Applying color theory in clinical practice to improve patient treatment

Asbjørn Jokstad
Science Manager, FDI World Dental Federation
Professor, University of Oslo, Norway

Learning objectives
Be familiar with the physical mechanisms of tooth coloring and its measurement
Recognize possible etiology for discoloration
Realize the potentials and limitations of esthetic restorative materials
Be acquainted with different shade guides and their characteristics
Know of commercially available digital systems for shade matching
Know procedures for optimizing correct shade matching & communication

Light-tooth interaction
Colors for teeth and dental materials are reported in the literature as:

- **Munsell values** *(Hue, Chroma, Value)*
- **Tristimulus values** $X, Y, Z$
- **CIE chromaticity values** $Y(\%), x, y$
- **CIE $L^*a^*b^*$**
Proportional contributors to tooth color

- The proportional contribution of enamel, dentin, pulp, gingiva and mucosa to the spectral reflection from the tooth in isolation remain uncertain.

- In general, dentin contributes the most as it is more chromatic than enamel.

- Enamel is very translucent and more grey-blue than dentin.
Definitely not realistic!

Learning objectives
1. Be familiar with the physical mechanisms of tooth coloring and its measurement
2. Recognize possible etiology for discoloration and best treatment
   • Extrinsic
   • Intrinsic

Extrinsic discolored teeth – etiology
N1-type colored material (chromogen) binds to the tooth surface. The color of the chromogen is similar to that of dental stains caused by tea, coffee, wine, chromogenic bacteria, and metals.
Extrinsic discolored teeth – etiology

N1-type colored material (chromogen) binds to the tooth surface. The color of the chromogen is similar to that of dental stains caused by tea, coffee, wine, chromogenic bacteria, and metals. N2-type colored material changes color after binding to the tooth. The stains actually are N1-type food stains that darken with time.

N3-type colorless material or prechromogen binds to the tooth and undergoes a chemical reaction to cause a stain. N3-type stains are caused by carbohydrate-rich foods (e.g., apples, potatoes), stannous fluoride, and chlorhexidine. (Nathoo 1997)

Discolored teeth – best treatments

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Appropriate method</th>
<th>Active agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface staining</td>
<td>Air Scaling / Brushing with (whitening) toothpaste + Patient counseling</td>
<td>Abrasives</td>
</tr>
<tr>
<td>Internal bleaching</td>
<td>10% carbamide peroxide Microabrasion followed by custom tray bleaching</td>
<td></td>
</tr>
<tr>
<td>Endodontically treated</td>
<td>30-38% H2O2, alone or with heat or light</td>
<td></td>
</tr>
<tr>
<td>Whitening</td>
<td>10% carbamide peroxide Custom bleaching trays worn by patient daily for two to six weeks</td>
<td></td>
</tr>
<tr>
<td>Tetracycline staining</td>
<td>Restorative treatment</td>
<td></td>
</tr>
<tr>
<td>Tannin / Oxidation products</td>
<td>Heriditary defects</td>
<td></td>
</tr>
</tbody>
</table>
Intrinsic discolored teeth – etiology

1. Hereditary defects
   Dentinogenesis imperfecta.
   - Teeth relatively normal at eruption
   - Discolor increases with time
   - More and more translucent, pink yellow, brownish or grey-brown
   - Enamel may chip off with subsequent heavy dentin discoloration

2. Toxic effects during tooth development
   Fluorosis: Surface may range between small opaque white spots to extensive yellow-brown bands and/or areas
Intrinsic discolored teeth - etiology

1. Hereditary defects: Dentinogenesis imperfecta, Amelogenesis imperfecta

2. Toxic effects during tooth development: Fluorosis - Tetracycline

3. Trauma: Sometimes in the early phase following a trauma, due to internal bleeding in the pulp, with retention of porphyrines and iron in the dentin. The discoloration may be reversible or remain, even if the pulpa remains vital

4. Pulp necrosis: Results usually in a tooth discoloration, but not always

5. Other reasons:
   Degradation products from metallic restoratives
   Seldom bleeders’ diseases
   Surface erosions
   Unknown reasons, possibly related to some childhood illness. E.g. hepatitis over a period
Discolored teeth – best treatments

<table>
<thead>
<tr>
<th>Etiology</th>
<th>Appropriate method</th>
<th>Active agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface staining</td>
<td>AirScaling / Brushing with whitening toothpaste + Patient counseling</td>
<td>Abrasives</td>
</tr>
<tr>
<td>Hereditary defects</td>
<td>Restorative treatment</td>
<td></td>
</tr>
<tr>
<td>Tetracycline staining</td>
<td>Custom bleaching trays worn by patient daily for six to 12 weeks</td>
<td>10% carbamide peroxide</td>
</tr>
<tr>
<td>Single or multiple discolored teeth</td>
<td>External bleaching—in-office one to three visits</td>
<td>30-38% H₂O₂, alone or with heat or light</td>
</tr>
<tr>
<td>Multiple teeth and entire arches</td>
<td>Custom bleaching trays worn by patient daily for two to six weeks</td>
<td>10% carbamide peroxide</td>
</tr>
<tr>
<td>Isolated brown or white discolorations of shallow depth in enamel</td>
<td>Microabrasion followed by neutral NaF applications</td>
<td>Abrasives + HCl up to 36%</td>
</tr>
<tr>
<td>White discoloration on yellowish teeth</td>
<td>Microabrasion followed by custom tray bleaching</td>
<td>Abrasives and acid; 10% carbamide peroxide</td>
</tr>
<tr>
<td>Endodontically treated teeth</td>
<td>Internal bleaching—in-office or walking</td>
<td>Na perborate or 35% H₂O₂</td>
</tr>
</tbody>
</table>

Learning objectives

1. Be familiar with the physical mechanisms of tooth coloring and its measurement
2. Recognize possible etiology for discoloration and best treatment
3. Realize the potentials and limitations of esthetic restorative materials

Dental Materials

Presently, there are no spectrophotometric quality control of materials with minimum criteria of performance. Among the direct materials, composite resins possess the best optical-physical properties regarding esthetics.
Technique in 1980

New products in 2004

Opaque
Dentin
Regular
Body
Translucent
Enamel

Shade
Selection

Enamel
Body
Dentin

Shade Selection
Dental Materials - composites, clinical observations

- Most materials become more opaque and lighter after a while intraorally, due to water uptake
  - This varies markedly among different materials

- Chemically polymerised composites discolor more into yellow than the light polymerised due to the polymerisation chemicals in the resin

- Chemically polymerised composites with microfillers discolor more compared to those with macrofillers.
Composites are tested in laboratory for discoloration potential. E.g.

1. Color Stability, in 60/80°C Water
2. Color Stability, Xenon light
3. Stain Resistance, in 37/80°C Coffee
4. Stain Resistance, in 37/80°C Tea

An absolute requirement is adequate preparation depth!

- The thickness of a restoration / veneer is critical to obtain a correct reflection spectrum and thus acceptable shade
- Not removing enough tooth substance will either result in poor esthetics or to overcontouring with risk for subsequent gingival recession. This is especially critical cervically.

Learning objectives

1. Be familiar with the physical mechanisms of tooth coloring and its measurement
2. Recognize possible etiology for discoloration and best treatment
3. Realize the potentials and limitations of esthetic restorative materials
4. Be acquainted with different shade guides and their characteristics
Shade guides

<table>
<thead>
<tr>
<th>Producer</th>
<th>Materials</th>
<th>Shade</th>
</tr>
</thead>
<tbody>
<tr>
<td>3M ESPE</td>
<td>Composite / Hybrid</td>
<td>VITA / Biodent / Own</td>
</tr>
<tr>
<td>Bisco</td>
<td>Composite / Hybrid</td>
<td>VITA</td>
</tr>
<tr>
<td>Coltene</td>
<td>Composite</td>
<td>VITA</td>
</tr>
<tr>
<td>Dentistry</td>
<td>Composite / GIC / Hybrid / Ceram / Prefabricated teeth</td>
<td>Biodent / VITA / Own</td>
</tr>
<tr>
<td>Discus</td>
<td>Composite</td>
<td>Own</td>
</tr>
<tr>
<td>DMG</td>
<td>Composite / Hybrid / GIC</td>
<td>VITA</td>
</tr>
<tr>
<td>Duceran</td>
<td>Ceram</td>
<td>Biodent / VITA</td>
</tr>
<tr>
<td>GC</td>
<td>Hybrid / GIC / Ceram</td>
<td>VITA</td>
</tr>
<tr>
<td>H. Kulzer</td>
<td>Composite / Hybrid / Prefab-teeth</td>
<td>Biodent / VITA</td>
</tr>
<tr>
<td>Jeneric</td>
<td>Composite / Ceram</td>
<td>Bioform / VITA</td>
</tr>
<tr>
<td>Kerr</td>
<td>Composite</td>
<td>VITA</td>
</tr>
<tr>
<td>Shofu</td>
<td>Ceram</td>
<td>VITA / Vintage Halo</td>
</tr>
<tr>
<td>Ultradent</td>
<td>Composite</td>
<td>VITA</td>
</tr>
<tr>
<td>VITA</td>
<td>Ceram / Prefabricated teeth</td>
<td>VITA / VITA3D</td>
</tr>
<tr>
<td>Vivadent</td>
<td>Composite / Ceram</td>
<td>Chromascap / VITA / Own</td>
</tr>
</tbody>
</table>

Large deviations between supposedly similar tooth shades from the same producer is not uncommon

Custom-made color shades using the actual restorative material is claimed to be better than using a standard color shade
Shade guides

- Large deviations between supposedly similar tooth shades from the same producer is not uncommon
- Custom-made color shades using the actual restorative material is claimed to be better than using a standard color shade
- Some tooth shades changes following immersion in disinfectants. Keep away from chlorine-containing solutions!

The 5 most common shade guides in use internationally

- White-red
- Yellow
- Orange
- Brown-red
- Brown-grey

Bioform -> Biotone -> Trubyte
Bioblend -> Portrait IPN
1990; Vivadent -> Kerascop

+/- neck?
Changed in the mid-seventies
A3.5 & D4 added in 1980
B1 & D1 sometimes excluded

Shade guides
“VITA-Shade” guides from different producers may often differ markedly from the original
A more modern principle for a shade guide
Learning objectives
1. Be familiar with the physical mechanisms of tooth coloring and its measurement
2. Recognize possible etiology for discoloration and best treatment
3. Realize the potentials and limitations of esthetic restorative materials
4. Be acquainted with different shade guides and their characteristics
5. Know of commercially available digital systems for shade matching

Digital Shade Matching Systems
A hand held optic device with dual light source connected through fiber optics to a spectrophotometer

• Dental Color Analyser (clearlight.com/~aei)
• Metalor-ikam system (metalor-ikam.com)
• Pocketspec (Pocketspec.com)
• ShadeVision /ShadeRite (X-Rite.com)
• Shadescan (Cynovad.com)
• Spectroshade (mhtint.com)
• ShadeEye NCC (Shofu.com)
Digital Shade Systems - Benefits

- Improved communication between dentist and lab
- Can integrate with
  - Intra-oral camera
  - Digital Camera
  - Image enhancing software
  - Mouth Simulator
  - Printer

Learning objectives

1. Be familiar with the physical mechanisms of tooth coloring and its measurement
2. Recognize possible etiology for discoloration and best treatment
3. Realize the potentials and limitations of esthetic restorative materials
4. Be acquainted with different shade guides and their characteristics
5. Know of commercially available digital systems for shade matching
6. Know procedures for optimizing correct shade matching & communication

Fixed Prosthetic Dentistry - shade selection

Before you start...

1. Have the patient remove lipstick or bright makeup
2. If patient is wearing bright clothing, drape him or her with a neutral colored cover, i.e. light blue or light gray
3. Keep a surface with a neutral color nearby
4. Clean the teeth if doubt of extrinsic discoloration
5. Don't recline your patient – keep at eye level
6. Do not wear glasses that changes with light
Fixed Prosthetic Dentistry - shade selection

... right environment

1. Do not use direct lights. Lighting should be in the most natural light possible. Incoming light may be altered if the window in your operatory has a lot of greenery around it.

2. Compare your shade selection under varying conditions such as with lip retraction versus lip down and when the patient moves their head in different directions or lighting angles.

3. Have also your patient press their tongue against the lingual surface, when doing an anterior tooth restoration.
Light sources

- Fluorescent
- Natural daylight
- Incandescent

The same teeth look different under different light sources.

---

Fixed Prosthetic Dentistry - shade selection

... right time

1. Select the shade at the beginning of the session before the tooth becomes dehydrated and your eyes fatigued.
2. An impression and the use of rubber dam will cause lighter teeth. Retraction cord may influence the tooth color both ways. Anaesthetics too?
3. The canines are good for selecting shade as they have the highest chroma of the dominant color of the teeth.
4. Once the tooth is fully prepared, use your guide to select the shade of the dentin in the tooth’s body.

---

Important:

1. The first impression is usually the most accurate in shade selection.
2. It is important avoid fatiguing the eyes. Do not stare for >3-10 secs. Gazing at a neutral color, e.g. blue or grey for approx. 30 seconds will help to cleanse and refocus the eyes.
Fixed Prosthetic Dentistry - shade selection

... the process ...
1. Place the shade tab parallel to the facial surface of the teeth, not in front or behind
2. Arrange each tab on the guide so that the incisal edge is facing out or away from the tab holder. Since incisal shading has the greatest influence on value, it is helpful to position the incisal area of the tabs closest to the teeth you are shading. This will also help avoiding color choice being influenced by the hue area of the tab
3. Always select the value reading first. It may help to squint
4. Now that the value reading has been taken, use your hue guide to select the color reading

Fixed Prosthetic Dentistry - shade selection

... finalising
1. Make your final shade selection after comparing your selections with those of a staff member and/or ask the patient's opinion on your choice
2. Make a mental note of morphological details
3. If unable to match, choose a lower chroma and higher value
4. Take photo with shade tab if possible

Communicate this to laboratory
Get as detailed as possible with characterization
Every piece of information helps:
- Surface texture
- Glaze
- Translucency
- Wear
- Proximal view with incisal/thickness of enamel
- Any unique color characterizations of the dentine
Thank you for your kind attention
World Dental Federation
Indian Dental Association

Fifth Joint CDE Programme

TAJ EXOTICA
GOA - INDIA
7-8 December 2002

Sponsors:
Colgate Palmolive, Dentsply Asia
World Dental Education Society, Singapore
“Unravelling the Cracked Tooth Syndrome”

Dr. SAW LIP HEAN, Malaysia

The first dentist in Malaysia who set up his private endodontic practice. He did his graduation and postgraduation from Melbourne. He is the President of Malaysian Endodontics Society and part time teaching faculty. He has lectured extensively in Malaysia. He will present how to diagnose, classify and help formulating a treatment plan for the Cracked Teeth/Roots. Case studies will be presented for discussion.

“A 15 years clinical experience in dental implants”

DR. NAILESH GANDHI, India

He is basically a Prosthodontist from Gujarat, India and practising Implantology since last 15 years. He is past president of Indian Dental Association, Founder President of Society of Oral Implantology in Gujarat, Vice Chairman FPA, Ex-member of Dental Council of India and presently Chairman of Continuing Dental Education committee of IDA. He received advance training in Implants by Dr. ODHI Taurum, USA. He has lectured extensively in India and abroad on implantology. His articles on Implants are published in Dental Asia & National Journals regularly. Presently he is only Indian appointed on Advisory Committee of “Dental Asia” for Dental Implants. He will be sharing his experiences of past 15 years in Implantology, review the current state of implantology in India and make recommendations based on evidence based practice in a variety of situations ranging from single tooth restorations to complete edentulism. He will present importance of length & width of bone, Implant Angulations Placement, emergence profile, as well as esthetic, considerations for successful implant practice.

“Preservation of Ideal Implant site to Achieve the ultimate esthetics.”

DR. SHAHIVIR S. NOORVEZDAN, India.

He did his BDS from Mumbai, India and Masters in Restorative Dentistry from University of Sheffield, UK in 1992. He did advance training in Implants at Germany and Holland. He has lectured and conducted many training courses on Implants in India and abroad.

He will be speaking on the ideal implant site-the extraction socket. The definite advantages of immediate implantation combined with innovative soft & hard tissue techniques, incision free procedures and temporation with non-functional leading to achieve esthetic excellence will be demonstrated with clinical cases.

“Clinical Management of Perio Disease using chemotherapeutics.”

DR. GITA AUPILISH, U.K.

Dr. Gita Auplish did her BDS from Guy's Hospital, London and Masters in Periodontics from Estimation Institute with distinction in 1998. Currently she is working as a specialist practitioner in Periodontology at Eastman Dental Hospital, London.

She will be speaking on Clinical management of Perio disease using chemotherapeutics.

“Clinical Management of early caries.”

Prof. Stephen J. Moss is a past president of the American Academy of Pediatric Dentistry. He did graduation and masters from NYU, USA. His major area of study is preventive dentistry. His present activities include developing international education programs designed to promote oral health. He will be speaking on Clinical management of early caries.

“Color Theory and application in dentistry”

DR. ASBJORN JOKSTAD, Oslo

Dr. Asbjorn Jokstad is a professor at the Institute of Clinical Dentistry, University of Oslo. He obtained a DDS degree in 1979, prepared a thesis for Dr. Olof (PhD) in 1992, and became specialist in prosthodontics in 1994. He has authored more than 100 publications focused on evidence based dentistry, dental materials and clinical trials, toxicology, prosthodontics and TMD, and has lectured extensively on these topics internationally. He is currently also the science manager of the FDI World Dental Federation.

The aim of this two-hour course is to review basic principles in colour theory, to explain how these principles influence our daily situation in the general dental clinic environments, to address how to convey information about appearance and to demonstrate how this knowledge can to be applied purposefully to provide better patient treatment.

“Periodontal Therapy : A preventive Approach.”

Dr. A. KUMARSWAMY, India.

He did his Masters in Periodontics from Mumbai, India. He has pioneered the philosophy and techniques in Perio-Aesthetics in India. Lectured in India and internationally number of times. He is Vice President of AAACD, Editor of ISP journal, Secretary of International Academy of Periodontology.

He will be presenting on prevention of occurrence and recurrence of periodontal disease. The talk will include prophylaxis, plaque control measures, diligent homecare regimen and the role of practitioner.