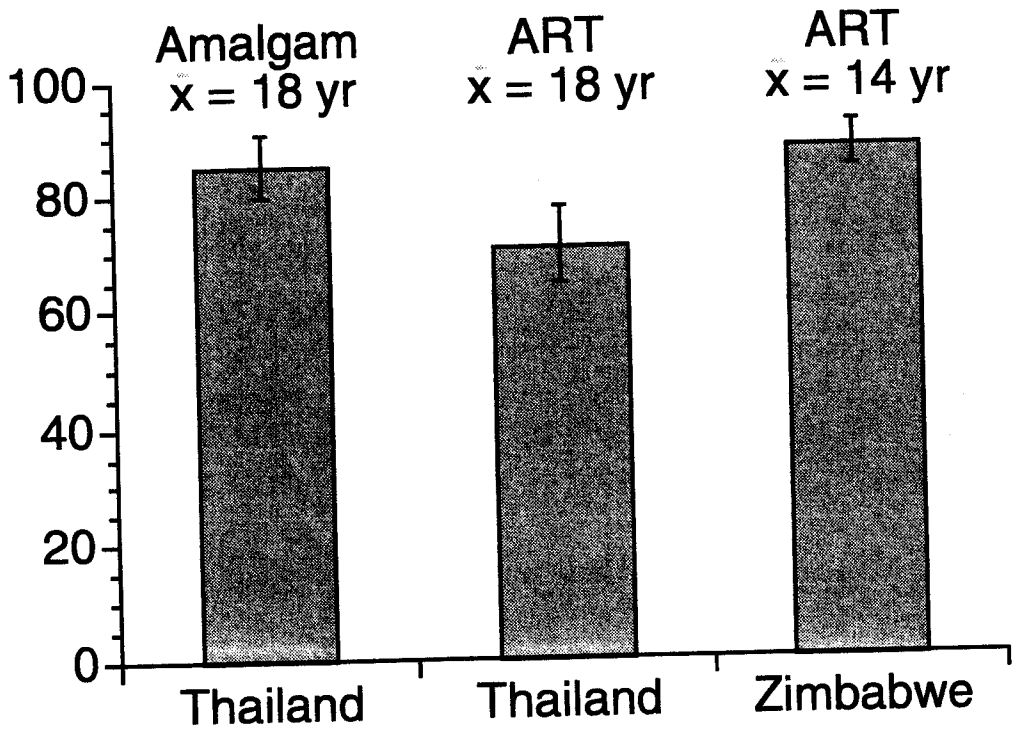
	Average life of restoration in years	
	Mjör, 1992	Mjör et al, 1997
Amalgam - Single surface - Multiple surfaces	 10 8	 8 6
Composite resin - Single surface - Multiple surfaces	 7 4	 6 3

In general dental practice, amalgam and composite restorations survive on average between 6 and 10 years

(Review by Downer et al., 1999)

How do ART restorations compare to conventional restorations in the permanent dentition?

Comparison of survival of single-surface ART restorations and amalgam restorations under field conditions



Thailand: mean age of the study group was 18 years.
Zimbabwe: mean age of the study group was 14 years.

How do ART restorations perform in the deciduous dentition?

Overview of survival of single-surface ART restorations in the deciduous dentition

Country	Period	Operator	Material	Age (y)	Number at last evaluation	Survival (%) year		
						1	2	3
Thailand	1991-94	D, DT	ChemFil	6-8	71	79		49*
Poland	1994-97	D	Fuji IX					100
China	1997-99	DT	Ketac Molar	3-4	73	87	72	
Syria	1997-98	D	Fuji IX / Ketac Molar	6-7	294	92		
China	1997-98	D	ChemFlex / Fuji IX	6-9	58	93		
South Africa	1998-99	D	Fuji IX	6-9		96		
South Africa	1998-99	D	Dyract	6-9		98		

D = Dentist, DT = Dental Therapist

*Loss-to-follow up was 59%

- More studies are needed to arrive at a conclusion as to the survival of ART restorations using glass-ionomers in the deciduous dentitions

How well do ART restorations perform?

Conclusions - 1

- A very large proportion of dentine lesions can be treated using the ART approach.
- Single-surface ART restorations were smaller in size than those produced in the conventional way, using rotary instruments.
- ART approach caused less discomfort than the conventional approach.
- The survival of the more recently placed single-surface ART restorations was higher than that of ART restorations placed in the early studies.
- The survival of single-surface ART restorations after 3 years with newer glass-ionomers was comparable to that of single-surface conventional restorations placed using amalgam after 3 years.
- The survival of single-surface ART restorations after 3 years with newer glass-ionomers was 88-89%.

How well do ART restorations perform?

Conclusions - 2

- More studies and of longer duration are needed to confirm these findings.
- ART needs to be considered as a caries treatment modality that is benefiting people.
- ART should be taken seriously by the dental profession.
- Educational courses need to be organised prior to applying the approach in the field and clinic.

SURVIVAL OF GLASS-IONOMER SEALANTS PLACED AS PART OF THE ART APPROACH

Which criteria have been used to evaluate glass-ionomer sealants placed as part of the ART approach ?

- Sealing as part of the ART approach has used glass-ionomer placed using the "press-finger" technique.
- A recent in-vitro study showed good penetration of glass-ionomer into the pits and fissures placed using the "press-finger" technique.
- The penetration was slightly better than of a composite resin sealant material placed using conventional means, i.e. flowed into the fissures.

Evaluation criteria for glass-ionomer sealants placed as part of the ART approach

Table 5. Evaluation criteria for glass-ionomer sealants

Score	Criteria
0	Present, good seal.
1	Present partly, visible pits and/or fissures are free of active caries. *No treatment is needed.*
2	Present partly, visible pits and/or fissures show signs of active caries. *Treatment is needed.*
3	Not present, pits and/or fissures show no signs of (active) caries. *No treatment is needed.*
4	Not present, pits and/or fissures show signs of active caries. *Treatment is needed.*
9	Unable to diagnose.

Sealed surfaces:

- Caries absent, scored by codes 0,1,3;
- Caries present, scored by codes 2,4.
- Sealants retained, scored by codes 0,1,2
- Sealants lost, scored by codes 3,4.

How well do sealants, placed as part of the ART approach, perform - 1?

- The success of sealants must be considered in two ways.
- While retention rate has routinely been used as a criterion for success, the ultimate success of a sealant should be expressed in terms of caries prevention.
- That is the reason why sealants are placed in the first place.
- Thus, biological outcomes should take precedence over mechanical outcomes.

How well do sealants, placed as part of the ART approach, perform? - 2

Considering sealant retention

Zimbabwe:

- Different selection criteria were used.
- Both studies sealed only tooth surfaces that had early enamel carious lesions that were either active or inactive.
- In addition, the most recent study only sealed such surfaces in high-risk individuals that had patent fissures.

China:

- Sealants were placed in a low caries risk child population.

How well do sealants, placed as part of the ART approach, perform? - 3

Overview of survival percentages of partially and fully retained sealants in the permanent dentition

Country	Period	Operator	Material	Age (y)	N. at last evaluation	Survival (%) years		
						1	2	3
Thailand	1991-94	D, DT	ChemFil	7-58	107	78	-	50
Zimbabwe *	1993-96	D, DT	ChemFil Superior	13-16	314	75	63	50
Zimbabwe **	1994-97	D, DT	Fuji IX	13-16	66	90	86	71
Hong Kong	1995-97	D	ChemFil Superior / Fuji IX	12	87	82	66	
China	1996-99	DT	Ketac Molar	12	178	89	79	72

D Dentist
DT Dental Therapist

* Sealants were placed in surfaces with signs of early enamel carious lesions
** Sealants were placed in surfaces with signs of early enamel carious lesions and patent fissures (high caries risk group)

How well do sealants placed as part of the ART approach, perform? - 4

Considering caries prevention

- Sealing (in)active early enamel carious lesions with glass-ionomer as part of the ART approach seems to be beneficial.
- In Zimbabwe, after 3 years, comparable surfaces that were not sealed had a 4 times higher chance of developing a dentine lesion than those that were sealed after 3 years.

How well do sealants placed as part of the ART approach, perform? - 5

Overview of caries free sealed surfaces in the permanent dentition

Country	Period	Operator	Material	Age (y)	N. at last evaluation	Caries free surfaces (%) years		
						1	2	3
Zimbabwe*	1993-96	D, DT	ChemFil Superior	13-16	314	99	96	92
Zimbabwe	1994-97	D, DT	Fuji IX	13-16	66	98	98	96
Hong Kong	1995-97	D	ChemFil Superior / Fuji IX	12	87	-	95	
China	1996-99	DT	Ketac Molar	12	178	100	99	98

How well do sealants placed as part of the ART approach, perform? - 6

Operator considerations

- As with ART restorations, an operator effect was observed in the earlier Zimbabwe study.
- Younger, less experienced operators performed less well as more experienced ones.

- There was no operator effect observed amongst the 5 dental therapists in the China study

How do glass-ionomer sealants compare to composite resin sealants - 1?

Retention considerations

- Originally, a low powder/liquid glass-ionomer was used.
- Sealants using the low powder/liquid glass-ionomers had a very low retention.
- Higher powder/liquid glass-ionomers were used for ART related sealants.
- It was pressed into pits and fissures using the "press-finger" technique. A higher retention percentage was the result.
- In general, the retention of resin based sealants is higher than that of glass-ionomers.

How do glass-ionomer sealants compare to composite resin sealants? - 2

Caries prevention

- The prime reason for placing sealants is to prevent caries.
- Caries development in sealed surfaces with early enamel lesions after 3 years with glass-ionomer was low.
- The overall caries preventive effect of sealants seems to be dependent on the caries activity in the mouth.
- The literature is inconclusive as to which of the sealants i.e. composite resin or glass-ionomer, prevents caries best.

ART related glass-ionomer sealants

Conclusions

- The newer glass-ionomer with a higher powder/liquid ratio are retained longer than the earlier glass-ionomers with a low powder/liquid ratio.
- This resulted in 71-72% of pits and fissures being partially or fully filled with glass-ionomer material after 3 years.
- Despite the limited retention, glass-ionomer sealants were able to prevent dental caries. Surfaces that were not sealed had a four times higher chance of developing caries than surfaces that had been sealed.
- More studies are needed to test different materials as sealants in addition to composite resin and glass-ionomer sealant materials.

Trainers guide to ART training courses

Module 6 - Failed ART restorations - Causes and Management

This module comprises a series of overhead transparencies, numbered 1-21 and 12 slides. The module describes the type of failures that have occured and discusses reasons why ART restorations have failed. It is essential that failures are indentified and rectified. Therefore, the management of the various types of failure is provided.

Time requirement for this module

- one hour

General introductory statements to the module:

Read chapter 6 in the book by J.E. Frencken and C.J. Holmgren entitled: Atraumatic Restorative Treatment (ART) approach dental caries. It provides the necessary background information needed to teach this module. Additional literature is provided in the references chapter.

ART COURSE

FAILED ART RESTORATIONS -

CAUSE AND MANAGEMENT

Failed restorations

- Failures in dentistry occur irrespective of the nature of treatment provided.
- In common with all restorative procedures, failures will occur from time to time with the ART approach.
- It is important to minimize the number of failures.
- This is achieved by:
    - restricting the use of the ART approach to situations where it is known to be effective
    - knowing how to manage failures by the most appropriate means when they have occured.

What are the perceived reasons for failure of ART restorations?

Caries

- Diagnosing the onset of caries at the margins of ART restorations is not always easy.
- When diagnosed it could be caries that was left behind initially or newly developed caries.
- In the Thailand study, caries was observed in 33% of the **failed** ART restorations, predominantly in combination with another defect.
- In the 1993-96 Zimbabwe study, caries was seen in 21% of the **failed** ART restorations.
- However, in the 1994-97 Zimbabwe study, caries was seen in only 4% of the **failed** ART restorations. In this study, more attention was given to determine the reasons for failure of the restoration. Failures were attributed almost equally to problems associated with the material or the operator.
- In the 1996-99 China study, caries was observed in 1.5% of the ART restorations assessed at 3 year.
- There seems to be a decrease in the proportion of caries as a reason for failure over time.

What are the perceived reasons for failure of ART restorations - 2?

Material related reasons

- The mechanical strength of the glass-ionomers that fractured (most frequent cause for failure).
- Excessive wear of the glass-ionomer resulting in exposure of the enamel of greater than 0.5mm at the margin (a rare cause for failure).

What are the perceived reasons for failure of ART restorations - 3?

Operator related reasons

- Incomplete removal of dentine caries that inhibited proper bonding of the adhesive material and resulting in loss of the restoration.
- Inadequate conditioning.
- Inadequate isolation of the operating site.
- Improper mixing of the glass-ionomer resulting in the mixture being too dry or too wet or containing too many air bubbles.
- Poor insertion of the glass-ionomer filling material into the cavity, particularly in small cavities, resulting in sub-surface voids which eventually become exposed.

These results seem to indicate that those who have more experience in performing ART restorations produce better results.

How can the number of failures be reduced?

Material related failures

- The mechanical strength of glass-ionomers needs to be improved or a material more capable of withstanding stress should be used.

Operator related failures

- Operators require an in-depth understanding of the setting chemistry and handling conditions of the restorative material in use.
- Operators should posess sufficient skills and motivation to produce quality ART restorations. The latter is obtained not only by reading the educational information available, but also through attending a training course on ART.

What are the reasons for replacement of amalgam and composite resin restorations in general practice - 1?

- A large proportion of restorations placed by oral care workers comprise replacement of existing restorations.
- It has been estimated that replacements constitute between 33% and 61% of all restorations performed.
- These estimates are of course dependent on a number of factors such as:
    - age and type of restoration
    - oral hygiene of patient
    - age of patient
    - material used.

What are the reasons for replacement of amalgam and composite resin restorations in general practice? - 2

- The predominant reason given for failure of both amalgam and composite resin restorations in general practice is secondary caries.
- Other reasons why amalgam restorations fail are marginal defects and bulk fractures.
- Composite resin restorations fail because of marginal defects and discoloration.

Conclusions about restoration failures

Concerning ART restorations

- Few ART restorations fail because of excessive wear (>0.5 mm.).
- Secondary caries as a reason for failure was more frequent in the earlier than the latter ART studies.
- The mechanical characteristics of glass-ionomer as a restorative material should be improved.
- Oral care workers should receive training through an ART course in order to reduce failure rate.

Concerning restorations in general dental practice

- A large proportion of restorations placed in the general dental practice comprises replacement restorations.
- Secondary caries is the main reason for amalgam and composite resin restorations to fail.

How to manage a failed or defective ART restoration?

A restoration may be considered to be unacceptable or unsatisfactory for a number of reasons:

- the restoration has shown severe wear,
- there is a fracture within the restoration,
- the restoration is completely or partly missing,
- a carious lesion has developed in the adjacent fissure or surface.

Principles of doing replacements

- Identify the probable cause/s of failure.
- For example, if the restoration has failed due to a faulty application of the ART approach, then the approach can be used again. But this time care should be taken to apply the procedural steps correctly. This means adequate removal of dentine caries, conditioning, mixing, insertion etc.
- If the failure is due to the ART approach being used in a situation where it is inappropriate, then an alternative, more appropriate approach should be considered. This of course depends on local circumstances.

How to manage a failed or defective ART restoration - 1?

1. THE RESTORATION HAS SHOWN SEVERE WEAR

Cause

- The wear of ART restorations placed with the newer glass ionomer materials has been shown to be slow.
- When repair is indicated, either glass-ionomer or another adhesive material can be used.

Management

- The existing restoration is retained but the area of wear is repaired.
- If glass ionomer is used, ensure that all the surfaces of the tooth and the remaining restoration are clean.
- Apply dentine conditioner over the existing restoration and the cavity walls, wash etc.
- Then place a new layer of glass-ionomer over the top.
- Apply the "press finger" technique and check that the restoration is not too high.

How to manage a failed or defective ART restoration - 2?

2. THERE IS A FRACTURE WITHIN THE RESTORATION - 1

Cause

- This most commonly happens if ART is used to treat a large multiple-surface cavity using glass-ionomer.
- Often the restorative material is then not strong enough. The cavity should initially have been restored using another adhesive restorative material.
- Insufficient removal of carious dentine and enamel may have caused the material to fracture.
- The use of ART in multiple-surface cavities should not currently be considered a routine application.

How to manage a failed or defective ART restoration - 3?

2. THERE IS A FRACTURE WITHIN THE RESTORATION - 2

Management

- Depending on the cause of the fracture and the operating facilities, the ART restoration can be replaced rectifying earlier mistakes.
- In many cases, another form of restoration should be performed.
- The method used to repair a fracture very much depends on the location of the fracture line and the mobility of the fractured part.
- If the fractured part is loose and can be removed, repair the defect as described for 'part of restoration missing'.
- However, if the fractured part cannot be removed, repair through ART is not normally possible. The fractured part needs to be removed with a rotary instrument.

How to manage a failed or defective ART restoration - 4?

3. RESTORATION IS COMPLETELY OR PARTLY MISSING - 1

- If a restoration is completely missing it could be either due to the failure of the ART approach itself or to failure to apply the approach correctly.
- Failure of the ART approach is most likely to occur when ART has been used in a situation where outcomes are less predictable.
- For example, in multi-surface cavities. If such cavities need to be restored it is recommended to use another adhesive restorative material. Alternatively, the replacement ART restoration should be adjusted at the finishing stage to be slightly out of occlusion.

How to manage a failed or defective ART restoration - 5?

3. RESTORATION IS COMPLETELY OR PARTLY MISSING - 2

Cause

The most common reasons for ART restorations to be completely missing include the following:

- insufficient carious dentine had been removed which inhibited proper adhesion of the material
- contamination of the cavity with saliva or blood during the restorative procedure
- failure to condition or inadequate conditioning
- incorrectly mixed material
- improper insertion of material in the cavity, particularly in small cavities, resulting in sub-surface voids

Management

Restoration is completely missing

- Whatever the reason may be, clean the cavity completely, apply dentine conditioner if a glass-ionomer is used, and refill the cavity properly.

How to manage a failed or defective ART restoration - 6?

3. RESTORATION IS COMPLETELY OR PARTLY MISSING - 3

Management

Restoration is partly missing

- If most of the restoration is missing, an attempt should be made to remove the remaining material. The tooth should then be restored with an appropriate restorative adhesive material (replacement).

- If only a small part of the restoration is missing, a repair should be done. The cavity and surrounding tooth surface and/or remaining restorative material should be cleaned. The cavity and remaining restoration is then conditioned. A new mixture of glass-ionomer is then inserted into the deficiency

How to manage a failed or defective ART restoration - 7?

4. A CARIOUS LESION HAS DEVELOPED IN THE ADJACENT FISSURE OR SURFACE

Cause

- Not all carious tooth tissues were removed at the time of preparation and further caries development has lead to exposing part of the initial carious.
- A new carious lesion has developed as a result of bacterial activity at the restoration margin or elsewhere on the tooth.

Management

- Gain access to the decayed area.
- Open the cavity as much as necessary.
- Remove carious dentine with an excavator taking special care at the enamel-dentine junction.
- After this, clean, condition and fill the new cavity adjacent to the restoration according to the standard ART procedures.

WHAT TO DO WITH FAILED OR DEFECTIVE ART- RELATED SEALANT - 1?

Situations

- The sealant part of ART restorations might become partially or completely lost.
- Also ART related sealants might become partially or completely lost.

Cause

- Application of glass-ionomer in shallow pits and fissures.
- Inadequate handling of material.
- Insufficient adjustment of the height of the restoration.
- Insufficient bonding of the glass-ionomer material used.

WHAT TO DO WITH FAILED OR DEFECTIVE ART RELATED SEALANT? - 2

Management

- If sealants have become partially or completely lost, determine if the exposed pits and fissures have signs of caries.
- If the pits and fissures are hard and there is no cavitation, then no additional treatment is required. Try to monitor the tooth for caries in the long term.
- If the surface is carious and the lesion is small without cavitation, reseal the lesion.
- If there is frank cavitation then a small sealed restoration should be placed.
- Resealing with glass-ionomer is done in the same way as described for initial sealing.
- If a cavity continues to extend under an old sealant, follow the instructions for the one-surface cavity procedure.

Slides showing repair of defected ART restorations

Repair of ART restoration due to marginal defect

Slide 6-1 Tooth #37. Sealant occlusal ART restoration after 2 years. Defect is visible in the centre of the surface. Adjacent pits and fissures were sealed. Evaluation score is 2. The reason for failure is most probably because of incomplete filling of the tooth preparation at start, as a result of entrapped air bubbles.

Slide 6-2 Cavity has been cleaned following the normal procedure for cavity cleaning using ART.

Slide 6-3 Repaired sealant ART restoration 1 year later.

Slide 6-4 Tooth #27. Sealant occlusal ART restoration after 2 years. Defect is visible at the periphery of the surface. Evaluation score is 2. Reason for failure is unknown.

Slide 6-5 Cavity has been further opened following the normal procedure for cavity cleaning using ART.

Slide 6-6 Repaired sealant ART restoration.

Repair of ART restoration due to wear

Slide 6-7 Tooth #46. Sealant buccal ART restoration after 3 years. Defect is obvious. Evaluation score is 8. The reason for failure is most probably because of incomplete filling of the tooth preparation at start, as a result of multiple layers of filling material. It seemed that the top layer was of insufficient quality.

Slide 6-8 Cavity has been cleaned following the normal procedure for cavity cleaning using ART.

Slide 6-9 Repaired sealant ART restoration. The top layer has been placed over the conditioned old filling material. Same filling material was used.

Dentinal lesion under glass-ionomer sealant

Slide 6-10 Tooth #36. Glass-ionomer sealant dislodged after 3 years. Dentinal lesion is present in occlusal central pit.

Slide 6-11 Cavity has been opened en cleaned according to the ART procedure.

Slide 6-12 Cavity preparation is filled according to ART

Trainers guide to ART training courses

Module 7 - Practical experience in the handling and mixing of adhesive materials for use in the ART approach.

Module objectives:
This module comprises of some guidelines on how best to train participants in mixing and handling adhesive restorative materials. This module is practical in nature.

Time requirements for this module
- one hour

General introductory statements to the module

Most of this module is devoted to mastering the technique of hand-mixing glass-ionomers. This is because glass-ionomers have been used in most of the studies on ART and as the hand-mix version of this material is suitable for use in outreach situations. If capsulated glass-ionomers and resin containing adhesive materials will be used, the handling of these material should be demonstrated, if needed

1. Glass-ionomers, powder and liquid

Requirements:
- set of powder, corresponding measuring scoop, liquid, spatula and mixing pad

Make sure that sufficient sets are available, e.g. one set for 2-3 participants. Start with demonstrating the proper manner of laying out the powder and liquid for mixing as explained in module 4. Use the manufacturer's instruction to mix the powder and liquid. Some manufacturers have produced a video film showing the mixing technique.

Salient points to note

- Most participants have difficulties in producing a good mixture of glass-ionomer the first time. They should be warned beforehand that this might take some practice. Mixing glass-ionomers is quite different from mixing ZnO-eugenol cement, which most participants master. In mixing glass-ionomers, one should strictly adhere to the measured powder to liquid ratio. We have noticed from previous classes that participants usually have difficulty initially in incorporating all the powder into the liquid. Obviously, this will lead to a runny mixture that is not acceptable. Also in the beginning, participants often spend longer than the allotted time for mixing. They may go on and on, as they are used to when mixing ZnO-eugenol cement. For participants who work with a chairside assistant, mixing powder and liquid may be something of the past.

- As a trainer, do not accept mixtures that are too dry or too wet. Give proper advice to the participants so that they can improve. Have the participants mix until they have shown the ability to produce a good mixture a number of times. This may take several attempts.

- Mixing glass-ionomers in hot and humid climates is more demanding than in temperate climates. The setting reaction is much faster. Make sure that mixing does not take too long.

2. *Glass-ionomers, capsulated*

Requirements:
- Capsules of powder and liquid
- Capsule pistol/gun
- Mixing machine

Glass-ionomer in capsules usually does not pose any difficulty in producing a standard mixture. While the price of the material is usually higher, its application is usually easier than for the handmix form.

Follow the manufacturer's instruction when demonstrating the use of the capsulated glass-ionomer.

3. *Resin-modified glass-ionomer*

There are two types: light and auto-cured. The requirements for showing the handling of these materials include:

Light-cured:
- Powder, corresponding measuring scoop, liquid, spatula and mixing pad
- Light-curing device

Auto-cured:
- powder, corresponding measuring scoop, liquid, spatula and mixing pad

The auto-cured resin-modified glass-ionomer cannot usually be used in outreach situations where lack of electricity might poses a problem. Furthermore, experiences in using this material as part of the ART approach is limited. Therefore, follow the manufacturers' instruction carefully when demonstrating how to mix these adhesive materials.

4. *Compomers and composite resins*

Requirements:
- compomer or composite resin material, capsules or tubes
- primer and bonding material
- application sticks
- light curing device
- water-air spray system

The use of resin containing adhesive materials will usually be restricted to the dental surgery.

References

- Frencken JE, Holmgren CJ. Atraumatic Restorative Treatment (ART) for dental caries. STIBOOK, 1999: chapter 2
- Manufacturers' instruction
- How to organize and run an ART training course - Module 4

Trainers guide to ART training courses

Module 8 - Practice of cavity cleaning and restoration placement using the ART approach on extracted teeth

Modules objectives:
This module comprises of guidelines on how to perform ART restorations on extracted teeth and on sharpening instruments. These practicals are performed in a room with the tables arranged in a square. This permits the trainer to easily go from one participants to another to give assistance and advise.

Time requirements for this module
- 3 hours, including break

ART restorations on extracted teeth
Requirements:
- extracted teeth with cavities. These cavities should not be too big, which unfortunately, is not always possible. If possible, mount these teeth beforehand in plaster of Paris.
- set of hand instruments
- materials needed for cavity cleaning such as, cotton wool pellets and water
- restorative material
- paper towels and petroleum jelly

Salient points to note
- Have the instruments and materials nicely arranged placed on a paper towel.
- Start with a demonstration on a cavity that is not too big. This will allow you to demonstrate the use of the hatchet.
- Stress the need to clean the dentine-enamel junction.
- Make sure that very thin enamel is removed.
- Pay special attention to cleaning the pits and fissures adjacent to the cavity.
- Do not accept mixtures that have an inadequate consistency.
- The 'press-finger' technique is difficult to perform on a multiple-surface cavity in an extracted tooth. It is only possible when a matrix holder is in place.
- Explain the procedures whilst demonstrating the various stages. Show the participants certain stages. Emphasis the need for a very good finger rest whilst using hand-instruments.
- The participants should place at least two restorations.
- If sufficient teeth with non-cavitated occlusal surface are available, then participants should also place a glass-ionomer sealant.

Sharpening hand instruments
Requirements:
- dental hatchet and excavator
- flat surfaced 'Arkansas' stone
- oil

Salient points to note

- Stress the utmost importance of working with sharp instruments.
- Utmost care must be taken when sharpening. Instruments should not be damaged by faulty positioning of the instrument.

References

- Frencken JE, Holmgren CJ. Atraumatic Restorative Treatment (ART) for dental caries. STIBOOK, 1999; pages 36-51
- How to organize and run an ART training course - Module 3 and 4.

Trainers guide to ART training courses

Module 9 - Practice of the ART approach on patients

Module objectives:
In this module, participants will place ART restorations and glass-ionomer sealants on patients. Experiences and possible problems encountered whilst placing ART restorations will be discussed at the end of the session. It is strongly advised to organize at least two half-day sessions. It is even better to organize three or four sessions. Participants will then leave the course with much more satisfaction and confidence.

Time requirements for this module
- 2-4 half days, depending on dental education and clinical experience of participants.

Requirements:
- pre-selected patients - preferably not young children.
- a treatment room. Can be a university clinic or a classroom in a school.
- sufficient sets of instruments and materials, including local aneasthesia
- water, soap and towels

Salient points to note
- Ask the participants to pair up to form a unit of operator and assistant. Each will do an ART restoration in turn.
- For adequate supervision and good guidance, a trainer/instructor should be responsible for not more than 6 units.
- Have the operator inform the patient what is going to happen
- Make notes of clinical situations that need discussion at the end of the day.

Round table discussion
At the end of the session experiences and problems encountered while placing ART restorations will be discussed. The trainer acts as the chairperson. The discussion is focused on a list of specific aspect of the ART approach. These aspects follow the chronologically steps of the ART procedure. They include experiences in: diagnosis of the carious lesion; opening of cavity with hatchet for access; cleaning the cavity with excavators; moisture control with cotton wool rolls; sensitivity felt by patients; conditioning the cavity and adjacent pits and fissures; mixing the material; application of material in cavity; removing of excess material; satisfaction by patients and operator. Keep the discussion strictly to this chronological sequences of steps. Make notes of the discussion. They will be needed the following day at the end of the 2nd session of practical training in performing the ART approach.

The same kind of discussion will take place after every practical session. Notes of previous discussions are then used to identify improvements.

Trainers guide to ART training courses

Module 10 - Free format discussion

Module objectives:
In this module, the use and integration of ART in a private practice and in an outreach situation is discussed. This topic may have been discussed during the first day. At that time, participants had no practical experiences in doing ART. Now they have and it is essential that they do not leave the course with only increased knowledge and skills of this approach to control dental caries, but that they also be able to place the approach in the overall oral health care services of a country.

Time requirements for this module
- 2 hours

The discussion is organized through group work. The trainer has constructed 2-3 questions. The responses are reported in a general session.

Requirements:
- Flip-over sheets or overhead transparencies
- colour markers

Salient points to note:
Outreach situations
- Try to arrange the groups such that people from the same area or the same country are together. They then can discuss the benefits of ART in the oral health care services of their own area/country.
- Identify the deficiencies in the oral health care services in the area or country first.
- Emphasis discussing how best to convince fellow health workers in decision-making positions in case it is decided to introduce ART.

Private practice:
- Have participants come up with case stories in which they think the ART approach is particularly helpful.
- Point to the fee structure and the charges for an ART restoration.

Trainers guide to ART training courses

Module 11 - Course evaluation

This is done through an open questionnaire. An example is enclosed. The results are to be reported to WHO/ORH in Geneva and WHO Collaborating centre in Nijmegen, the Netherlands using a standard form.

Time requirements
- half hour

Final remarks
If needed, the course can be extended with a session on 'how to carry out field studies on ART'. Guidelines on this topic are available at WHO/ORH and WHO Collaborating Centre, attn Dr. J. Frencken, P.O. Box 9101, 6500 HB Nijmegen, the Netherlands..