

Materials Used in Orthodontics

By – Dr Harsh Modi

Introduction:

Advancement seen in the field of orthodontics has been primarily due to improvement in the field of material science.

Classification:

1. Arch wire materials
2. Brackets and attachment materials
3. Auxiliary force delivery system
4. Impression materials
5. Luting materials
6. Sealants and adhesion promoters
7. Etching/ conditioning and crystal growth systems
8. Bonding materials

1. Arch wire Materials

Ideal Requirements

1. Large springback:

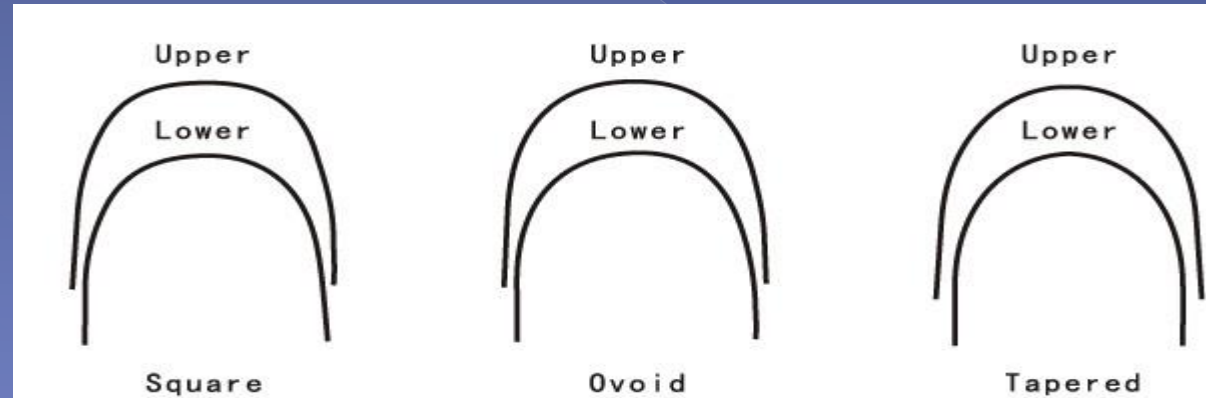
It is the maximum elastic deflection or working range.

2. Low stiffness

It provides more constant force & greater ease at a given force.

3. Formability

it provides ability to bend a wire.



4. Friction

Wire should produce least amount of friction.

5. Biocompatibility

it should be biocompatible and should also resist corrosion.

6. Capability to be welded or shouldered

7. Modulus of resilience

it represents the workability to move the tooth.

Classification of Archwire materials

<A>Based on materials constituent

- ❖ Gold
- ❖ Stainless steel
- ❖ chrome cobalt
- ❖ Nickle titanium
- ❖ beta titanium
- ❖ alpha titanium
- ❖ titaniumum niobium alloy
- ❖ Multi stranded arch wires
- ❖ composite wires
- ❖ optiflex archwires

 Based on Arch-wire cross-section

- ❖ Round
- ❖ square
- ❖ rectangular
- ❖ miscellaneous

<C>Based on micro-structural arrangements

- ❖ simple cubic
- ❖ face centered cubic
- ❖ body centered cubic

<C>Based on the diameter of the arch-wire

a. Round

- ❖ 0.08"
- ❖ 0.10"
- ❖ 0.12"
- ❖ 0.14"

b. Square

- ❖ 0.16" * 0.16"
- ❖ 0.17" * 0.17"

c. Rectangular

- ❖ 0.17" * 0.25"
- ❖ 0.17" * 0.28" etcs

Gold

Gold alloys were used prior to the 1930s.

Classification: (according to ADA)

Type 1- increased gold content

Type 2- relatively lesser content of gold



Advantages

1. Extremely formable
2. Low modulus of elasticity
3. Good jointability
4. Good environmental stability
5. Excellent biocompatibility

Disadvantages

1. Low springback
2. High cost
3. Low yield strength

Stainless steel



- ❖ Introduced in 1929 by Wilkinson.
- ❖ Mainly the austenitic form is made use of in orthodontics.

Advantages

- ❖ high stiffness
- ❖ high yield strength
- ❖ high resilience
- ❖ high formability
- ❖ Good environmental stability
- ❖ good jointability
- ❖ adequate springback
- ❖ biocompatible
- ❖ corrosion resistant
- ❖ economical

Disadvantages

- ❖ **soldering is demanding**
- ❖ **lower spring back than Ni Ti alloys**
- ❖ **high modulus of elasticity**
- ❖ **more frequent activations are required to maintain the same force levels**

Chrome cobalt

Also known as Elgiloy.

The wires made from this alloy are generally supplied in the ductile form, allowing them to be easily deformed and shaped in to appliances.

Advantages:

- ❖ Excellent tarnish and corrosion resistance
- ❖ greater resistance to fatigue
- ❖ greater resistance to distortion
- ❖ good formability
- ❖ functionally remains active for a longer duration if used as a resilient spring

Disadvantages

- ❖ **has to be heat treated**
- ❖ **soldering is demanding. A low fusing solder has to be used.**
- ❖ **higher forces are required for similar activations stainless steel wires.**

Nickle-Titanium

It is also known as NiTinol.

There are basic 2 types:

1. Thermal nitinol
2. Elastic nitinol

1. Thermal Ni-Ti alloy

It is composed of equal parts of nickle and Titanium.

Compositional variations lead to changes in the martensitic and Austensitic forms.

2. Elastic Ni-Ti Alloy

It maintains its high elasticity and flexibility.

Advantages:

- ❖ high spring back

- ❖ **high stored back**
- ❖ **high elasticity**

Disadvantages

- ❖ **High friction**
- ❖ **Low stiffness**
- ❖ **easily fractures**
- ❖ **limited bending**
- ❖ **can't be welded or soldered**
- ❖ **expensive**

Copper Ni-Ti Alloy

Addition of copper to this is helpful in many ways.

- 1.It decreases the loading and unloading forces causing delivery of more constant forces for small activations.
- 2.It increases surface smoothness
- 3.It also helps in controlling the transformation of temprature.

Advantages

- ❖ more resistant to permanent deformation
- ❖ better springback
- ❖ more constant forces are exerted over small activations

Beta titanium (TMA)

The absence of Nickel makes the wires useful in patients allergic to Nickel.

Distinctive features and Advantages

- ❖ Good springback
- ❖ Low force delivery
- ❖ good formability and weldability
- ❖ low stiffness
- ❖ Low loaddeflection rate
- ❖ environmentally stable
- ❖ excellent corrosion resistant
- ❖ can be joined by electrical resistant welding

Disadvantages

- ❖ More friction
- ❖ becomes brittle on overheating

Alpha Titanium

**This alloy is made of closely packed Hexagonal crystals.
Due to the design –these wires are more stiff as compared to
Nickle titanium wires.**

Titanium Niobium alloy

- ❖ These Wires have less stiffness as compared to TMA wires resulting in an increase in formability of wire.
- ❖ They are ideal as finishing wires as they can be bent more easily and still are able to maintain the low force levels required.
- ❖ there is no leaching out of Nickle from the alloy.

Multi stranded Archwires

Classification

1.Round

2.Rectangular

3.Based on number of strands

- 3 strands

- 6 strands

4.Based on the mode of joining the strands

- Braided

- Twisted

Composite Coated wires

Wires are made of a combination of materials coated one on top of another or fibres.

Optiflex Arch wires

These are made of Silicon placed in the middle .

Advantages

- ❖ adds strength
- ❖ protects the core from moisture

These wires provide light continues forces so useful during initial phase of orthodontic treatment.

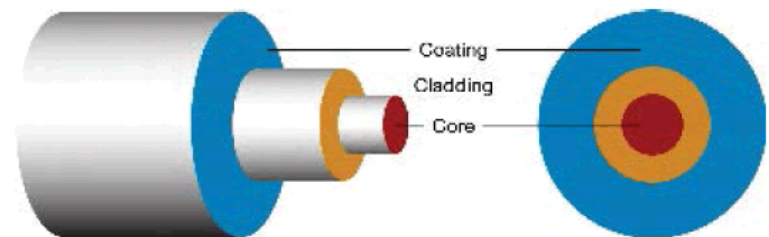


Figure 3: Composition of clear optical fiber: Core – Silicon Dioxide (Silica), Cladding - Silicon Resin (Silane), Coating - Nylon (Nylon 6-6)

2.Brackets

Bracket is defined as :a device that projects horizontally to support auxiliaries and is open on one side usually in the vertical or horizontal.

CLASSIFICATION:

Brackets can be classified in to
Material used in Manufacture

1. Metal
2. Plastic
3. Polycarbonate
4. Fibre glass reinforced plastic
5. Polyurethene
6. Ceramic
- ❖ Alumina based:
 - Monocrystalline
 - Polycrystalline
 - Laminated brackets.

❖ Zirconia based brackets

7 Titanium

Morphology of the Bracket

- 1 Siamese
- 2 Mini-twin
- 3 Single wing
- 4 Self-ligating, etc.

Technique for Which it is Used

- 1 Begg light wire appliance
- 2 Edge-wise appliance
- 3 straight wire appliance
- 4 tip edge appliance
- 5 lingual pre-adjusted edge-wise appliance ,etc



Types of Brackets

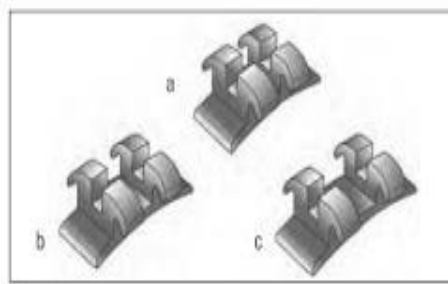


Fig 10-89 The edgewise twin brackets are available in narrow (a), medium (b), and wide (c) sizes to match the different tooth forms.



Fig 10-90 The combination tube is fitted with a tube for the edgewise arch and a tube for a facebow.

1.Edge wise type

they have a horizontal slot facing labially.

Advantages:

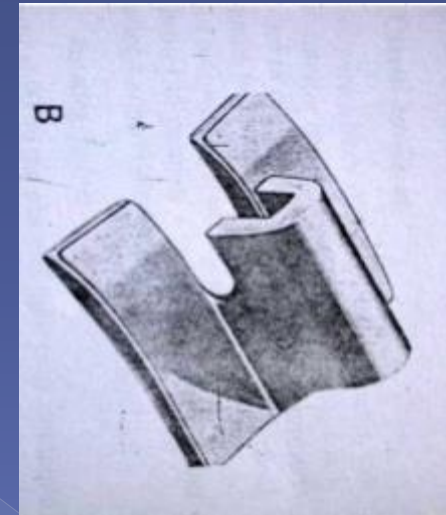
-provide greater control over tooth.

2.Ribbon arch brackets

they have a vertical slot facing occlusal/ Gingival direction.

Advantages:

-Round wires are used with this to bring tipping of teeth in labio-lingual as well as mesiodistal direction.
so, they are used in Begg appliances.



3. Weldable and bondable Brackets:

They can be bonded with bonding adhesives

Or

welded on bands & later on cemented.

4. Metallic Brackets

stainless steel brackets are most commonly used.

Advantages:

- ❖ can be recycled and sterilized.
- ❖ resist deformation and fracture
- ❖ not much expensive
- ❖ exhibit least friction

Disadvantages:

- ❖ **esthetically not pleasing**
- ❖ **stains the teeth.**



5. Ceramic brackets

Made of Aluminium Oxide or Zirconium Oxide.

Advantages

- ❖ dimensionally stable
- ❖ durable
- ❖ resist staining
- ❖ biocompatible
- ❖ extremely esthetics

Disadvantages

- ❖ Brittle so fracture easily
- ❖ To compensate brittleness so they are made bulky so size is increased.
- ❖ exhibit greater friction
- ❖ More chances of enamel fracture while debonding
- ❖ High cost of material



6. Polycarbonate brackets (Plastic brackets)

Made of Polycarbonate.

Advantages:

Good Esthetic values

Disadvantages:

- ❖ discolours easily in patient who smokes or drinks coffee.
- ❖ poor dimensional stability
- ❖ slot tends to distort
- ❖ friction between plastic and metal is very high

7. Fibre-Glass reinforced Brackets:

-basic content is Polycarbonate+ reinforced with glass

Advantage:

No enamel damage during debonding.

Disadvantages:

- ❖ wear off easily if in contact with opposing teeth
- ❖ Can't be recycled satisfactorily.

8. Metal reinforced ceramic brackets

Advantages:

- ❖ they produce very less damage to enamel while debonding.
- ❖ decrease friction values

9. Titanium brackets:

It is the latest metal to be used.

Advantages:

- ❖ more biocompatible
- ❖ allows superior finish so decrease the friction
- ❖ can be helpful in patients with Nickel hypersensitivity.

Disadvantages:

- ❖ more expensive

3. Auxiliary force delivery systems

They include:

1. springs
2. elastics and elastic modules
3. magnets

1. Springs

Various types of springs are used as auxiliaries to generate tooth-moving forces.

Uses of springs in fixed appliances

- ❖ uprighting springs (to upright teeth)
- ❖ rotating springs (to rotate teeth in a particular direction)
- ❖ torquing springs (to bring root movements)
- ❖ open coil springs (to open\regain space)
- ❖ closed coil spring (to retract or close already existing or created spaces)

Stainless steel springs are preferred over Ni-Ti as it exerts greater force.

Springs are mainly used in Begg appliances and Tip edge appliances.

Elastics and Elastic Modules

Classification

1. Latex and latex based systems

- plain
- colored

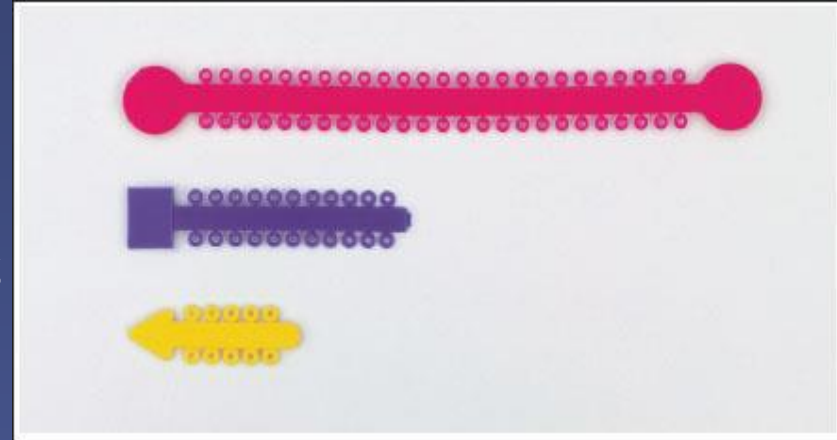
2. Polyurethane based systems

- plain
- colored

3. According their ability to release flourides

- Flouride releasing
- non-flouride releasing

4. Silicon based



Elastics

They are active components of fixed appliances.

Classification:

- Latex
- non-latex

Different forms:

1.Elastics

- they are colour coded.
- forces delivered depend on their diameter.

uses:

- closure of space
- to correct open bites
- to correct inter-arch relationship



Applications of elastics

1. Class 1 elastics
for closure of space & retraction of teeth.
2. Class 2 elastics
useful in treatment of class2 malocclusion.
3. Class 3 elastics
useful in treatment of class3 malocclusion.
4. Crossbite elastics
useful in treatment of molar crossbites.
5. Box elastics
useful in correction of anterior openbites

Elastic chain

- They are elastics available as long chains of interconnected rings.
- made of polyurethane
- available in different forms.

Uses:

- closure of spaces between teeth by stretching the rings.

Elastic threads

They are made of a core of Latex rubber surrounded by a sleeve of woven silk and is available in a spool.

Use:

- to close the space
- to derotate the tooth

Elastic modules

They are made of elastic rings separated by a variable distance.

Use:

- to close space
- for derotation of teeth

Magnets

Magnets have been used for generation of tooth moving forces In both repulsion as well as attraction mode.

Types of Magnetic materials used:

- ❖ _platinum cobalt
- ❖ Aluminium-Nickle- Cobalt
- ❖ Ferrite
- ❖ Chromium-cobalt-Iron
- ❖ Samarium-Cobalt
- ❖ Neodymium-Iron-Boron

Uses:

- ❖ _Diastema closure
- ❖ Arch expansion
- ❖ Distal driving of molars
- ❖ Removable appliances for treating impacted teeth

- ❖ Active vertical corrector
- ❖ Magnetic bracket system

Advantages:

- ❖ decreased patient co-operation
- ❖ Frictionless mechanics
- ❖ predictable force level
- ❖ Force doesn't decay overtime but over distance, hence, periodic reactivations are movement dependent.

4. Impression Materials

For the purpose of achieving essential diagnostic records, study models – good impression material is required.

1. Irreversible Hydrocolloids (Alginate)

Alginate is called Irreversible as it forms an elastic material through a chemical reaction that cross-links its polymer chains.

Advantages:

- ❖ Easy to manipulate
- ❖ comfortable for patient
- ❖ pleasant taste
- ❖ relatively inexpensive
- ❖ able to displace the blood and saliva

- ❖ hydrophilic
- ❖ Compatible with stone, so easy to pour and retrieve the cast.
- ❖ can be used with stock trays

Disadvantages

- ❖ may tear easily on removal from mouth.
- ❖ must be poured immediately as dimensionally unstable.
- ❖ they have limited detail reproduction
- ❖ they can be used pouring the cast only once.
- ❖ Incompatible with epoxy resin.

Uses:

- ❖ preparation of study models or diagnostic casts
- ❖ For recording impressions
- ❖ for appliances construction
- ❖ for recording impression of edentulous and partially edentulous arches.

Composition

Ingredient	Function	Amount(%)
1.Potassium alginate	Dissolves in water and reacts with calcium	18
2.Calcium sulphate dihydrate	Reactor and forms cross linking	14
3.Potassium sulphate, Potassium Zinc flouride silicate or Borate	To counteract the effect of hydrocolloid	10
4.Diatomaceous earth or Zinc oxide	Controls consistency	50-60
5.Sodium phosphate	retarder	2

6.Glycol	To make powder dustfree	small
7.Pigments	To provide colour	traces
8.peppermint	Pleasant taste	traces
9.Chlorhexidine	disinfectant	1-2
10.Sodium silico phosphate	Controls pH	4

	Regular set	Fast set
Mixing time	1	0.75
Working time	3 - 4.5	1.25 - 2
Setting time	1 - 4.5	1 - 2

Disinfection

the impression can be immersed in disinfectant like
1% sodium Hypochlorite
2% Glutaraldehyde

- It is used for making impression in Orthodontics so frequently that it is available in different Flavoured materials.

2.Modified Alginates:

it can be modified by adding Silicone polymers. it is available in 2 paste system.

5. Luting Materials

Luting materials mainly include dental cements.

Orthodontics application of cements is limited to luting of appliances eg, Bands...

Ideal requirements:

- ❖ adequate working and setting time
- ❖ high tensile, compressive and shear strength
- ❖ resistance of dissolution
- ❖ clinically acceptable bond strength
- ❖ low adhesive remnant index
- ❖ anticarcinogenic property
- ❖ low adhesive remnant index following bonding

Zinc Phosphate cement

It is one of the oldest luting cements used in dentistry.

Advantages :

- ❖ _good handling property.
- ❖ Longevity of the cement in the mouth is quite good.
- ❖ manipulation is less critical.

Disadvantages:

- ❖ _doesn't bond with the tooth structure, so retention is only by means of mechanical retention.
- ❖ pH is acidic-so causes pulpal irritation.
- ❖ no specific anticarcinogenic effect.
- ❖ lacks Antibacterial action.
- ❖ it is brittle.

Zinc Polycarboxylate cement

It is the first dental material developed with adhesive potential with Enamel and Dentin.

Advantages:

- ❖ bond to enamel and dentin as well as some of the cast restorations.
- ❖ less irritating.

Disadvantages:

- ❖ properties depend highly on handling procedures.
- ❖ short working time
- ❖ exacting technique is required to ensure bonding.

Application:

- ❖ cementation for orthodontic bands
- ❖ as luting agents
- ❖ as cavity bases

Glass Ionomer cement

Synonym:

- ❖ Polyalkenoate cement
- ❖ Alumino silicate Polyacrylic Acid (ASAP)

Advantages:

- ❖ easy to mix
- ❖ high strength and stiffness
- ❖ Leachable flouride
- ❖ good resistance to acid dissolution
- ❖ potentially adhesive characteristics
- ❖ translucency
- ❖ reasonably Biocompatible

Disadvantages:

- ❖ initial slow setting
- ❖ moisture sensitivity
- ❖ radiolucent

- ❖ possible pulpal sensitivity
- ❖ Vulnerable to wear
- ❖ low fracture toughness
- ❖ variable adhesive characteristics
- ❖ slow development of strength
- ❖ low wear resistance

Application (In ortho):

- ❖ cementation of cast-alloy and porcelain restoration
- ❖ cementation of orthodontic bands
- ❖ Bonding of brackets

6. Adhesion promoters

- Adhesion is a process of forming an adhesive joint.
- the initial substrate is called the adherent whereas the material producing the interface is called the adhesive.

The bonding mechanism holding the bracket to the tooth can be subdivided in to two components:

- adhesion
- attachment

Thus, bonding=adhesion+ attachment

Ideal requirements of orthodontic adhesives:

- ❖ to have suitable flow properties
- ❖ wettability
- ❖ penetration without undue slumping=thixotropy
- ❖ provide high bond strength to enamel and dentin.
- ❖ provide an immediate and durable bond
- ❖ prevent of the ingress of bacteria
- ❖ be safe to use
- ❖ biocompatible
- ❖ be simple to use
- ❖ to minimize setting shrinkage, their overall water absorbing tendency should be minimum
- ❖ aesthetics
- ❖ colour stability

Some orthodontic adhesives

There are mainly 2 categories of adhesive materials.

1. Self matrix (Glass Ionomer cement)

2. Resin matrix (Resin composite)

3.

A third category of material has been introduced- which is nothing but a combination of self matrix and resin matrix.

so known as resin ionomer hybrids.

According to ISO they are termed as

Light activated water based cements.

Advantages of these hybrids:

- ❖ ability to bond to enamel and dentin with greater strength.
- ❖ fluoride releasing action
- ❖ prolonged working time.
- ❖ command set
- ❖ improved resistance to desiccation
- ❖ enhanced strength

Some currently available hybrids:

1. Resin modified glass ionomer cement.
2. Compomers (Polyacid modified resin composites)

1. Resin modified GIC:

They contain component of both GIC and Composites.

Advantages:

- ❖ more aesthetic than GIC.
- ❖ they bond to tooth without dentin bonding agent.
- ❖ their transverse strength is double that of conventional GIC.

Contraindicated:

Use of dentin bonding agent with them is not preferred as it decreases the fluoride release.

2. Compomer

They are much like composites and are supplied as anhydrous single paste.

Advantages:

- ❖ excellent aesthetics
- ❖ low solubility
- ❖ high bond strength
- ❖ high fracture toughness

Disadvantages:

- ❖ require bonding agent
- ❖ less fluoride release than GIC

7. Acid etching

This technique consists of applying an acid in an appropriate concentration to the enamel surface. once it dissolves it involves 10-15 micrometer depth.

Surface becomes highly irregular and forms a mechanical lock with resin. After polymerization it forms a strong bond to the enamel surface.

Procedure of acid etching:

- ❖ surface should be cleaned first, should be free of debris and other organic matters.
- ❖ 30-40% phosphoric acid is applied
 - with brush or injected .
 - either in form of aqueous solution or gel
 - for 30-60 seconds
- ❖ washing the surface for 20 seconds

❖ surface should be dried properly

Care should be taken to prevent contamination of water on the dried surface. If contamination occurs then re-etching is performed for

8. Bonding Materials

- Bonding is based on the mechanical locking of an adhesive to irregularities in the enamel surface of the tooth and to mechanical locks formed in the base of the orthodontic attachment.
- Successful bonding in orthodontics requires attention to 3 components:
 - 1.the design of attachment base
 - 2.the tooth surface and its preparation
 - 3.the bonding material

Bonding materials

Ideal Requirements:

- ❖ dimensionally stable
- ❖ quite fluid in form
- ❖ should have excellent inherent strength
- ❖ easy to use

Materials in use:

1. Acrylic (bis-GMA) resin
 - preferred bonding materials
 - available in different formulations, variety of colours
 - either chemically activated
or Light activated
2. Fluoride releasing bonding materials

Types of bonding procedure

1. Direct bonding

It is a successfully used practice.

Advantages

- easy
- faster
- less expensive

Disadvantages

- doesn't provide accurate placement of Brackets as indirect bonding does.

2. Indirect bonding

Advantages

- more precise location of brackets
- in case of poor visibility when direct bonding is not possible-indirect bonding helps.

THANK YOU

References:-

- 1) Gurkeerat Singh
(Textbook of Orthodontics)
- 2) S.I Bhalajhi
(Orthodontics- The art and science)