Caries Management by Risk Assessment: The Caries Balance

John D.B. Featherstone
Professor and Dean
E-mail jdbf@ucsf.edu
School of Dentistry
University of California San Francisco

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What is Dental Caries?
- Dental caries is tooth decay
- Specific bacteria (Streptococcus mutans, Streptococcus sobrinus, and lactobacilli) on the tooth surface feed on carbohydrates and make acids as waste products
- Acids travel into the tooth and dissolve mineral - if mineral loss is not halted or reversed a cavity is formed
- Dental caries is a transmissible bacterial infection

“White spot” lesion
Frank occlusal cavity
The Caries Balance

**Protective Factors**
- Saliva flow and components
- Fluoride, Calcium, Phosphate remineralization
- Antibacterials: chlorhexidine, xylitol, new?

**Pathological Factors**
- Acid-producing bacteria
- Frequent eating/drinking of fermentable carbohydrates
- Sub-normal saliva flow and function

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Featherstone, Community Dent Oral Epidem, 1999

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Pathological Factors

- Cariogenic bacteria: mutans streptococci (
  *S. mutans and S. sobrinus*) and lactobacillus species
- Frequency of ingestion of fermentable carbohydrates: sucrose, glucose, fructose, cooked starch
- Reduced salivary function (medication induced; radiation therapy; disease; genetic)

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Scanning Electron Micrograph of bacteria on a tooth surface

Acid producing bacteria are usually less than 1 percent of the total flora in the plaque

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Stay in balance to survive

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Protective Factors

- Saliva flow and components
- Fluoride, Calcium, Phosphate remineralization
- Antibacterials: chlorhexidine, xylitol, new?
**Streptococcus mutans** culture showing active cell division. *S. sobrinus* is similar. Sucrose leads to extracellular polysaccharides that stick the plaque together.

**Lactobacillus** culture. Lactobacilli species produce predominantly lactic acid from fermentable carbohydrates.

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**Mutans Streptococci**

This group of bacteria contains two primary species that appear in humans:

- **Streptococcus mutans** - almost universal
- **Streptococcus sobrinus** - virulent, high risk

Both species produce acids and can live in acid.

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**Clinical Study Results**

**NIH/NIDCR Grant**

**Caries Management By Risk Assessment**

1999-2004

Principal Investigator:
John Featherstone

Co-investigators:
Chuck Hoover, Stuart Gansky, Marcia Rapozo-Hillo, Kim Tran, Joel White, Jane Weintraub

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**Caries Management Study**

N=115

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<thead>
<tr>
<th>Conventional Treatment Plan</th>
<th>All Restorations Complete</th>
<th>Final Observations Radiographs DMFS</th>
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N=116

(ChX + F)

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<th>Baseline Observations</th>
<th>Saliva Sample</th>
<th>MS, LB and F Radiographs</th>
<th>DMFS 1-7 cavities</th>
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<tbody>
<tr>
<td>S1</td>
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Randomization

2 Years

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What about the clinical relevance?

Does drilling and filling really fix caries?
**Decayed Surfaces vs. log MS and log LB**

(Revised bacterial classifications 1-07)

Baseline Bacterial Levels vs Decay

Existing Cavity = High Risk

**Patients With Frank cavities**

- One or more frank cavities indicates high risk for future new carious lesions
- Moderate to high levels of mutans streptococci
- Moderate to high levels of lactobacilli
- Patients have a high bacterial challenge that most likely can not be completely overcome by fluoride alone
- Placing restorations does not reduce the bacterial loading in the rest of the mouth

**Caries is a Transmissible Bacterial Infection**

- Time for a paradigm shift
- Children infected by mother, caregiver, siblings
- Fluoride is effective only up to a point
- High bacterial challenge can not be completely overcome
- Placing “fillings” has little effect on cariogenic bacterial loading in the mouth
- Need to deal with the infection

**Would you put a new roof on while the house is burning?**

Placing a restoration does not significantly reduce the bacterial loading in the remainder of the mouth.
First Colonizable Hard Surface. Soft tissues can also be colonized before teeth erupt.

Pathological Factors
- Cariogenic bacteria: mutans streptococci (S. mutans and S. sobrinus) and lactobacillus species
- Frequency of ingestion of fermentable carbohydrates: sucrose, glucose, fructose, cooked starch
- Reduced salivary function (medication induced; radiation therapy; disease; genetic)

Demineralization:
- Cariogenic Bacteria (S. Mutans and S. Sobrinus), Lactobacilli
- Fermentable Carbohydrates: Sucrose, Glucose, Fructose, Cooked starch
- Organic Acids which penetrate enamel and dentin, dissolve tooth mineral

Non-cariogenic Sweeteners
- Sorbitol
- Aspartame
- Saccharin
- Sodium cyclamate
- Xylitol

Pathological Factors
- Cariogenic bacteria: mutans streptococci (S. mutans and S. sobrinus) and lactobacillus species
- Frequency of ingestion of fermentable carbohydrates: sucrose, glucose, fructose, cooked starch
- Reduced salivary function (medication induced; radiation therapy; disease; genetic)
Male, 55 years old, before radiation to the head and neck for cancer treatment. Causes saliva flow and function to be cut by at least 90%.

Same male, after radiation to the head and neck. Six months later, showing rampant decay and massive destruction of the teeth.

Protective factors
- Salivary components and flow
- Fluoride, calcium and phosphate: remineralization
- Antibacterials from extrinsic sources

Saliva Contains Numerous Important Components
- Calcium, phosphate and fluoride
- Proteins and lipids that form the pellicle that protects the tooth surface
- Proteins that keep calcium in solution - they maintain supersaturation
- Buffers: bicarbonate, phosphate, peptides
- Antibacterial substances & immunoglobulins

Protective factors
- Salivary components and flow
- Fluoride, calcium and phosphate: remineralization
- Antibacterials from extrinsic sources

Demineralization:- Step 2

Dental Mineral = Carbonated Hydroxyapatite
Acid soluble

If fluoride is present in the solution between the crystals it inhibits mineral loss

Scanning Electron Microscope image of Normal Enamel Surface
Protective Factors

SEM of enamel surface 60,000X, showing crystal ends

Transmission Electron Microscope image of enamel cross-section at 60,000X showing individual crystals and the prism (rod) boundary

Acid-damaged enamel crystals from a carious lesion at 3,000,000x showing rows of calcium atoms. Hexagonal white patches (arrows) are where acid has dissolved mineral from calcium deficient/carbonate rich regions.

Dissolved regions

Dr. Fluoride protects against mineral loss

Water amongst the crystals

Remineralization/Tooth Repair

Fluoride speeds up remineralization and makes acid resistant mineral

Calcium in tooth water (from saliva) + Phosphate in tooth water (from saliva) → Remineralization Builds on existing crystal remnants New mineral less soluble Fluoride helps

Demineralized surface blocks need to be replaced with new calcium, phosphate and fluoride to make a more acid resistant surface on the crystal
SEM in the body of a carious lesion (~30,000x) showing remaining crystal remnants awaiting remineralization.

Sound enamel crystal (3,000,000x) dissected from inner enamel showing carbonate rich acid soluble regions (white patches).

Enamel crystal after remineralization with calcium, phosphate and fluoride, showing a well-formed, low solubility, fluorapatite-like veneer overlying the original defective crystal.

Enamel/dentin crystal = Carbonated apatite

Partly dissolved crystal

Calcium + Phosphate + Fluoride

Acid resistant

Calcium

PO$_4$

Fluorapatite-like coating on crystals

Fluoride works primarily via topical mechanisms

- Fluoride inhibits demineralization by adsorbing from solution onto tooth mineral crystal surfaces
- Fluoride enhances remineralization by combining with calcium and phosphate to make a “fluorapatite-like” remineralized veneer.
Fluoride works primarily via topical (surface) mechanisms
(Fluoride in water, foods, beverages, products)

- Fluoride inhibits demineralization
- Fluoride enhances remineralization
- Fluoride can inhibit plaque bacteria

Fluoride can not enter bacteria in its ionic form, but as the bacteria produce acid HF is formed, which diffuses readily into the cells.

Numerous clinical trials showed ~30% reduction with fluoride dentifrice 1000-2800 ppm F.
Curnow, Pine, et al, 2002 reported 56% reduction with supervised brushing twice daily.

Fluoride levels in the mouth are sufficient to enhance remineralization.

Stannous Fluoride Stabilized Formula 2007
Over the counter fluoride rinses (0.05% NaF) are very effective in high caries risk patients when used once or twice daily for one minute, plus a fluoride-containing dentifrice. O’Reilly and Featherstone, 1987

Office-Applied Fluoride Products

- **Gel (≥ 5,000 ppm F)**
  - Do not require continuing patient compliance
  - Forms slowly soluble calcium fluoride-like deposits in lesions and the plaque
  - Gives slow release fluoride for several weeks
  - Three times a year for high risk patients

Evidence-based Clinical Recommendations: Professionally Applied Topical Fluoride
The Council on Scientific Affairs, American Dental Association
May, 2006

- Fluoride gel applied for 4 minutes or more is effective
- Fluoride varnish applied every 6 months is effective
- Two or more applications of fluoride varnish per year are effective in high caries risk individuals
- Office topical applications no added benefit for low risk individuals

High fluoride concentration (5,000 ppm F) toothpaste more effective than 1100 ppm F in high risk individuals
Baysan A et al, Caries Res 2001. 5000 ppm F toothpaste gave statistically significant extra reduction in root caries compared to 1100 ppm F toothpaste.
However, caries progression still occurred in many subjects even with high concentration fluoride use
High concentration fluoride products for high risk patients. Proven effective for root caries.

Conclusions - Fluoride

- The anti-caries effects of fluoride are primarily topical (surface) in plaque
- The systemic benefits of fluoride are minimal
- Therapeutic levels of F can be achieved from drinking water and fluoride products
- Fluoride therapy may not overcome a high bacterial challenge

Calcium Phosphopeptide: CPP/ACP
Eric Reynolds - Australia

Background and mechanism
Laboratory studies: Three decades
Clinical Studies: clinical evidence

Conclusions

- Limited calcium and phosphate in individuals with reduced salivary function is a common problem
- Calcium and phosphate delivery can be enhanced to improve remineralization
- Great need for novel improved remineralization methods to better alter the “caries balance”, especially in individuals with high bacterial challenge
- MI paste, MI Paste Plus (with fluoride)

Representation of a proposed CPP-ACP complex

Cross et al. 2007 Curr Pharm
The Caries Balance

Pathological Factors
- Acid-producing bacteria
- Frequent eating/drinking of fermentable carbohydrates
- Sub-normal saliva flow and function

Protective Factors
- Saliva flow and components
- Fluoride, calcium, phosphate: remineralization
- Antibacterials: chlorhexidine, xylitol, new?

Caries is a Transmissible Bacterial Infection
- Multiple acid-producing species of bacteria are responsible
- Children are infected by mothers, care-givers, siblings, playmates, through saliva transfer
- Babies and infants are most susceptible from birth to about 4 years of age
- Children infected early have more cavities later in life
- Need to break the chain of infection and deal with the bacteria

Similarity of bacteriocins of *S. mutans* from mother and infant

R.J. Berkowitz and H.V. Jordan

Demonstrated the likelihood of transmission from mother to child

Oral colonization of *S. mutans* in Six-month-old Predentate Infants

J. Dent Res. 80:2060-2065, 2001

- Showed that *S.*mutans colonized even before teeth erupted (50% of infants).
- Related to high *S.* mutans in mothers, increased frequency of sugar intake, breast feeding and habits with saliva transfer from mother to child
Chlorhexidine Gluconate 0.12%, 10 ml, daily for 1 week reduces MS markedly and LB somewhat after restorations completed. Repeat every month.

Chlorhexidine was effective at reducing the bacterial challenge in high caries risk individuals even when compliance was problematic.

Preferred regimen is once a day rinse for one week every month for a year.

Monitor success by bacterial testing.

Ideally we need a better antibacterial therapy.

Must combine with remin/fluoride.

What about toddlers/preschoolers?

- No good antibacterial vehicle available for toddlers - chlorhexidine has negatives.
- Chewing xylitol gum inappropriate & mints might be aspirated.
- Xylitol wipes? - Spiffies: Unpublished data show caries reduction over one year in infants.
- Enlist the mothers and caregivers.

Xylitol

- Xylitol is a 5 carbon “sugar alcohol”
- It looks like sucrose and has about the same sweetness by weight.
- It is used in some foods, chewing gum, candies, lozenges, and dental products as a sweetener.
- Cariogenic (caries causing) bacteria can not feed on it.
- Humans can feed on it and use it as an energy source.
- It inhibits the transfer of bacteria from person to person by altering the way the bacteria stick to surfaces.

Influence of maternal xylitol consumption on acquisition of mutans streptococci by infants

E. Soderling, P. Pienihakkinen, J. Tenovuo
J. Dent. Res. 79:882-887, 2000

Use of xylitol gum by mothers reduced colonization in infants.
Xylitol was better than chlorhexidine varnish, which was better than fluoride varnish.
Parallel study showed marked caries reductions after 5 years (10 year results still hold up).

Treat the mother or caregiver to reduce caries in the child

- Mother or caregiver with active caries must be taken care of.
- Chlorhexidine rinses during 3rd trimester continuing after birth.
- Fluoride therapy to control the decay.
- 4-5 g/day xylitol chewing gum for 5 minutes each time and/or mints.
Xylitol

- Xylitol chewing gum use enhances remineralization
- It inhibits the transfer of bacteria from person to person by altering the way the bacteria stick to surfaces
- It inhibits future recolonization

Xylitol Gum, Mints

- Xylitol
  - Noncariogenic sweetener
  - Inhibits transfer of bacteria from mother to child
  - Can reduce loading of cariogenic bacteria in the mouth

Xylitol

Peter Milgrom - University of Washington

Caries response is dose dependent
Gummy bears successful as a delivery vehicle

A Few Xylitol Gum Sources

  You can buy gums and mints from this company, including dispensers.
- Omni Preventive Care 3M ESPE.  Office and home care products:
  http://solutions.3m.com/wps/portal/3M/en_US/preventive-care/home/
- Zellies. Ellie has the full range plus educational materials:
  http://www.zellies.com
- Spry is another company that markets gum and mints to dental offices:
  http://www.homesteadmarket.com/xylitol_mints.html

Use The Caries Balance to Assess the Risk
The Caries Balance

**Protective Factors**
- Saliva flow and components
- Fluoride, calcium, phosphate: remineralization
- Antibacterials:- chlorhexidine, xylitol, new?

**Pathological Factors**
- Acid-producing bacteria
- Frequent eating/drinking of fermentable carbohydrates
- Sub-normal saliva flow and function

Caries

No Caries

Sometimes there is a delicate balance

Caries Risk Assessment

**An Actual Case - 1**

21 year old female referred by general dentist
(a) First cavity of her life
(b) Numerous interproximal lesions on radiographs, several into dentin
(c) Apparently good oral hygiene
(d) College student living in an apartment
(e) White patches observed - Orthodontic treatment completed three years before
(f) Did bacteria test – Ivoclar/Vivadent CRT

Vivadent Test Strips. An actual case. Used to measure mutans streptococci and lactobacilli

Mixed saliva is added to the two sided selective media slide (mutans streptococci and lactobacilli)

Incubate for 72 hours and read versus density scale

Caries Risk Assessment

**An Actual Case - 2**

Pathological factors
(a) Mutans streptococci and lactobacilli very high
(b) Frequent (greater than 3 times) between meal snacks of sugars/cooked starch - college student not eating regular meals
(c) No saliva reducing factors: 1) medications, 2) radiation to the head and neck, 3) systemic reasons
(d) Saliva flow normal (approximately 2.0 ml/min)
(e) Previously appliances present - orthodontic brackets
Caries Risk Assessment
An Actual Case - 3

Protective factors:
(a) Use of fluoride toothpaste not regular
(b) Saliva normal and adequate
(c) Insufficient to overcome the high and frequent acid challenges
(d) Treatment regimen
(e) Chlorhexidine rinse daily one week each month
(f) High concentration fluoride toothpaste daily
(g) Diet diary and modification of snacking. Add xylitol gum. Motivated/intelligent individual.
(h) Restore tooth with cavity. Monitor the remainder
(i) Caries controlled

Orthodontic brackets attract cariogenic bacteria, leading to “white patch” decay

Putting into practice the results of many years of research.
“Caries Management by Risk Assessment” based upon the “Caries Balance”
CDA Journal
Feb/March 2003
http://www.cdafoundation.org/journal

The Caries Imbalance

Risk Factors
- Acidogenic bacteria
- Frequent carbohydrates
- Sub-normal saliva

Protective Factors
- Saliva
- Fluoride, Ca, P
- Antibacterials

Disease Indicators
- Cavities/dentin
- Enamel lesions
- Restorations < 3 yr
- White spots

Caries Progression
- No Caries

Featherstone, Young, Wolff, 2007

Putting into practice the results of many years of research.
“Caries Management by Risk Assessment”
October, November 2007. On line, free
California Dental Association Journal
based upon the “Caries Balance”
http://www.cdafoundation.org/journal
### Barriers to CAMBRA Implementation

- Up front cost to patients
- Lack of insurance coverage
- Practitioners and patients do not have therapeutic measures in their mind as part of the treatment plan
- Insufficient training
- Lack of acceptance by traditionally trained clinicians - afraid of the unknown
- Lack of willingness to make the change

### Caries Risk assessment (Age 6 years and older/adult) - 1

1. **Disease Indicators = Clinical Observations**
   - (a) Visible cavities present
   - (b) Caries restored in last 3 years
   - (c) Interproximal caries lesions/radiolucencies
   - (d) White spots on enamel surfaces

Any one of these signals a bacteria test for MS and LB

These are all clinical observations that tell us nothing about the cause of the disease - they indicate presence of disease

### Caries Risk assessment (Age 6 years and older/adult) - 2

2. **Risk Factors (Biological determinants of caries risk)**
   - (a) MS and LB medium or high - by culture
   - (b) Visible heavy plaque on teeth
   - (c) Frequent (greater than 3 times) between meal snacks of sugars/cooked starch
   - (d) Deep pits and fissures
   - (e) Recreational drug use
   - (f) Inadequate saliva flow (less than 0.5 ml/min)
   - (g) Saliva reducing factors: 1) medications, 2) radiation to the head and neck, 3) systemic reasons, e.g. Sjogren’s syndrome
   - (h) Exposed tooth roots
   - (i) Orthodontic appliances present

### Caries Risk assessment (Age 6 years and older/adult) - 3

3. **Protective Factors**
   - (a) Lives/works/school in community with fluoridated water
   - (b) Uses fluoride toothpaste once daily
   - (c) Use fluoride toothpaste at least twice daily
   - (d) Uses fluoride rinse/gel daily
   - (e) Uses 5000 ppm F toothpaste daily
   - (f) Fluoride varnish in last 6 months
   - (g) Office F topical in last 6 months
   - (h) Chlorhexidine rinse prescribed/used daily for 1 week ever month last 6 months
   - (i) Xylitol gum/candies 4 times daily last 6 months
   - (j) Calcium/phosphate paste last 6 months
   - (k) Saliva flow visibly adequate or > 1 ml/min by test

### Caries Risk Assessment (Age 6years - adult)-5

4. **Bacterial test for high risk individual as a baseline measure**
5. **Count the yes’s. Assess caries risk and circle risk as extreme, high, moderate or low**
6. **Treatment Plan**
   - Includes home care, office preventive treatments and restorative work
7. **Home Care Recommendations**
8. **Recall and Re-assessment of Caries Risk**
Extreme Caries Risk Individuals

- **High Risk plus severe hyposalivation. Measure saliva flow rate (less than 0.5 ml/minute)**
- **Same as for high risk individuals PLUS:**
- Baking soda rinse 4x daily (2 teaspoons in 8 ounces water)
- Consider fluoride trays for home use (1.1% neutral sodium fluoride gel) daily
- Consider calcium phosphate home use gel
- Recall 3 months and repeat F varnish etc.

Caries Risk (Age 6 years-Adult):

**Patient Recommendations**

- **Daily oral hygiene.** Fluoride-containing toothpaste
- **Diet.** Limit between meal snacks, limit sodas.
- **Fluoride.** Increase stepwise depending on risk level.
  1. Toothpaste 2x daily, (2) F rinse (0.05% sodium fluoride) daily,
  3. 5,000 ppm F dentifrice/gel nightly. Consider fluoride varnish.
- **Sugar free gum/candy.** Xylitol containing gum/candy, 4x daily.
- **Antibacterial rinse.** Chlorhexidine gluconate (0.12%) once daily for one week every month for 6 months.
- **For Dry Mouth (EXTREME RISK).** Baking soda toothpaste with fluoride, xylitol gum, rinse frequently with baking soda suspension in water (2 teaspoons/250 ml water).

Caries Risk assessment (Age 6 years and older/adult)-4

- **Tests**
  (a) Stimulated saliva flow rate is measured by chewing and spitting for 3-5 minutes (timed). Amount (in ml) divided by time = rate (ml/min). Less than 0.7 ml/min is low and , less than 0.5 ml/min is dry.
  (b) Bacteria testing by the CRT (Caries Risk Test, from Vivadent, Amherst, NY) or Dentocult (www.edgedental.com). Use selective media sticks for mutans streptococci and lactobacilli. Incubate 72 hours and read as low medium or high.
  (c) Follow up with repeat tests at 3-6 months until stable

What is the Caries Risk of this Individual? 15 year old female

- No new caries lesions in the last 5 years
- No symptoms of salivary dysfunction (dry mouth), no medications with salivary side effects
- Assume low cariogenic bacteria levels
- Not a frequent snacker
Low Risk Patient

Pathological Factors
- Low Acid-producing bacteria
- Saliva normal
- Carbohydrates o.k.

Protective Factors
- No new caries in 5 years
- Saliva normal
- Fluoride, calcium, phosphate
- Remineralization:
  - 2 x daily F toothpaste
  - Antibacterials: No need

The Caries Balance

Pathological Factors
- Acid-producing bacteria
- Frequent eating/drinking of fermentable carbohydrates
- Sub-normal saliva flow and function

Protective Factors
- Saliva flow and components
- Remineralization:
  - Fluoride, calcium, phosphate
  - Antibacterials: chlorhexidine, xylitol, new?

What is the Caries Risk of this Individual?
19 year old female

- Several radiographic lesions into dentin
- Symptoms of salivary dysfunction (dry mouth), taking anti-anxiety medication, and major analgesic daily for three years.
- Risk assessment signals to do a bacteria test - medium LB and medium MS
- Admits to being a frequent snacker

High/Extreme Risk Patient

Protective Factors
- Fluoride - remineralization
- F Toothpaste once daily only
- Minimal calcium, phosphate
- Antibacterials: none used

Therapy for Low Caries Risk Individual
15 year old female

- Maintain 2 x daily fluoride toothpaste brushing and other habits.
- Recall 12 months.
High Risk Patient

Protective Factors
- Office applied Topical Fluoride
- Chlorhexidine 10 ml daily one week a month for 6 months
- Brush with high 5000 ppm F toothpaste daily - enhance remineralization
- Xylitol gum daily
- Consider MI paste
- Recall 3 or 6 months

Caries On Hold

No New Caries

Caries risk assessment procedures and treatments for children aged 0-5 years, can be accessed in the October 2007 CDA JournalRamos-Gomez et al., www.cdafoundation.org/journal

FDI statement 2002
Minimally Invasive Dentistry

- The basic principle is to preserve as much of the natural tooth structure as possible while at the same time encouraging remineralization of early lesions to inhibit further progression.
- Maintaining a balance between caries pathological and protective factors is the key to success and the oral health of the patient

Featherstone, April, 2004
Conservative Caries Management by the Dental Team

- Detect caries lesions early enough to reverse or prevent progression
- Assess caries risk
- Use fluoride and/or antibacterial therapy based on observations
- Use minimally invasive restorative procedures to conserve tooth structure

It is an uphill struggle to get faculty, students and practitioners to accept the practical application of the "caries balance" and caries management by risk assessment, BUT it works and patients are grateful.