CHAPTER

1

Introduction to Restorative Dentistry

Restorative dentistry, the mother of all branches of dentistry, deals with restoration of teeth that are defective because of trauma, disease or any other abnormality to achieve functions and esthetics. Restorative dentistry includes restorative dentistry, preventive dentistry and esthetic dentistry. The ultimate aim is to prevent the destruction of teeth followed by restoring the damaged tooth to its function.

DEFINITIONS

Restorative dentistry is defined as "*the branch of dentistry, which deals with the diagnosis, prognosis, treatment and prevention of defects of teeth; restoring them to their form, function and esthetics; subsequently, maintaining the stomatognathic system*".

Mosby's Medical Dictionary defines restorative dentistry as "the phase of dentistry concerned with restoration of teeth that are defective through disease, trauma or abnormal development to a state of normal function, health and esthetics, including preventive, diagnostic, biologic, mechanical and therapeutic techniques as well as material and instruments science on application".

Mosby's Dental Dictionary defines restorative dentistry as "the branch of dentistry that deals with the esthetic and functional restoration of the hard tissues of individual teeth".

Conservative dentistry is concerned with the conservation of tooth tissues in the oral cavity. It includes the practice of restorative dentistry and endodontics, facilitating various kinds of direct and indirect restorations of individual teeth.

EVOLUTION OF RESTORATIVE DENTISTRY

Since literature was meagre in ancient days, the genesis of dental practice could not be ascertained. Early efforts were made by the Europeans and the Arabians; however, they were interested mainly in gold work prosthesis. Gold is considered to be one of the oldest materials used in dentistry.

As early as 2700 BC, Etruscans and Phoenicians were practicing gold crowns. The practice continued up to 500–700 BC. Hippocrates (460–370 BC), the father of medicine, was born in 460 BC in Cos (Greece). Many of his writings have references of teeth, their formation, eruption and other maladies. In one of his books, he observes; in case of toothache, if the tooth is decayed and loose, it must be extracted. If it is neither decayed nor loose, but still painful, it is necessary to desiccate it by cauterizing. Splinting of loose mandibular anterior teeth by gold wires has been shown in Fig. 1.1 (an ancient photograph). Restorative aspect was not practiced during that period. Celsus (25 BC–50 AD) was perhaps the first to recommend filling of large cavities with paper, lead and other substances somewhere around 1st century AD. Dental amalgam was first used by a Chinese, Su-Kung, in 650 AD. The use of gold leaf to fill cavities was perhaps the most significant development of medieval and early modern period from standpoint of restorative dentistry. It is known with certainty that gold leaves were used extensively at the time of Columbus.

Fig. 1.1: Splinting of mandibular anterior teeth with gold wires

Oral hygiene measures were adopted by various religious sects. Both Hindus and Muslims made it mandatory to follow the oral hygiene measures meticulously.

Sushruta was perhaps the first dental anatomist in the world who had described the anatomy of jaw bones with great accuracy. He also described that the lower third molar could press the inferior dental nerve. The chief contribution to dentistry (from the beginning of Christian era to about 1500 AD) seems to be a shift from prosthesis to restoration of carious teeth. According to Arabian author Rhazes (841–926), carious teeth were filled with ground mastic, alum and honey during that period.

A description of removal of carious matter from teeth before filling with gold leaf was given by Giovanni da Vigo (1460–1525) in his article 'Practica in arte Chirugica' Copiosa (1514).

Andreas Vesalius (1514–1564) in his book on anatomy '*De humani corporis fabrica*' published in 1543, categorically said that teeth were not bones. However, his opinion that teeth grow throughout life, was discarded.

Ambroise Pare (1517–1590) is credited with having prepared artificial tooth from bone and ivory.

Jacques Guillemeau (1550–1613) who was a pupil of Pare, prepared a paste by fusing together certain waxes, gums, ground mastic, powdered pearl and white coral. He used this paste as a filling material.

Beginning of Dental Science (1600–1840)

It was during this period that the foundation for restorative dentistry as a science was laid down. Prior to that, dentistry was merely an art practiced by barbers, surgeons or artisans.

In the beginning of 17th century wax models used in connection with prosthetic work were first mentioned by Matthaeus Gottfried Purmann. Charles Allen (1687) gave first written material on dentistry 'Operator for the Teeth'. By the beginning of 19th century, dentistry was no longer in hands of barbers/artisans but was practiced by professionally minded dentists/surgeons.

Pierre Fauchard (1678–1761), popularly known as father of dentistry (Fig. 1.2), described the materials and practices of his time in his book '*Traite des dents*' (Treatise on the Tooth). He was among a few scholars who described the causes of tooth decay and their prevention. He suggested humoral imbalance as the main cause for dental decay. Earlier the explanation of caries and toothache was attributed to the tooth worm. At that time, the restorative materials mentioned were lead, tin and gold, though his preference was for tin.

Fig. 1.2: Pierre Fauchard (1678–1761)

He brought a new dignity and decorum to the dentist's office by insisting that the patient be seated in an arm chair which is steady and firm, suitable and comfortable, the back of which should be of horse hair or with a soft pillow raised more or less according to the stature of the patient and particularly to that of the dentist.

Robert Bunon (1702–1748), a well known dentist of that era, challenged the belief that maxillary canines should never be extracted because this would damage the eyes. He also refuted the notion that the pregnant women should not be given dental treatment.

John Hunter (1728–1793) published a book, "*The Natural History of Human Teeth*" in 1771, which dealt mostly with dental anatomy, anatomy of jaws and muscles of mastication. He was the pioneer in coining the terms incisors, canines and premolars. He also gave the idea that the teeth do not grow throughout life.

Low fusing metal alloy was introduced by Jean Darcet in 1770. Bowden (1775) made the first reference to use gold base to support ivory teeth with gold pins.

A baked porcelain complete denture was made in a single block by French dentist Dubois de Chemant in 1788. Josiah Flagg (1790) invented first dental chair with adjustable headrest and extended armrest for holding instruments (Fig. 1.3). Since then, there is continuous improvement in the design of dental chair to provide better comfort both to the patient and the operator (Figs 1.4 and 1.5).

RC Skinner contributed maximum in the dental literature. His book '*A Treatise on the Human Teeth*' practically a sixteen page pamphlet was published in 1801. The book mainly dealt with dental diseases and their prevention.

The combination of silver and mercury to form 'silver paste' was announced by M Taveau of Paris in 1826. This was the beginning of dental amalgam which is recognized as one of the outstanding developments in the field of dentistry.

Fig. 1.3: First dental chair

Fig. 1.4: Improved dental chair

Fig. 1.5: Modern dental chair

Chapin Harris (1806–1860) published his book '*The Dental Art: A Practical Treatise on Dental Surgery*' regarding various aspects of dentistry. He was also instrumental in starting the first scientific journal '*American Journal of Dental Sciences*' on 1st June, 1839. He was so attached with the journal that for the first ten years, he bore all the expenditure himself.

Period of Improvement in Dentistry (1840–1900)

On 6 March 1840, first dental college 'Baltimore College of Dental Surgery' came into existence with only five admissions.

In 1840, American Society of Dental Surgeons was established and a couple of years later they banned the use of silver amalgam. In 1845, Amalgam pledge was taken by the members of society. Later in 1855, Dr Townsend of Philadelphia proposed a combination of four parts of silver and five parts of tin. This was unbalanced alloy having poor edge strength but this was used until about 1863. Dental profession remained hesitant about the use of amalgam until GV Black (1885) in his article 'Physical Characteristics of Filling Materials', suggested a formula for amalgam so that it neither expanded nor contracted and also hardness was sufficient. His contributions for restorative dentistry are unmatched. His writings might be more than hundred years old but are followed even today. Greene Vardiman Black is rightly remembered as the father of restorative dentistry (Fig. 1.6).

Gutta-percha, the exudate from trees of Sapodilla family, was discovered in India in 1842. Gutta-percha along with zinc oxide eugenol was used for purpose of temporary fillings as advocated by Hill in 1848.

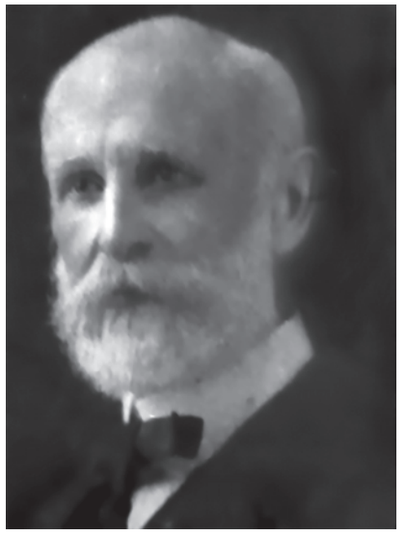

Fig. 1.6: Greene Vardiman Black (1836–1915)

Zinc oxide eugenol cement was introduced in 1858. These were very easy to handle and manipulate even in the presence of moisture, well tolerated by pulp and provided good marginal seal; however, lacked strength, had prolonged setting time and low resistance to abrasion.

In 1871, a translucent cement (silicate cement) was introduced by Fletcher in England. Dr. Pierce introduced zinc phosphate cement in 1879.

Gas and gasoline furnaces were introduced by Charler (1889) for high fusing porcelain inlays and electric furnace was introduced by Lewitt Ellsworth Custer (1894).

Dentistry in 20th Century

With the beginning of 20th century, the quality of restorative material were refined and improved.

William H. Taggart (1855–1933) introduced casting method for inlay in 1907. Lane suggested the idea of casting by using investment containing high percentage of silica to Plaster of Paris at 650°C to compensate for casting shrinkage. Schen (1932) developed a technique employing hygroscopic expansion of investment to compensate for shrinkage of casting. Sonder (1942) recognized that thermal expansion of investment was greatly inhibited by rigid metal casting ring and advocated lining the ring with soft asbestos.

Gaylor (1935) first described chemistry of amalgam reaction. She was also responsible for naming various phases as gamma, gamma 1 and gamma 2. Innes and Youdelis (1963) presented improved alloy containing high copper content (12%) in form of silver-copper eutectic spheres. This new alloy was named admixed alloy. Further, Asgar (1974) developed single composition high copper alloy.

Self-curing acrylic resins for anterior restorations was developed in Germany in 1937 by Walter Wright.

In an effort to improve the physical properties of unfilled acrylic resins, Bowen of National Bureau of Standards developed a polymeric restorative material reinforced with silica particles, commercially known as composite.

Polycarboxylate cement was introduced by Dennis Smith in 1968. This cement was only dental cement with adhesive qualities.

Glass-ionomer cement was invented by Wilson and Kent (1971), with the need to improve upon the properties of silicates and polycarboxylate cements, so as to provide adherence to tooth and a better seal. Improvements in all these materials continued with the advent of antibacterial composites, giomers, etc.

CHRONOLOGY OF MAJOR EVENTS IN RESTORATIVE DENTISTRY

1400: Use of gold in leaf form for filling teeth by Joannes Arculanus.
1538: Important observations on development of teeth by Andreas Vesalius.
1560: Preparation of artificial teeth from bone and ivory by Ambroise Pare.
1650: Copper amalgam by Stocker.
1684: Use of wax in taking impressions of the teeth by Matthaeus Gottfried Purmann.
1687: First written material on dentistry "Operator for the Teeth" by Charles Allen.
1728: Use of lead, tin and gold for filling by Pierre Fauchard.
1767: Gold foil by Robert Woffendale.
1770: Low fusing metal alloy by Jean Darcet.
1774: Porcelain as dental restorative material by Alexis Duchateau.
1789: A French dentist De Chemant patented 1st porcelain tooth material.
1790: First dental chair by Josiah Flagg.
1806: 26 different shades of porcelain by Guiseppangelo Fonzi.
1808: Fonzi, Italian dentist, invented terrometallic porcelain tooth that was held in place by platinum pin or frame.
1812: Non-cohesive gold for filling by Marcus Bull.
1818: Father of amalgam—Dr. Louis Regnart.
1819: Bell's Putty (a kind of silver amalgam) by Charles Bell.
1826: "Silver paste" (a mixture of silver and mercury) introduced by M. Taeveau.
1838: Hand drill with adjustable head by John Lewis.
1838: Condensation of gold foil by E. Meritt.
1839: American Journal of Dentistry was published.
1840: First dental college of the world, i.e. Baltimore Dental College.
1840: First national dental organization, i.e. The American Society of Dental Surgeons.
1845: Dental drill by William Rogers.
1848: Gutta-percha temporary stopping by Hill.
1855: Cohesive annealed gold foil by Robert Arthur.
1857: Impression compound by Stent.
1858: Flexible engine cable by Charles Merry.
1861: Zsigmondy/Palmer Notation.
1862: Angled handpiece by Charles Merry.
1864: Rubber Dam by Sanford C. Barnum.
1868: Textbook of Restorative Dentistry by Dr. Jonathan Taft.
1871: Dental engine by Morrison.
1871: Steel matrix for proximal cavities by Louis Jack.
1872: Carborundum disc by Robert Arthur.

1873: Silicate cement by Fletcher.
1873: Gold shell crowns by JB Beers.
1873: Zinc oxide and clove oil by Chisolm.
1875: Separators by Jarvis.
1879: Zinc phosphate cement by Dr. Pierce.
1885: "Physical Character of Filling Material" book published by Dr GV Black
1889: WD Miller—Chemicoparasitic theory of caries.
1890: "Descriptive Anatomy of Human Teeth" book published by GV Black.
1897: 1st diamond dental bur by William and Schroeder.
1903: Dr. Charles Land patented 1st ceramic crown.
1907: Practical method of casting of gold inlay by WH Taggart.
1910: High silica investment material by Von Horn.
1915: Pin retention by Burgess.
1925: Agar-agar compound by Poller.
1930: Calcium hydroxide paste by Hermann.
1935: Chemistry of reaction of amalgam and phases.
1937: Reversible hydrocolloids by Sears.
1937: Acrylic resins by Walter Wright.
1941: Silver wires (which were later called silver cones or silver points) by Jasper.
1944: Gottlieb-Proteolytic theory of caries.
1951: Ultrahigh speed air rotor handpieces.
1953: Fluid turbine type handpieces by Nelson and Nelson.
1955: Phenomenon of acid etching by Buonocore.
1955: Schatz and Martin—Proteolysis chelation theory of caries.
1958: Cemented pins by Dr. Miles Markley.
1959: 1:1 ratio of mercury: alloy by Dr. Wilmer Eames.
1960: Composite by RL Bowen.
1960: Friction lock pins by Dr. Philip Goldstein.
1963: High copper alloy (Admixed type) by Innes and Youdelis.
1963: Vita Zahnfabrik introduced 1st commercial porcelain.
1965: McLean and Hughes introduced aluminous porcelain.
1966: Self-threading pins by Going.
1967: Eggers Lura proposed sucrose chelation theory of caries.
1968: Polycarboxylate cement by Smith.
1971: Glass ionomer cement by Wilson and Kent.
1971: Dental notation by FDI, i.e. Federation Dentaire Internationale.
1972: 1st Machinable mica glass ceramic (Macor M) was patented by Corning Glass Works Co.
1973: Duret et al first used CAD-CAM.
1974: Single composition high copper alloy by Asgar.
1976: Base metal alloys by Bauer and Eden.
1980: Amalgapin by Shavell.
1980: LK Bandlish introduced Bandlish theory of dental caries.
1982: Nakabayashi introduced concept of bonding.
1983: Simmons introduced miracle mix.
1984: Adair and Grossman developed castable glass ceramic (DICOR).
1984: Microabrasion concept introduced by McClosky.
1985: Hobo S and Iwata T developed castable apatite ceramic (Cerapearl).
1985: McLean and Gasser developed glass cermet.
1989: Wohlwend, et al developed injection moulded glass ceramic.
1989: 1st resin modified glass-ionomer (Vitrebond) was developed by 3M.
1993: Dentsply launched Dyract, 1st compomer.
1994: Imazato et al developed antibacterial composite containing MDPB.
1995: High viscosity glass-ionomer cements was introduced.
1997: Heraeus Kulzer introduced packable composites.
1998: Ceramay introduced leucite reinforced porcelain.
1998: Mount introduced newer classification of carious lesions.
1999: Sikri suggested modified classification of caries/cavities.
1999: Deb, et al. developed glass-ionomer cement containing strontium oxide.
2000: Fast setting glass-ionomer cement was introduced by 3M ESPE.
2002: Shofu introduced Giomers.
2003: Lohbauer, et al. developed fiber reinforced GIC.
2003: Mazzaoui, et al. developed CPP-ACP added GIC.
2005: Pamir, et al. developed glass-ionomer cement containing titanium tetrafluoride.
2005: Hurrell-Gillingham, et al developed glass ionomer containing iron oxide.
2006: Gu, et al. added hydroxyapatite and hydroxyapatite/ZrO_2 in glass-ionomer cement.
2006: Prentice, et al. developed glass-ionomer cement containing boric acid.
2007: 3M ESPE introduced siloranes containing composite.
2010: Poly quaternary ammonium salts in antibacterial glass-ionomer cement.
2010: Kerr introduced Vertise flow, self-adhering flowable composite.
2010: Dentsply introduced smart dentin replacement technology.
2010: 'Biodentine' was introduced by Septodont
2011: Kerr introduced 'sonic fill' composite filling system, whereby ultrasonic energy allows composite to be evenly distributed in cavities up to 5.0 mm.

2012: Coltene Whaledent introduced 'componeers' as direct ready made composite veneers having a thickness of 0.3 mm, requiring no tooth preparation for application.
2014: 3M ESPE introduced Aligner impression (Invisalign)
2015: GC introduced Equia and Equia forte (Glass-ionomer based bulk restorative material)
2016: Ivoclar-Vivadent introduced Cention N [Akasite (alkaline filler) direct composite]
2017: Dexis launched CariVu for detection of caries/cracks
2017: Harvey patented 'Stamp' technique (occlusal topography), mainly for composite restorations
2017: Carestream Dental introduced CS 3600 intraoral scanner (digital impression)
2018: Dexis introduced portable digital X-rays

AIMS AND OBJECTIVES

The aims and objectives of restorative dentistry are:

1. Preservation of the healthy tooth structure; maintain integrity of the remaining tooth structure and pulp vitality as well.
2. Prevention of diseases affecting the tooth tissues (mainly caries; developmental diseases and iatrogenic fractures, etc. can be prevented at different stages).
3. Abolition and prevention of pain is also part of the 'preventive regime'.
4. Interceptive procedures, if need be, to control active disease process and to prevent further progression of the disease.
5. Restoring teeth to their form and function along with imparting pleasing esthetics. The restoration should create precise marginal seal and smooth marginal junction. It should also provide adequate strength to both the tooth and the restorative material.
6. Maintaining the oral health, following periodic evaluation. The disease process is to be managed at its incipient stage.

Aims and objectives

- Preservation
- Prevention
- Interception
- Restoration
- Esthetics
- Maintenance

INDICATIONS

The categories that primarily need restorative (restorative) treatment are:

1. *Caries:* All or any type of carious lesions on any surface of the tooth and in any age group are indicated for restorative treatment (Fig. 1.7A, B).
2. *Malformed teeth:* Developmental defects, viz. peg shape/mulberry shape teeth, hypoplastic, microdontia, etc. need restorative treatment for improvement of functions and esthetics (Fig. 1.8A, B).
3. *Discolored/stained teeth:* Management of discolored/stained teeth with bleaching, microabrasion and/or veneering, etc. (Fig. 1.9A, B).
4. *Fractured teeth:* Fracture of part of tooth tissue or even avulsion is treated by restorative procedures (Fig. 1.10A, B).
5. *Tooth substance loss:* Features like, attrition, abrasion, erosion, abfraction, etc. are managed in restorative dentistry (Fig. 1.11A, B).
6. *Defective restoration:* Defective restorations, because of any reasons, are repaired or replaced using restorative techniques (Fig. 1.12A, B).

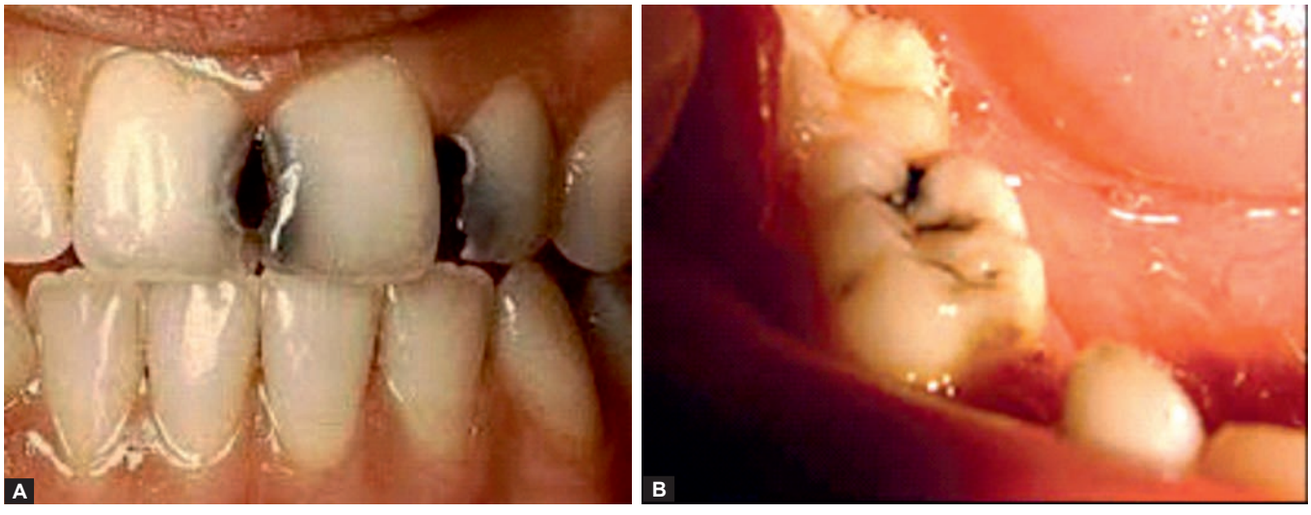

Fig. 1.7: Proximal caries: **(A)** Anterior teeth; **(B)** Posterior teeth

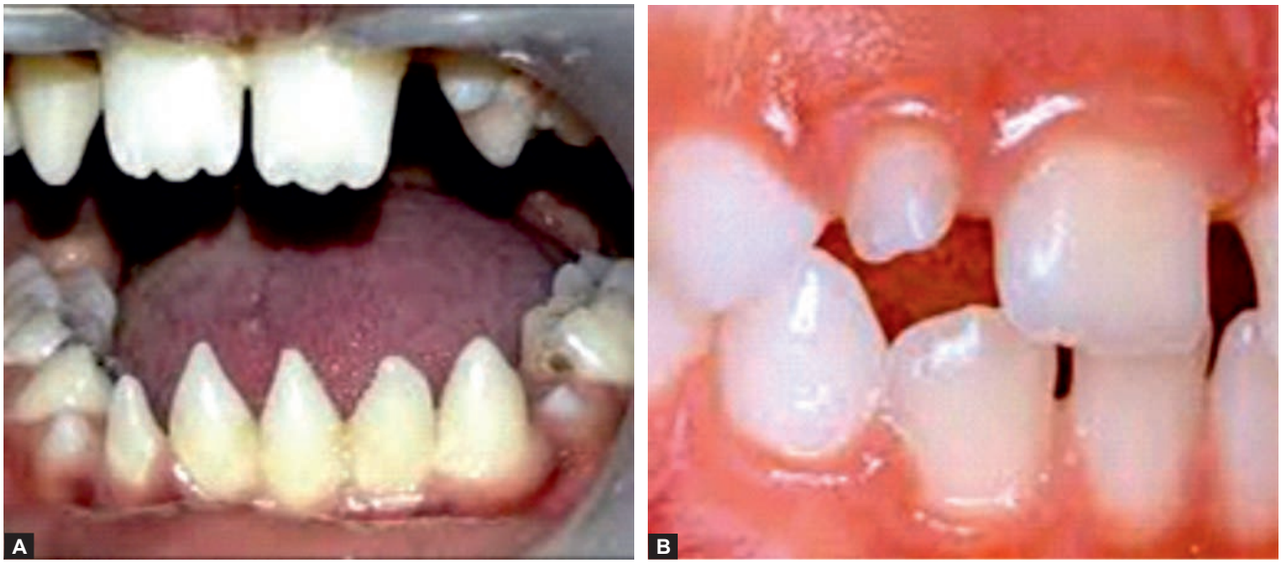

Fig. 1.8: Malformed teeth: **(A)** Peg shaped; **(B)** Microdontia

Fig. 1.9: Abnormal tooth color: **(A)** Discolored tooth; **(B)** Stained tooth

Fig. 1.10: Tooth fracture: **(A)** Incisal edge fracture (maxillary incisor); **(B)** Half crown fracture (maxillary incisor)

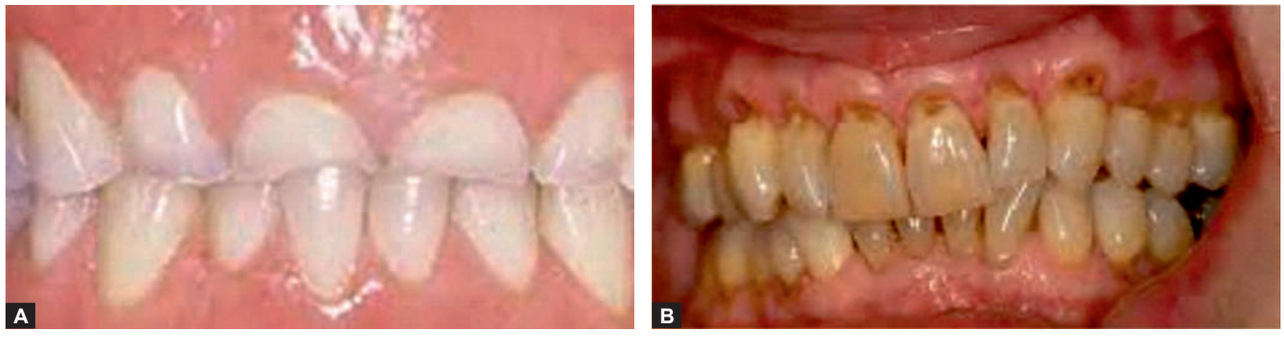

Fig. 1.11: Tooth substance loss: **(A)** Attrition (maxillary incisors); **(B)** Abfraction (maxillary teeth)

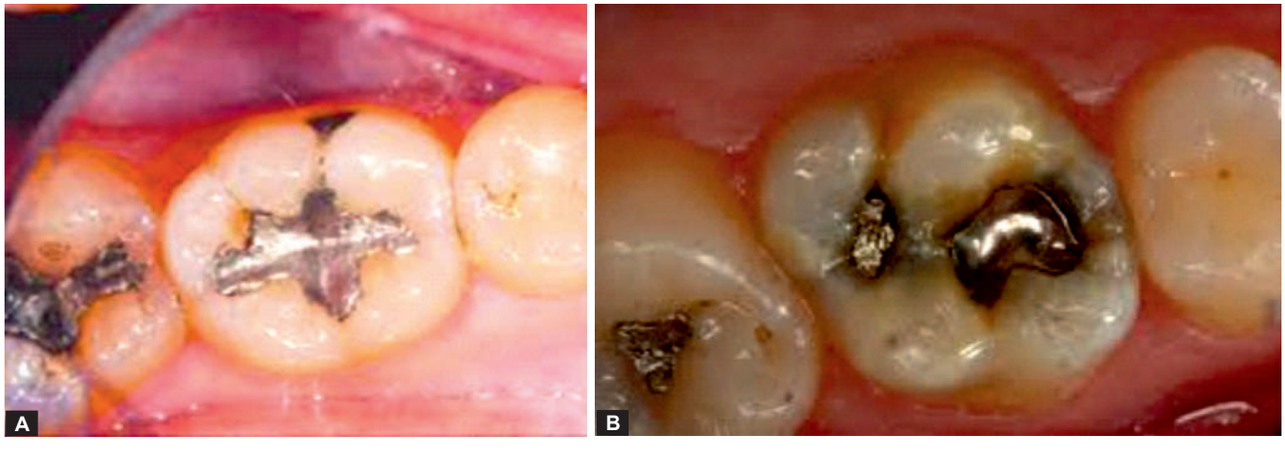

Fig. 1.12: Defective restorations: **(A)** Marginal defect (mandibular first molar); **(B)** Leakage/secondary caries (maxillary first molar)

7. *Esthetic improvement:* Esthetic corrections of diastema, asymmetrical size, etc., are managed by restorative procedures (Fig. 1.13A, B).

Indications

- Caries
- Malformed teeth
- Discolored/stained teeth
- Fractured teeth
- Tooth substance loss
- Defective restoration
- Esthetic improvement

FUTURE OF RESTORATIVE DENTISTRY

The future of restorative dentistry seems to be bright. The developments of new technology will continue. The armamentarium for prevention and diagnosis will flourish. A chair-side litmus paper test will be a valuable tool to analyze the status of the pulp. Nanotechnology, i.e. fabrication of very small size machines is being tried in medical field. Medical nanorobots have been proposed for pharmaceutical research, clinical diagnosis, rewriting DNA sequences in cells repairing brain damage, etc. This technology

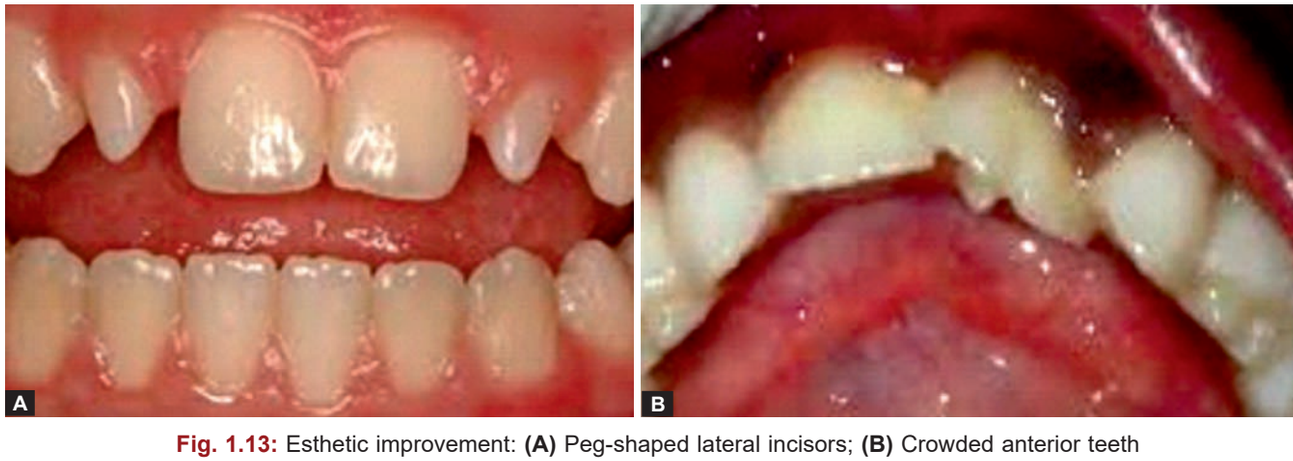

Fig. 1.13: Esthetic improvement: **(A)** Peg-shaped lateral incisors; **(B)** Crowded anterior teeth

will be utilized in dentistry too. Nanodentistry may evolve through several stages of technical developments, initially using genetic engineering, tissue regeneration and later involving growth of new tooth *in vitro*. One day the complete replacement of dentition should become feasible with installation of biologically autologous tooth replacement. Nanodentistry can also result in renaturation procedure, which means replacement of old amalgam fillings with biological materials.

In addition to all these, the durability and appearance of teeth can also be increased by replacing the upper enamel with covalent bonded artificial materials, like sapphire and diamond, which have more strength and hardness. Other changes, which can be predicted in dentistry, are the development of caries vaccinations, lasers replacing high-speed handpieces, three-dimensional radiographs and last but not the least the computer helping to enhance both delivery and predictability of dental procedures. The future dental surgeons, in all probability, will see convenient and better dentistry.

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