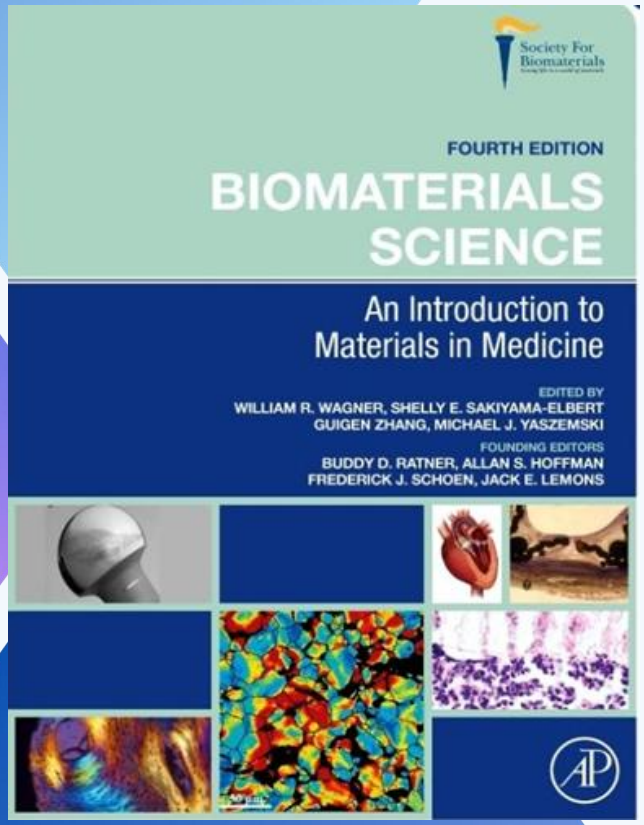


Dental Applications in Biomaterials – 2

Dental Implants

History and Present status of Implant Dentistry

Ancient Implants

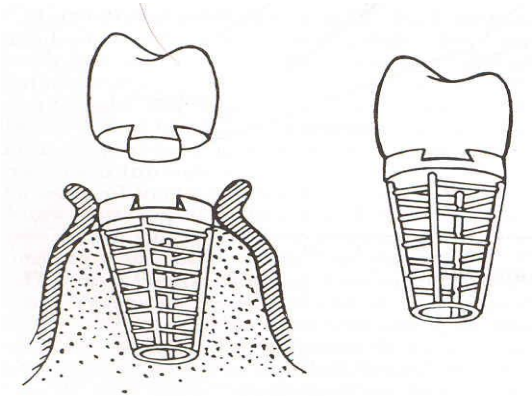
- 16 th Dark stone
  (Egyptian-South American)
- 17 th Carved ivory teeth

Early Implants

- 1809 Gold implant
- e.20th Lead, iridium, tantalum, stainless steel, and cobalt alloy
- 1913 hollow basket

  iridium + gold wires

  (Greenfield)



Early Implants

- 1937 Adams's submergible threaded cylindrical implant with round bottom

- 1938 Strock's (long term) threaded vitallium implant

  (cobalt+chrome+molybdenum)

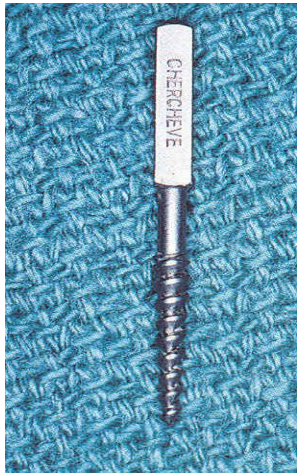
- The modern implants appear to be variants or composites of some of the designs of early

Subperiosteal Implants

- Placing implants on and around bone rather than in it
- 1943 Dahl of Sweden placed with 4 projecting posts
- Direct bone impression
- Cobalt-chrome-molybdenum casting
- CT-generated CAD-CAM model

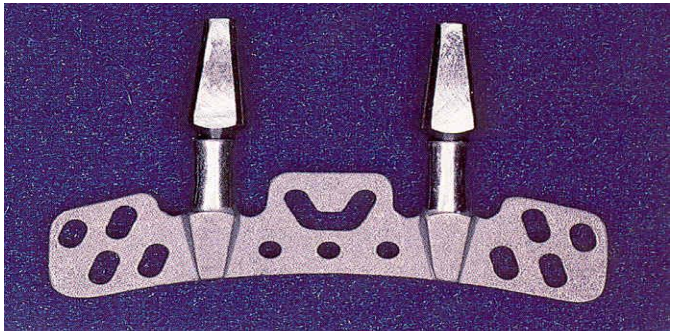
One-stage pins and screws

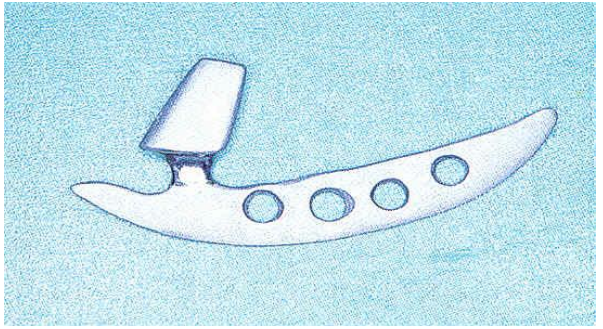
- Early 1960s pin, screw, and cylinder shaped implants
- One piece and not submerged
- Did not osseo-integration
- Fibrous peri-implant membrane
- Shock-absorbing claim



Blade Implants

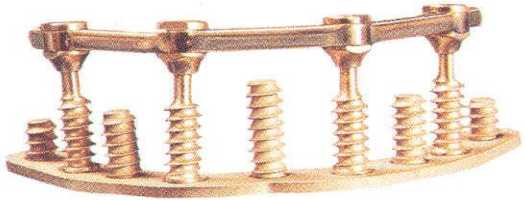
- 1967 Linkow blade implant-in narrow ridge
- Required shared support with natural teeth
- 1970 Roberts and Roberts – Ramus blade implant (titanium)

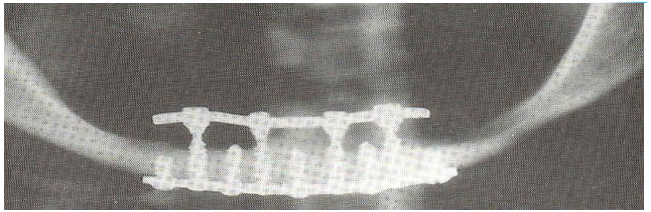


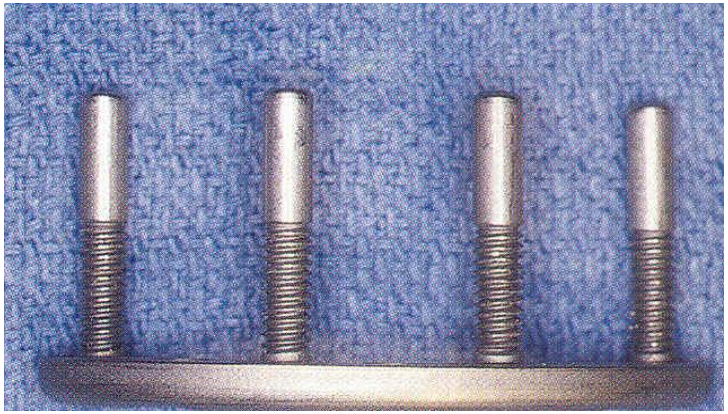


Transosteal Implants

- 1975 Small introduced transosteal mandibular staple bone plate
- Limited to mandible only

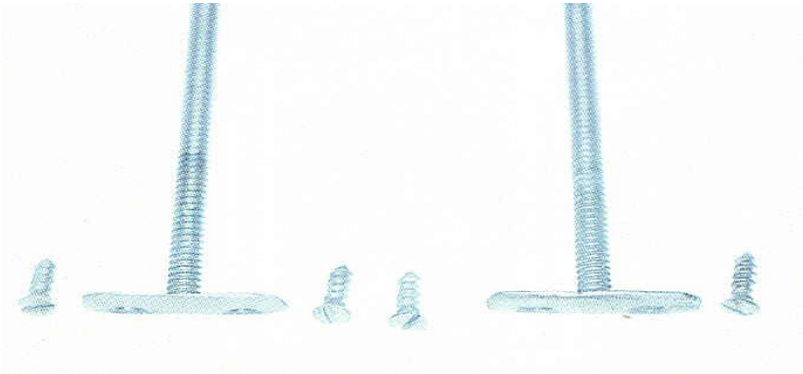






Transosteal Implants

- 1970 Cranin - single transosteal implant
- 1989 Bosker – transmandibular implant



- The First Dental Implant Consensus Conference, sponsored by the National Institutes of Health (NIH) and Harvard University in 1978, was a landmark event.

“ Dental Implants: Benefits and Risks”

- The Toronto Conference opened the door to prompt widespread recognition of the Branemark implant.
- The discovery of osseointegration has been one of the most significant scientific break throughs in dentistry.

Endosteal root-form implants

- 1978 Two-stage threaded titanium root-form implant was first presented in North America by Branemark (Toronto conference)
- Terms “fixture”
- First fixture was placed in 1965
- Well-documented, long term prospective study

Present Status

- Three Basic:

“ In Bone”

“Through Bone”

“On Bone”

“In Bone”

- 1. Ramus concepts (Harold and Ralph Roberts)
- 2. Pin concepts (J. Scialom→ Michelle Chercheve)
- 3. Disk concepts (Gerard Scorteci)
- 4. Plateform concepts (Harold + Roberts/Linkow)

Present Status

- Many other root-forms have been introduced.
- Body shaped competition
- Surface competition – roughness
- Varieties competition
- Connection competition

Material for Implant

Dental Implants

- Implant material should have suitable mechanical strength, biocompatibility, and structural biostability in physiologic environments.

Dental Implants

- The development of biomaterials sciences has resulted in classification schemes for implantable materials according to chemical composition and biologic response.

Biologic classification

- Based on tissue response and systemic toxicity effects of the implant
- Biotolerant
- Bioinert
- Bioactive

Long term effects

- Biotolerant materials, such as polymethylmethacrylate (PMMA), are usually characterized by thin fibrous tissue interface.
- Chemical product irritate surrounding tissues.

Long term effects

- Bioinert materials, such as titanium and aluminum oxide, are characterized by direct bone contact, or osseointegration, at the interface under favorable mechanical conditions.
- Non-reactive

Long term effects

- Bioactive materials, such as glass and calcium phosphate ceramics, have a bone-implant interface characterized by direct chemical bonding of the implant with surrounding bone.
- Free calcium and phosphate compounds at the surface.

Tissue response to implant materials

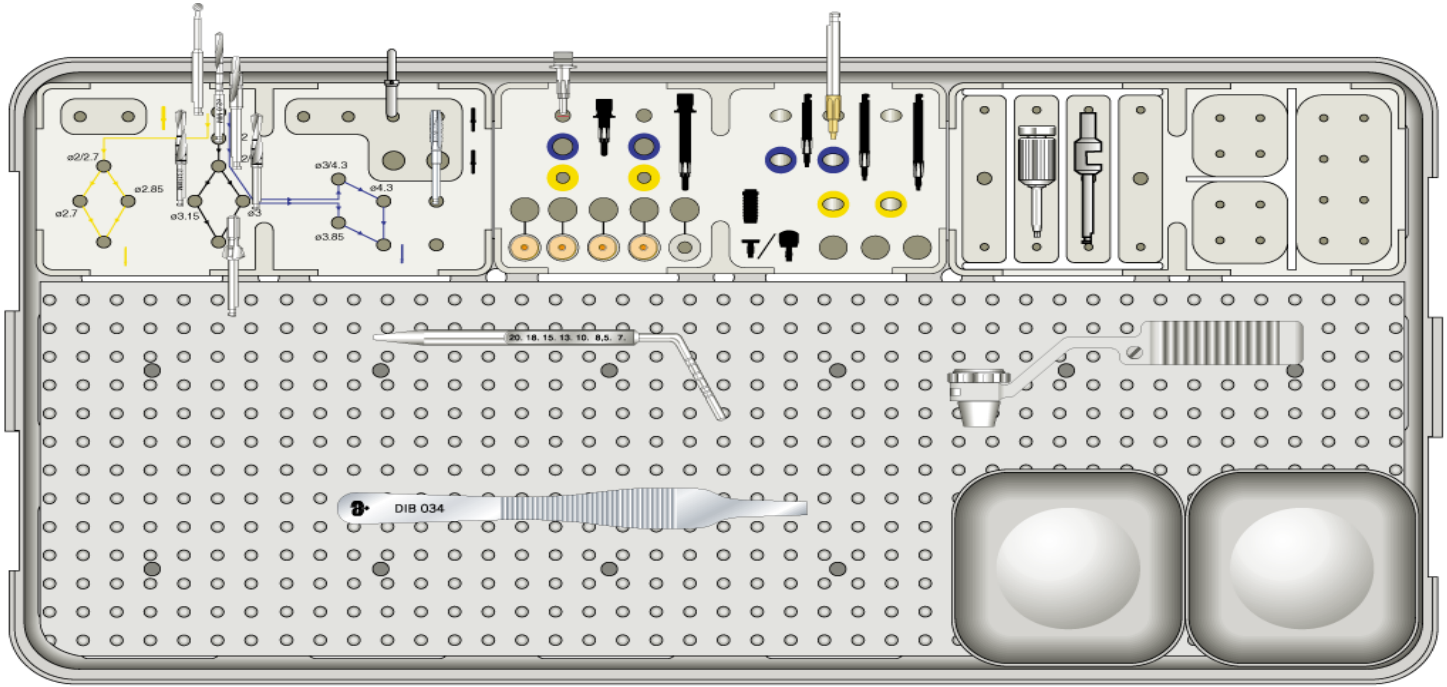
- Most commonly used biomaterials:
- Commercially pure (CP) titanium
- Titanium-aluminum-vanadium alloy (Ti-6Al-4V)
- Cobalt-chromium-molydenum (Co-Cr-Mo) alloy is most used for subperiosteal implants.

Tissue response to implant materials

- Calcium phosphate ceramics, Hydroxyapatite (HA), used for augmentation material or coating on surface.

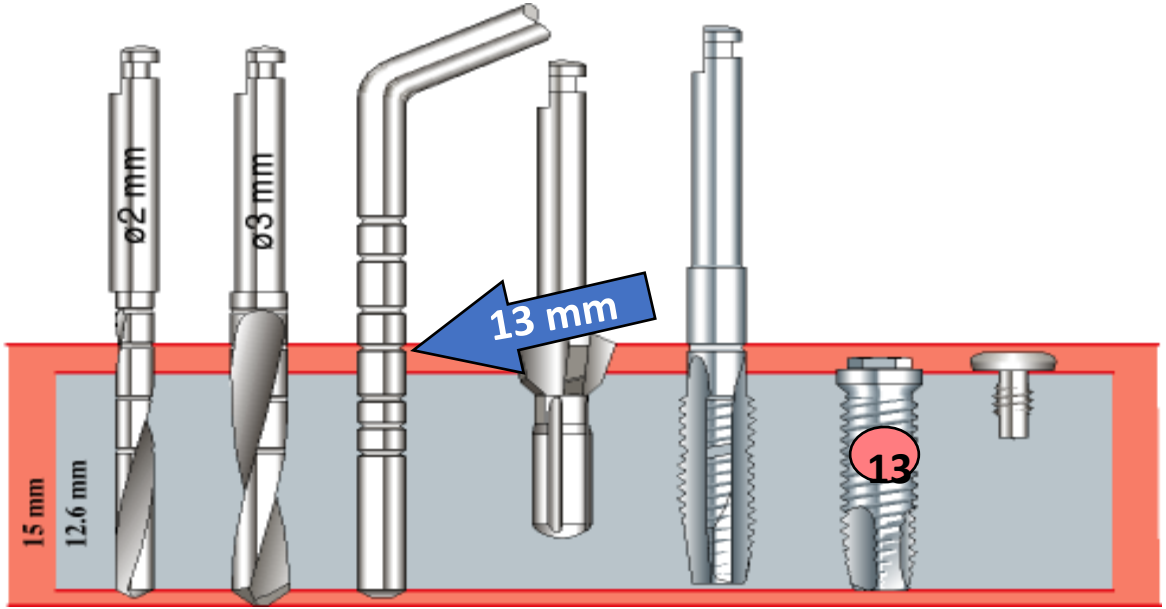
Fixture Placement
and
Second Stage Procedure

Fixture Placement



Fixture Placement Procedure
For
Mk III ∅ 3,75
13 mm

Depth Measurement System



1 Drilling procedure - High speed

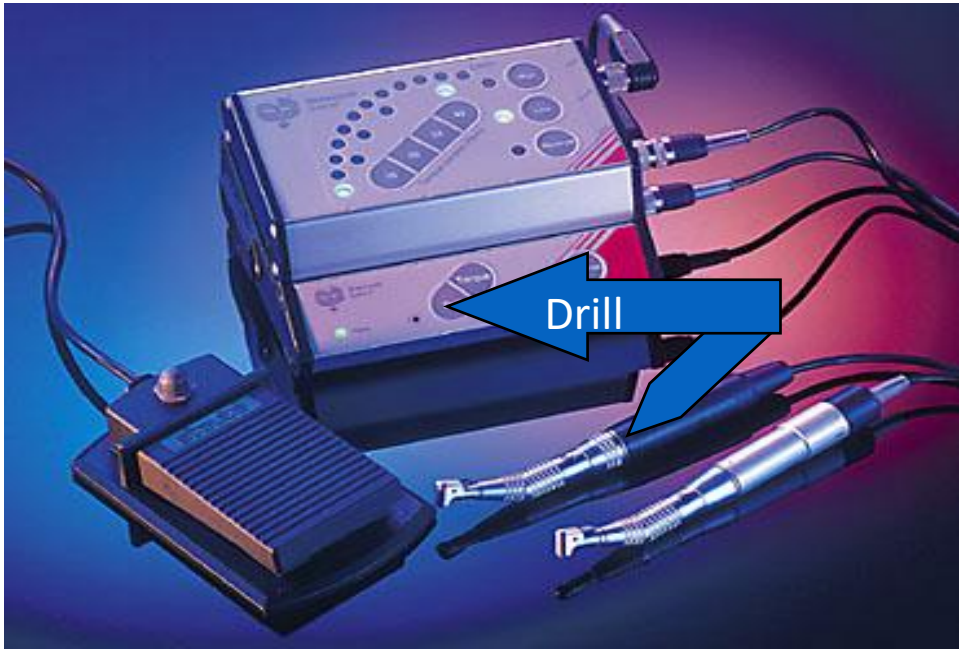
2 Fixture placement - Low speed

OsseoCare™

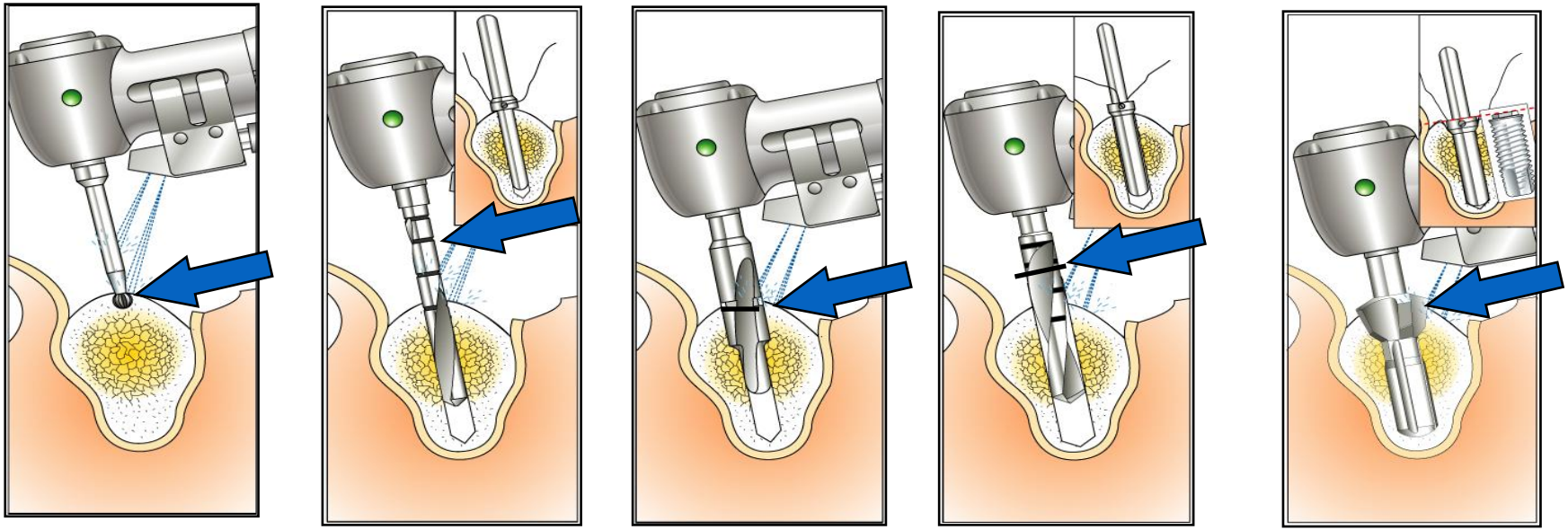
Drilling - High speed

Controller Set™

Drilling - High speed



Drilling Procedure

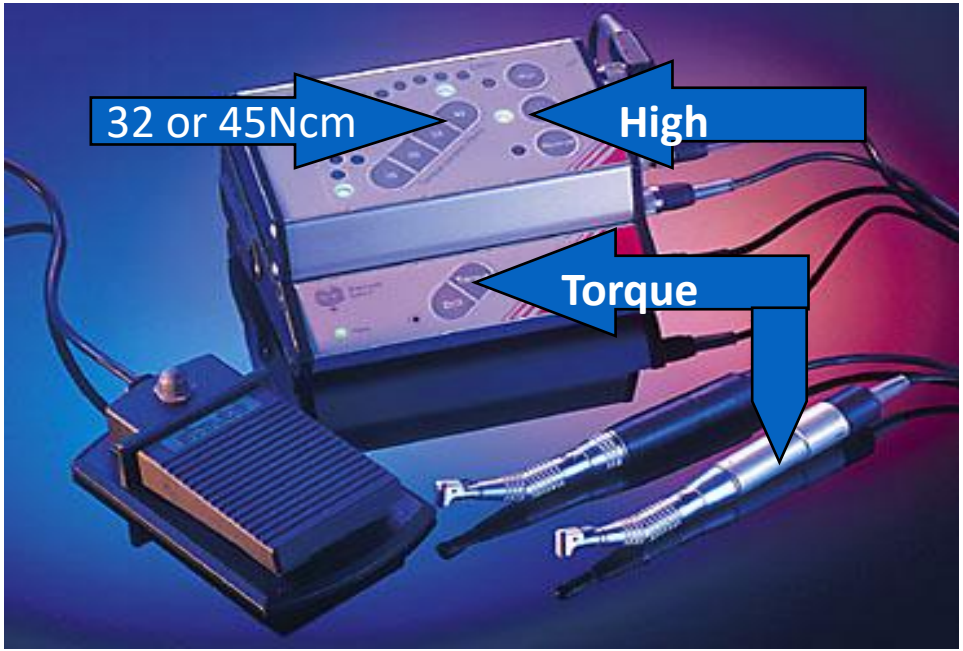


OsseoCare™

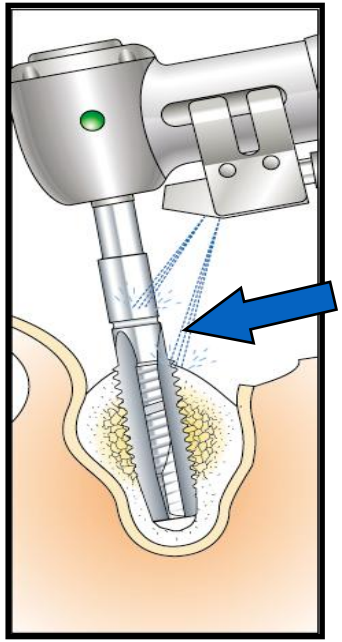
Fixture placement - Low speed

Controller Set™

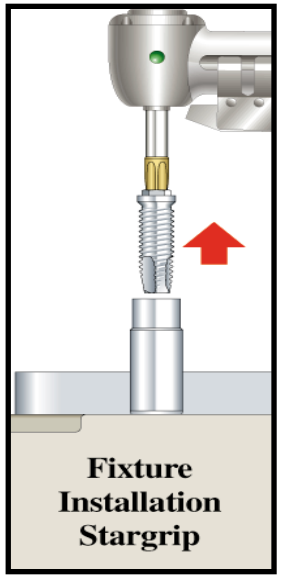
Fixture Placement -Low speed

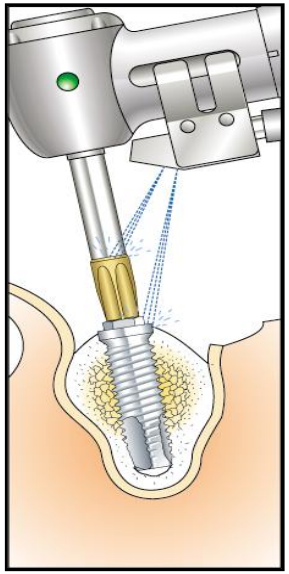


Screw tap

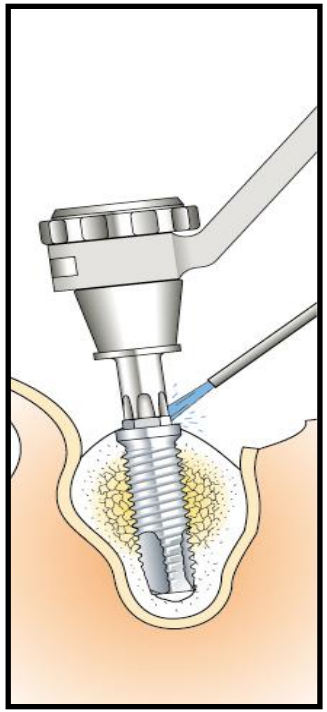


Fixture Placement





Cylinder wrench

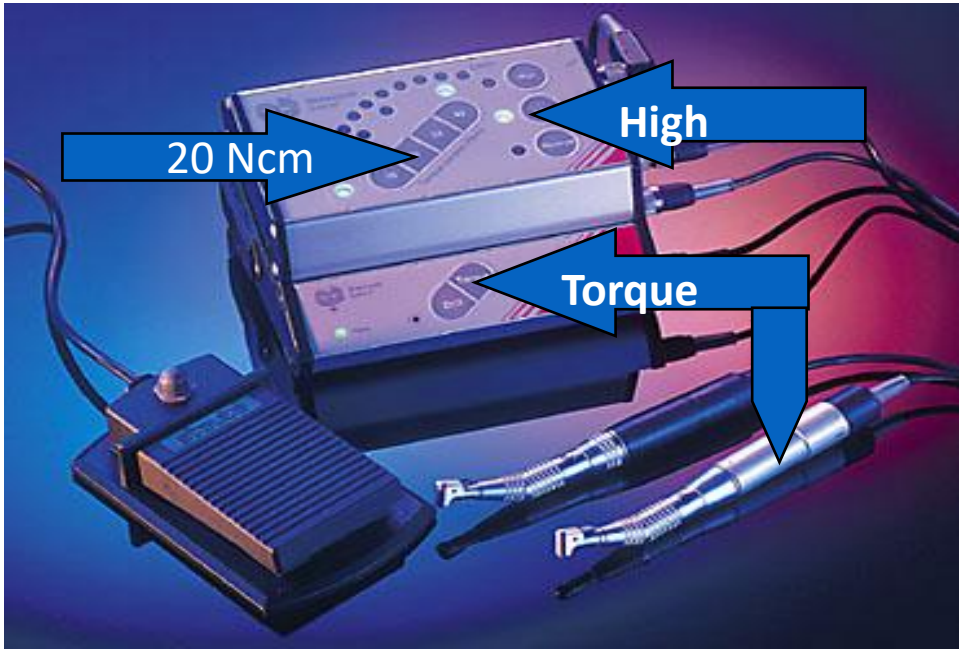


OsseoCare™

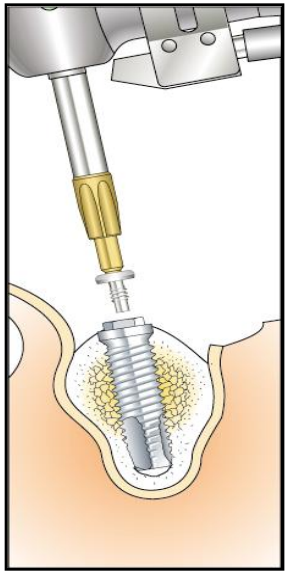
Cover screw - Low speed

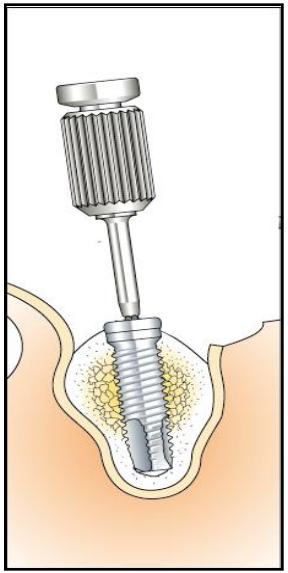
Controller Set™

Cover screw - Low speed

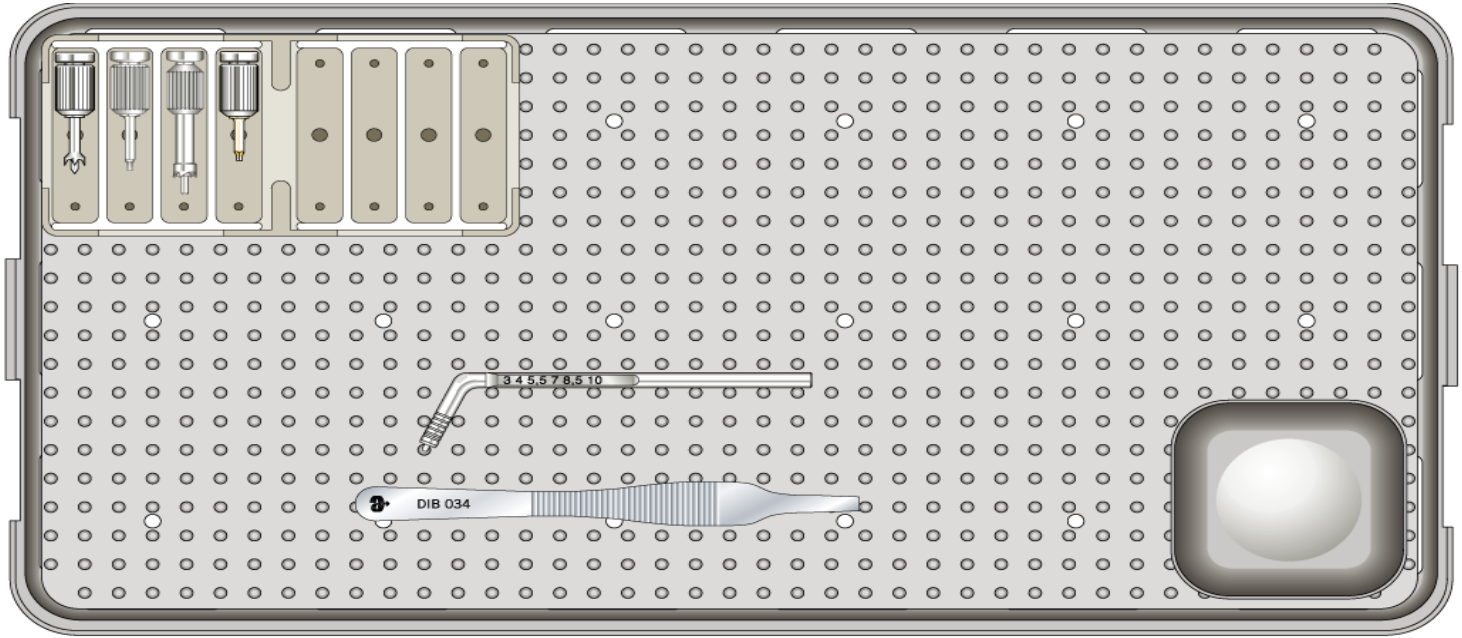


Cover screw

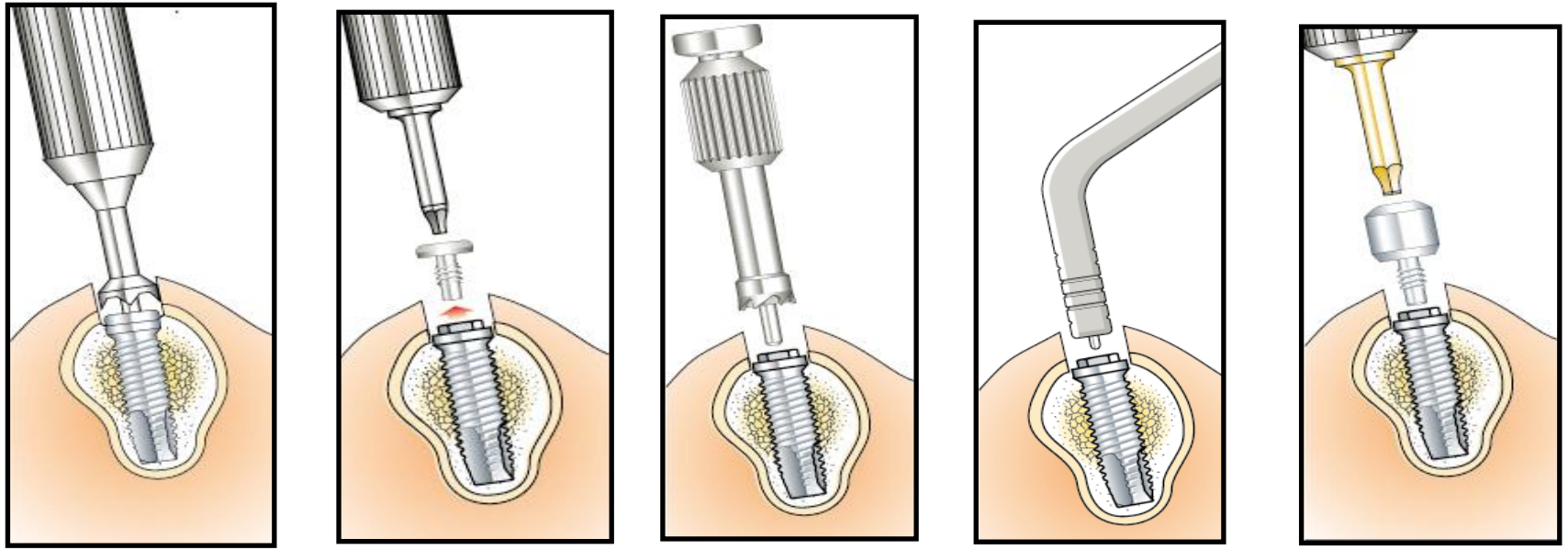




Second Stage Procedure

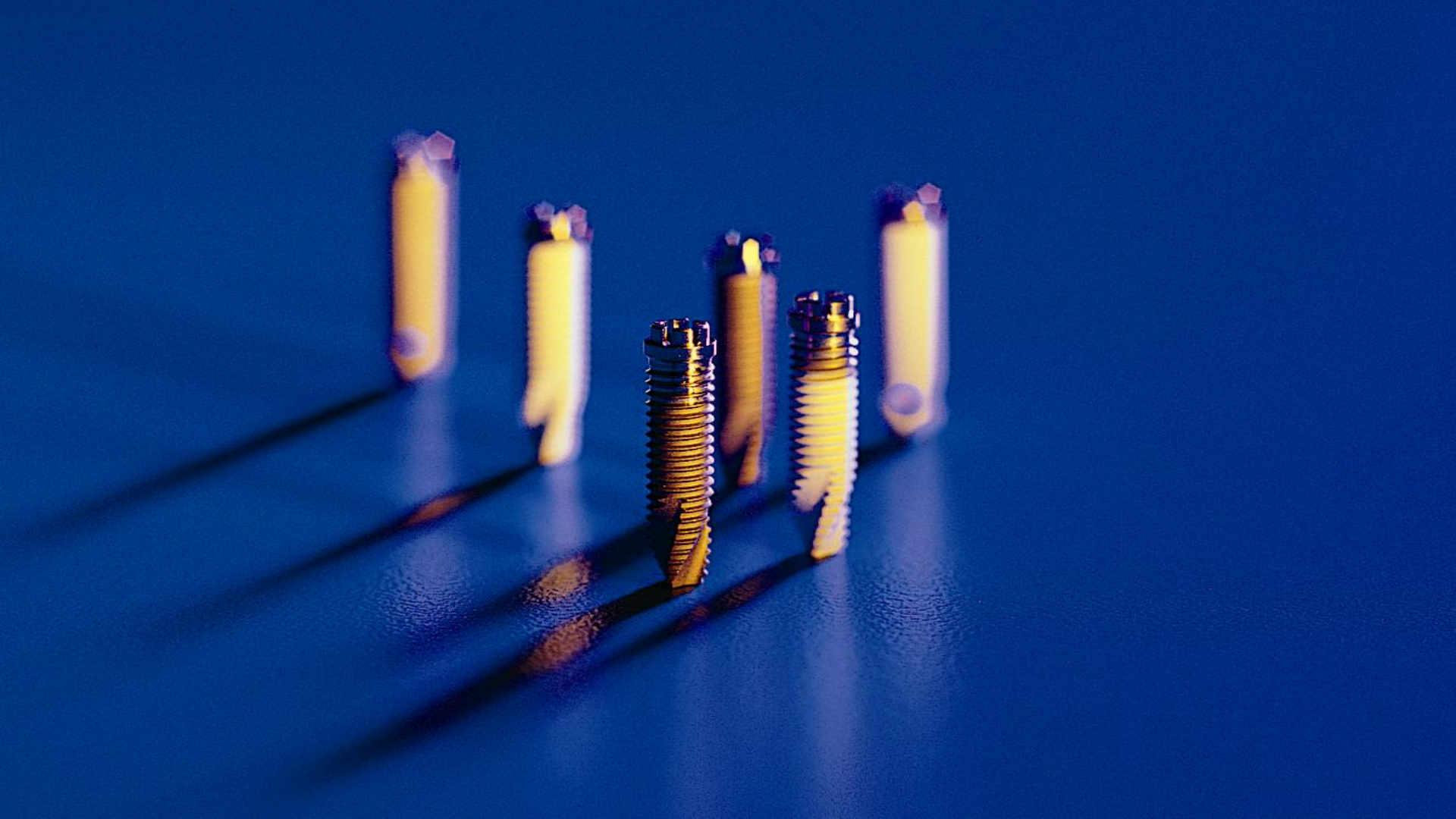


Second Stage Procedure



Spline Dental Implant System

U.S. Patent No. 5,449,291



What Is ISO 9001?

- Industry quality standards developed by the International Standards Organization (ISO) to establish and implement quality systems world-wide
- Currently adopted by 46 Countries including USA

What Is Required for ISO 9001 Certification?

- Upper management understanding & support of ISO 9001 requirements
- Communication of requirements to all Sulzer Dental employees
- Development and implementation of ISO based procedures
- Yearly audits of internal processes, by independent agencies, to monitor compliance to ISO requirements

Innovation Highlights
Coatings

HA-Coatings

- First commercially available HA-Coated dental implant
- Only manufacturer to control every step of the process, from feedstock production to final coating

Innovation Highlights
Coatings

MP-1

- Patented process that significantly increases the percentage of Crystalline HA for a more stable surface

MTX

- Microtextured Titanium
- Grit blasted with hydroxlapatite powder and then acid washed

Innovation Highlights
Interface

Spline

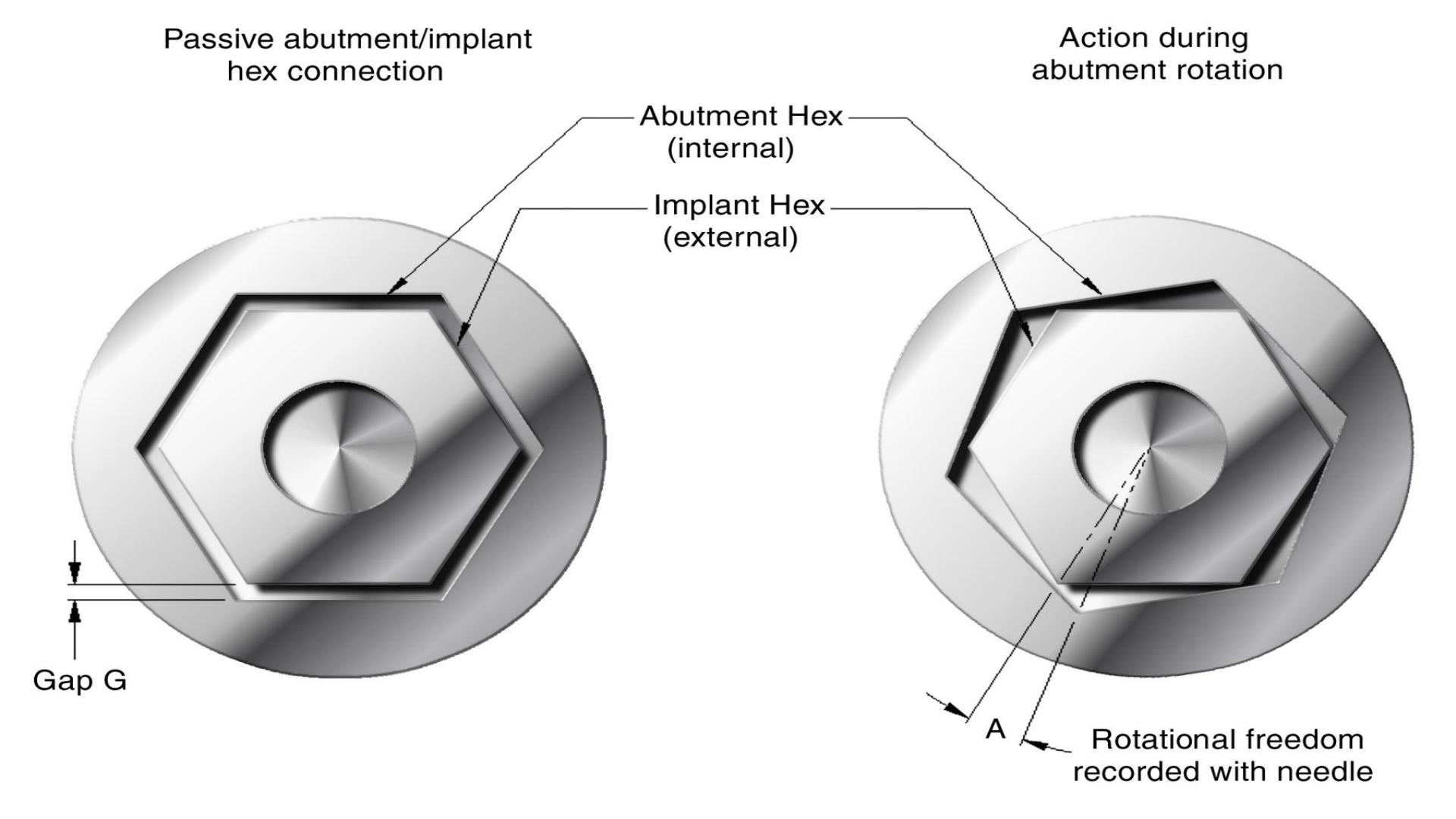
- Unique interface offering increased strength, reduced micromovement, and improved tactile sense of component engagement

Why an Alternative Interface?

What Dental Implant Interfaces Are Currently Available
And
Do They Meet Current Needs?

External Hex

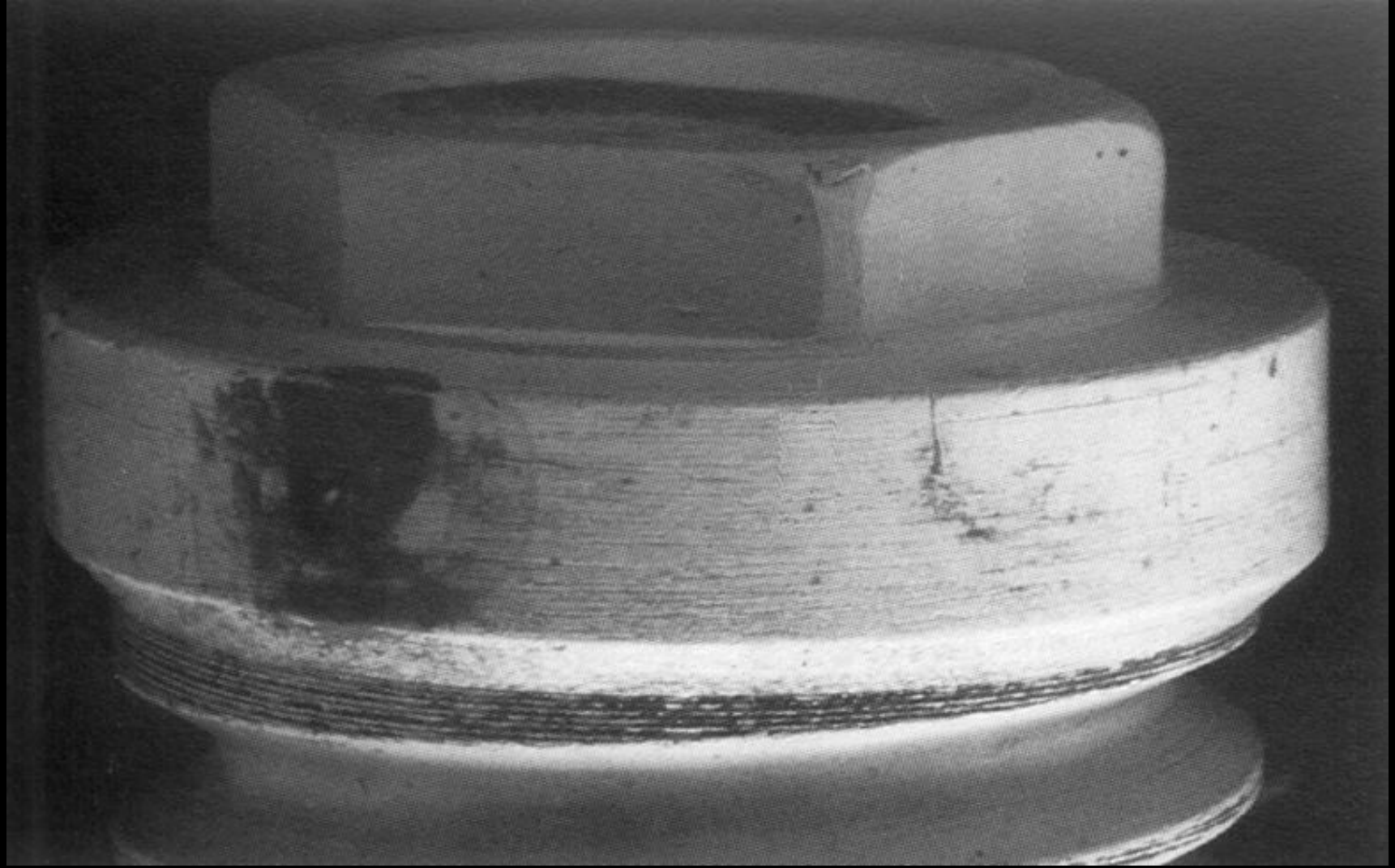
- Originally designed to place the implant
- Designed only for multiple units
- Never intended for use as single unit
- Micromovement in the interface


Passive abutment/implant
hex connection
Action during
abutment rotation
Abutment Hex
(internal)
Implant Hex
(external)
Gap G
A
Rotational freedom
recorded with needle

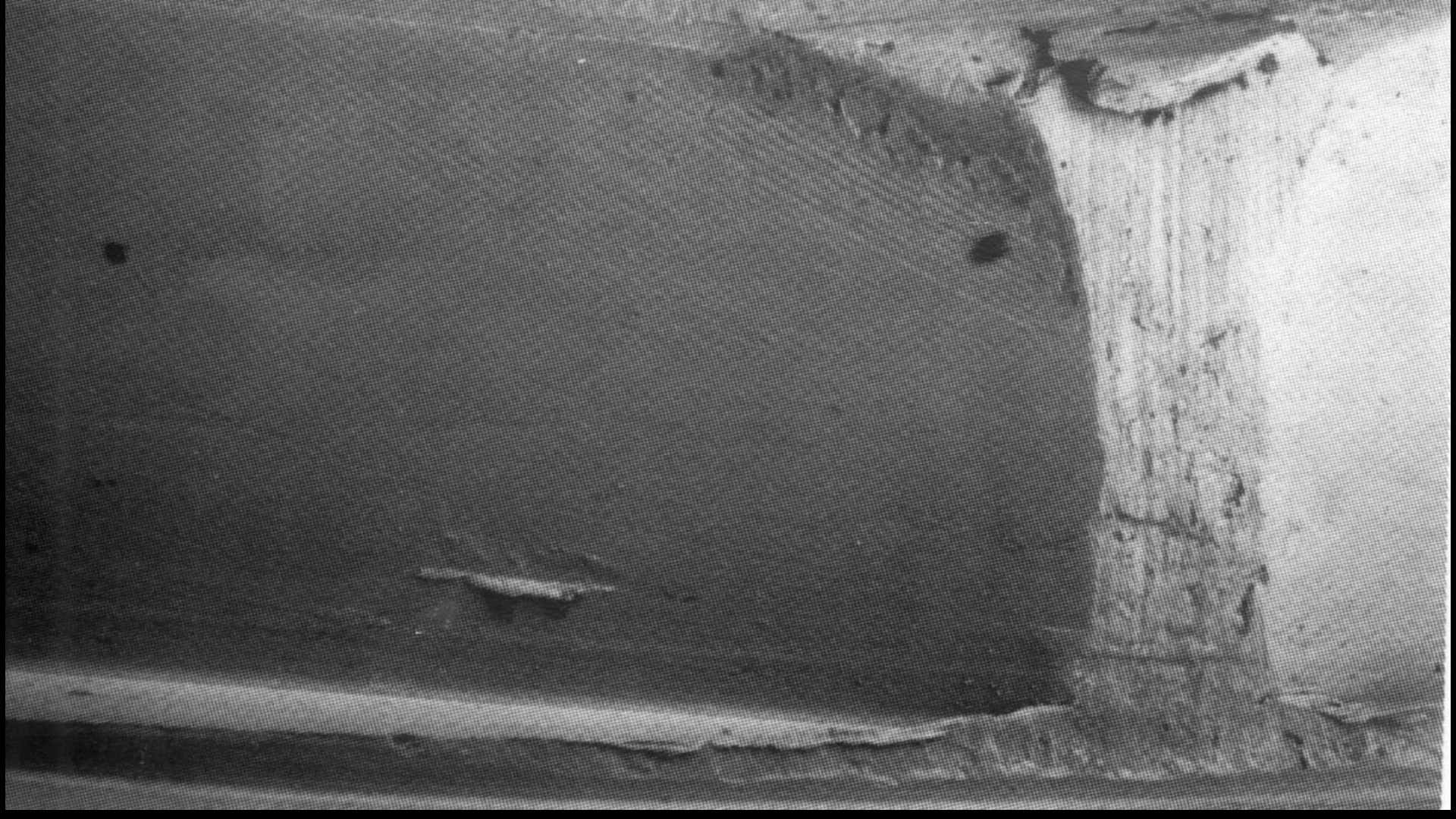
Problems With External Hexed Implants

- 49% of treated maxillae and 20.8% of the mandibles exhibited prostheses with loose gold prosthesis retaining screws
- 13.6% of maxillary cases had loose screws after final tightening
- 11.4% of those cases reported problems with esthetics (ie. proximal contact problems)
- 25% of the patients experienced failing screws

Jemt - Int J. Oral Maxillofac. Implants; 1992: 7: 40-44
Wie - Clin. Oral Impl. Res; 1995: 6: 47-53



Where is the Failure Mode?



Spline: Design Focus

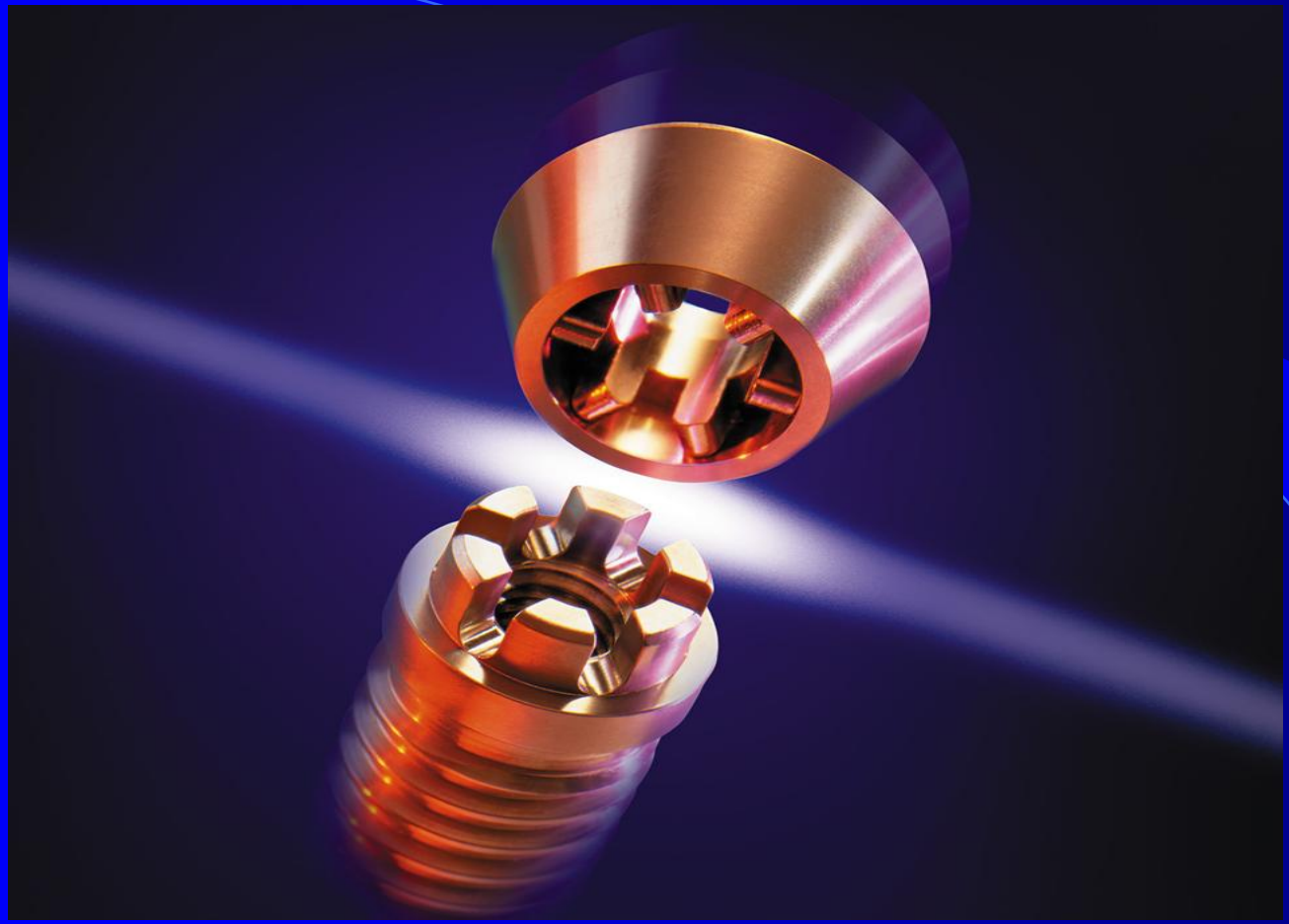
- Stable screw joint
- High strength
- Minimal micromovement
- Enhanced tactile sensitivity
- Esthetic prosthetic versatility

Spline

- A series of six interdigitating projections and slots that prevent relative motion between machined components

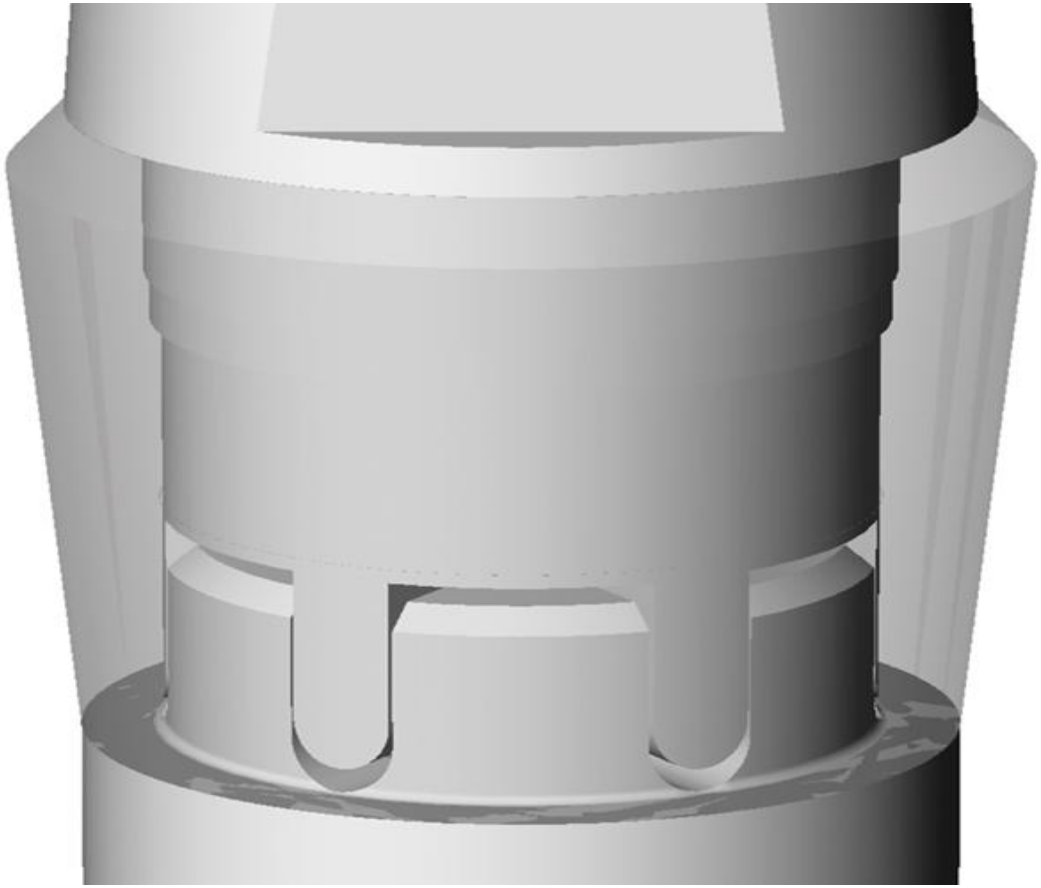
Spline Interface - *Features*

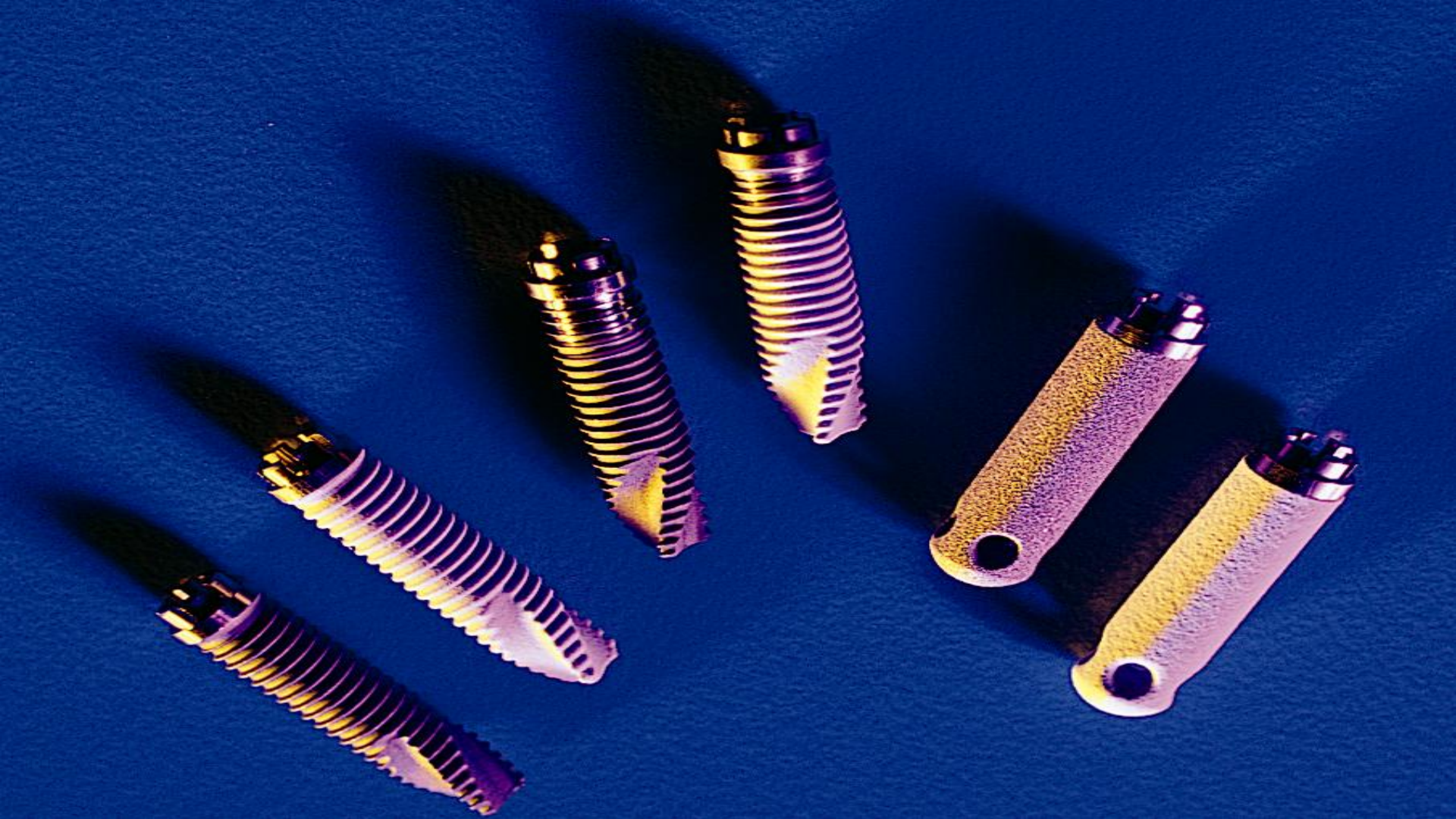
- Projections (tines) 1mm tall
- Chamfer on coronal edge of implant projections, combined with rounded, recessed tines in the abutment
- Interface commonly used in high-tech industries such as aerospace
- Design facilitates piloting
- No uncertainty in seating



Spline Interface - *Benefits*

- Improved tactile sensitivity
- Reduced micromovement
- Reduced screw loosening
- Increased torsional strength
- Improved torque retention
- Improved static & fatigue strength





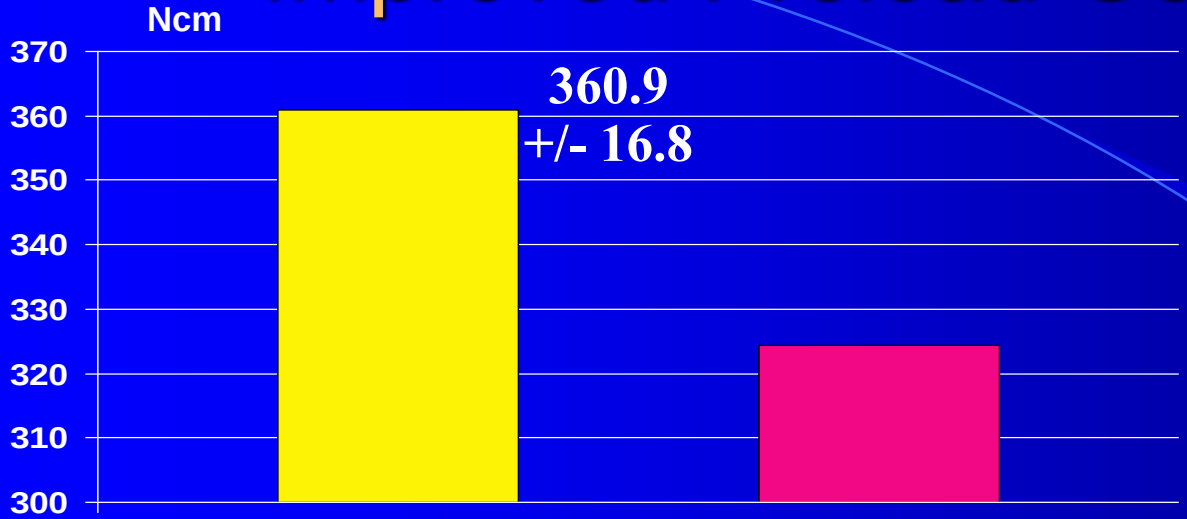
Improved Preload Generation

- Spline

  360.9 N of Preload
- Steri-Oss External Hex

  324.4 N of Preload

Improved Preload Generation



Sulzer Dental
Spline Interface

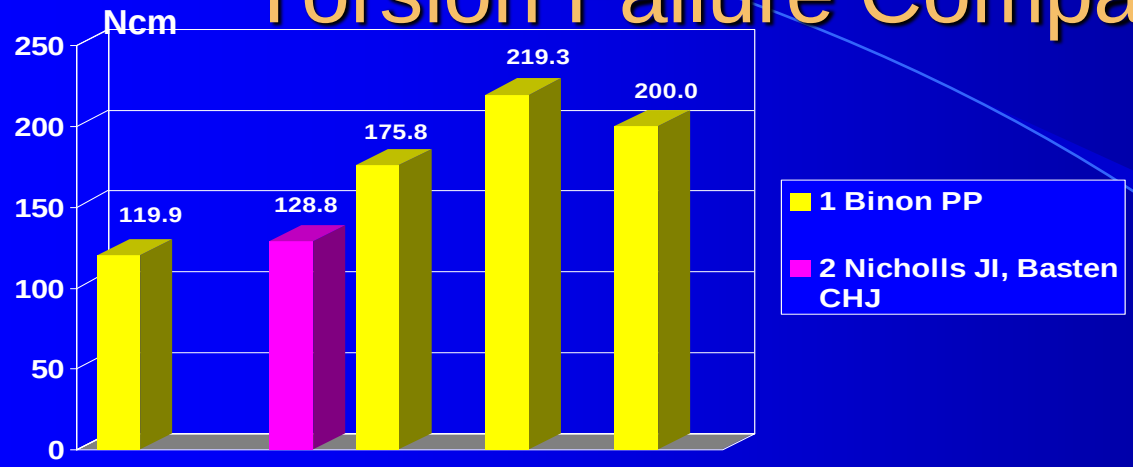
Steri-Oss
HexLock®

Master J., Holloway J., Rotational Resistance and Preload of Hex and Spline Implants

Torsional Strength Test

- Spline was strongest interface; failed at 219.3 Ncm
- Morse Taper failed at 200 Ncm
- External Hex (CP-3) Failed at 175.8 Ncm
- External Hex (CP-1) Failed at 119.9 Ncm

Torsion Failure Comparison



Nobel BioCare 3.75mm	Nobel BioCare 3.75mm	Lifecore 3.75mm	Spline 3.75mm	ITI 3.8mm

Note: 3.75mm implants flare to 4.0mm at the interface.

1. Binon PP. Int J Prosthodont 1996; Vol 9, No 5; 419-433
2. Nicholls JI. Basten CHJ. Postgraduate Dent 1995; No 2:4-14

Torsion Failure Mode

- The Spline Dental Implant system is designed to fail at the abutment level preserving the integrity of the implant contrary to the standard external hex interface

Compressive Strength

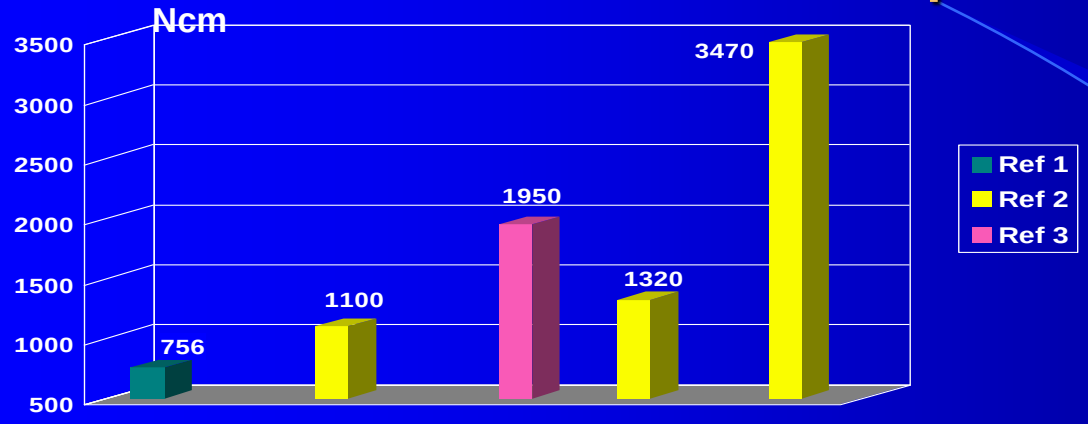
- Spline

  3470 Newtons
- Morse Taper

  1320 Newtons
- External Hex

  1100 Newtons

30-Degree Compressive Load To Failure Comparison



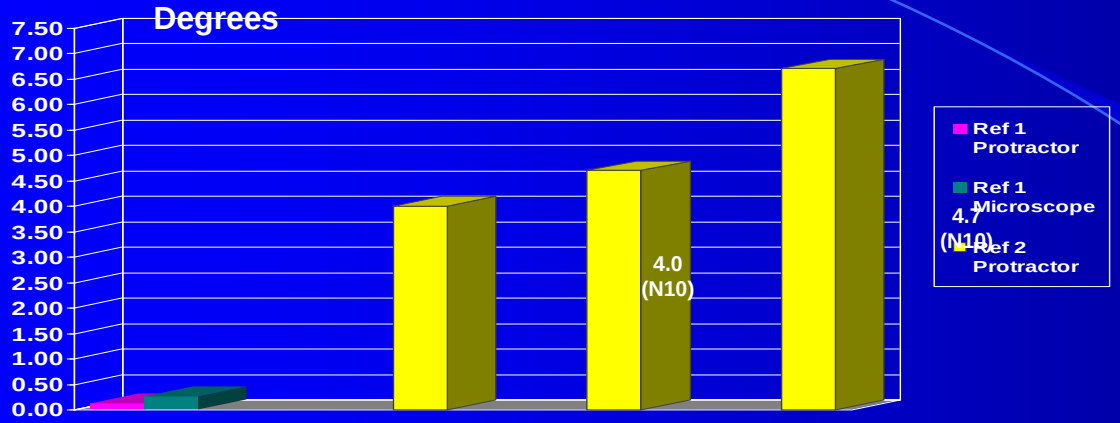
Ext Hex GR1 | **Ext Hex GR5** | **8° Morse ITI** | **11° Morse Astra** | **Spline**

References:
1. Balfour A, O'Brien GR. J Pros Dent 1996; 73:36-43
2. Binon PP. Int J Prosthodont 1996; Vol 9, No 5; 419-433
3. Sutter F, Weber HP, Sorenson J, Belser U. Int J Periodont Rest Dent; 1993; 13:409-431

Rotational Movement

- Spline .12
  Degrees
- External Hex Implants
  - Crossmark 4.0
    Degrees
  - 3i 4.7 Degrees
  - Nobel BioCare 6.7 Degrees

Rotational Abutment Movement (Tolerance)



6.7
(N10)

4.7
(N10)

0.12
(N50)

0.267
(N10)

Sulzer Dental
Spline
3.75mm

Crossmark
Ext Hex

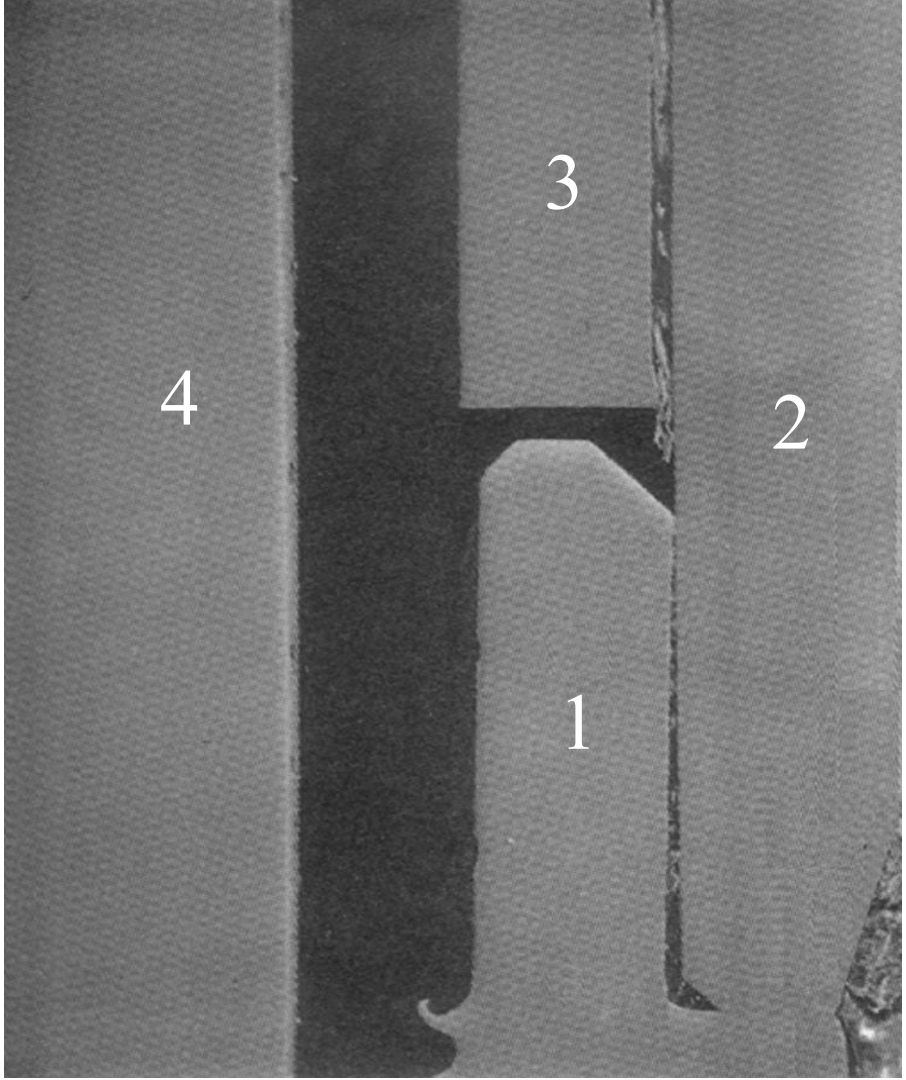
3i Ext Hex

Nobel BioCare
Ext Hex

References:
1. Binon PP. Int J Prosthodont 1996; Vol 9, No 5; 419-433
2. Binon PP. Int J Prosthodont 1995; Vol 8, No 2; 162-178
3. Nicholls JI, Basten CHJ, Postgraduate Dentistry 1995; Vol 2, No 1
4. Binon PP. Postgraduate Dentistry 1996; Vol 2, No 4

Precise Fit…
Reduced Movement…
Increased Strength

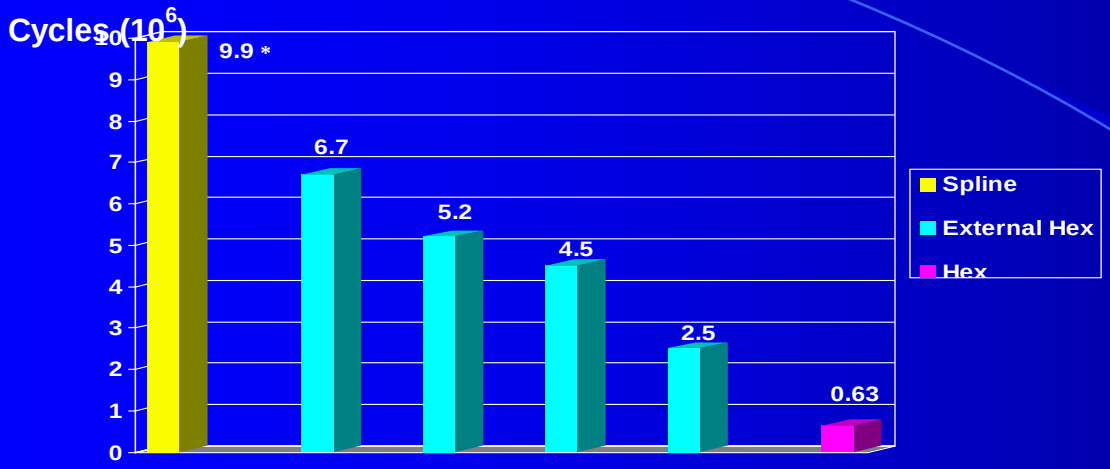
1. Implant Tine
2. Abutment Cuff
3. Abutment Body
4. Abutment Screw


3
4
2
1

Cyclic Loading

- Spline (200.0 N Applied Load)
  - Less than .3 degrees of movement - 9.9 million cycles
  - 8 out of 10 went to 10 million cycles and had 15.1 Ncm of residual torque on the screw
- Hex Abutments (133.3 N Applied Load)
  - 6.7 million cycles less than 2 degrees
  - 5.2 million cycles 3 degrees
  - 4.5 million cycles 4.4 degrees
  - 2.5 million cycles greater than 6 degrees

Rotational Movement vs. Joint Failure



< 0.3 Degrees	< 2 Degrees	3 Degrees	4.4 Degrees	> 6 Degrees	Hex Removed
N9, Ref. 2	N5, Ref. 1	N5, Ref. 1	N5, Ref. 1	N5, Ref. 1	N8, Ref. 1

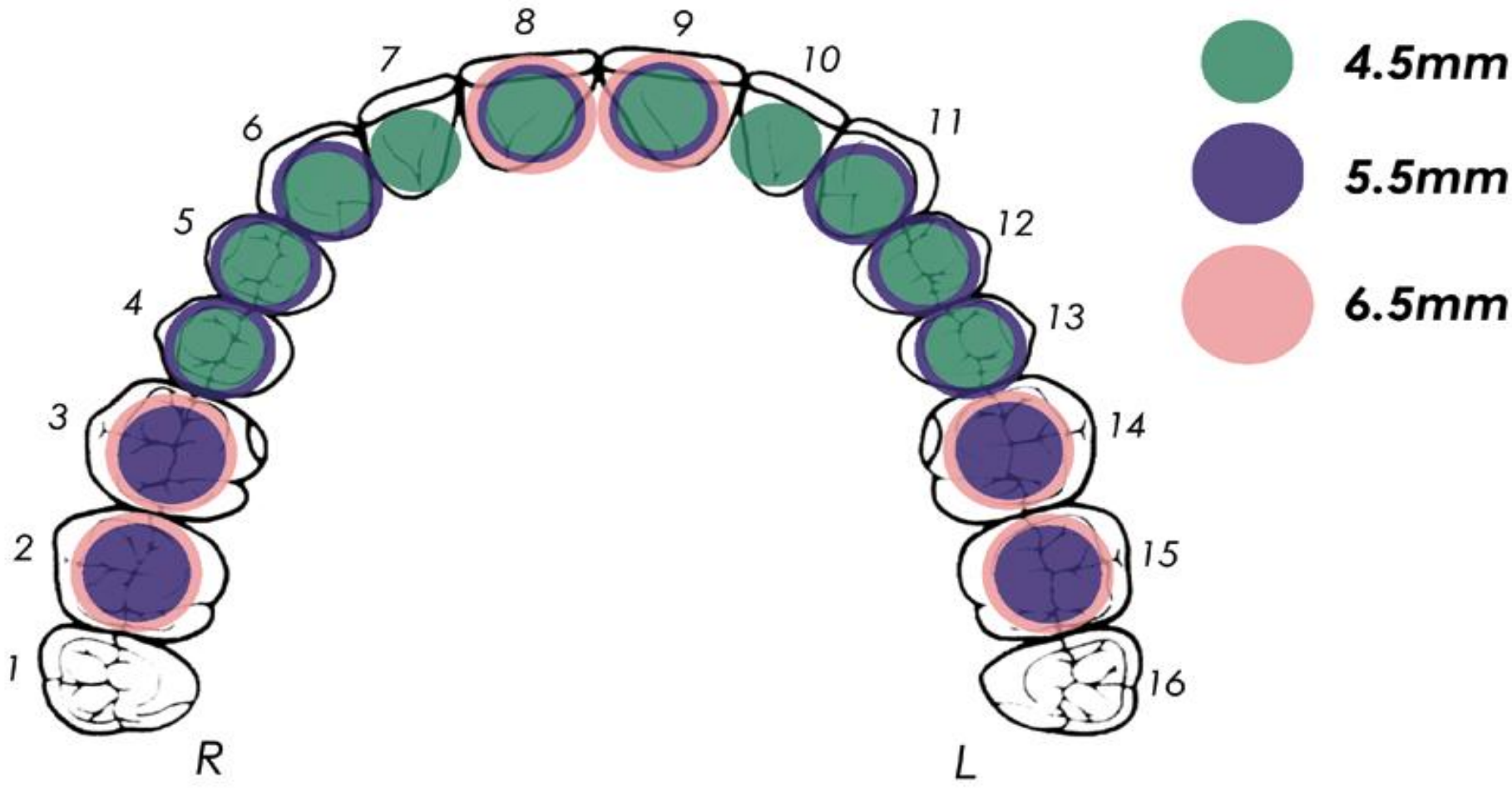
References:
1. Binon PP. Int J Prosthodont 1996; Vol 9, No 2; 149-160
2. Binon PP. Int J Prosthodont 1996; Vol 9, No 5, 419-433

*9 of 9 ran out to 10 million cycles / test terminated

Measurements of the Teeth -

Tooth	Mesiodistal Diameter at Cervix (CEJ)	Labio- or Bucco-lingual Diameter
Central incisor	7.0mm	6.0mm
Lateral incisor	5.0mm	5.0mm
Canine	5.5mm	7.0mm
First premolar	5.0mm	8.0mm
Second premolar	5.0mm	8.0mm
First molar	8.0mm	10.0mm
Second molar	7.0mm	10.0mm

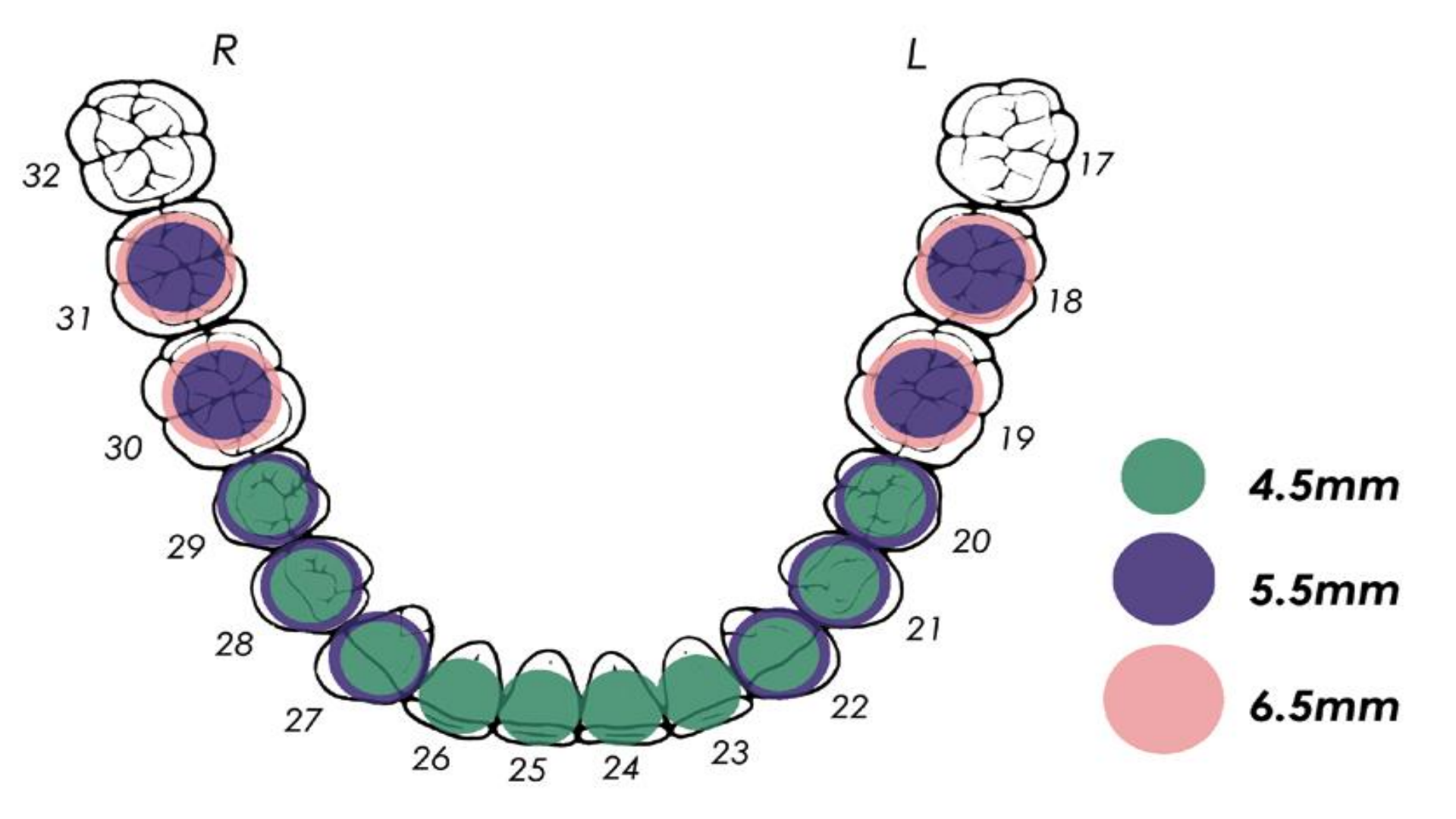
Wheeler, Dental Anatomy, Physiology and Occlusion, 7th ed., Philadelphia, Saunders, 1993.


8
9
7
10
6
11
5
12
4
13
3
14
2
15
1
16
R
L
4.5mm
5.5mm
6.5mm

Measurements of the Teeth - Mandibular

Tooth	Mesiodistal Diameter at Cervix (CEJ)	Labio- or Bucco-lingual Diameter
Central incisor	3.5mm	5.3mm
Lateral incisor	4.0mm	5.8mm
Canine	5.5mm	7.0mm
First premolar	5.0mm	6.5mm
Second premolar	5.0mm	7.0mm
First molar	9.0mm	9.0mm
Second molar	8.0mm	9.0mm

Wheeler, Dental Anatomy, Physiology and Occlusion, 7th ed., Philadelphia, Saunders, 1993.

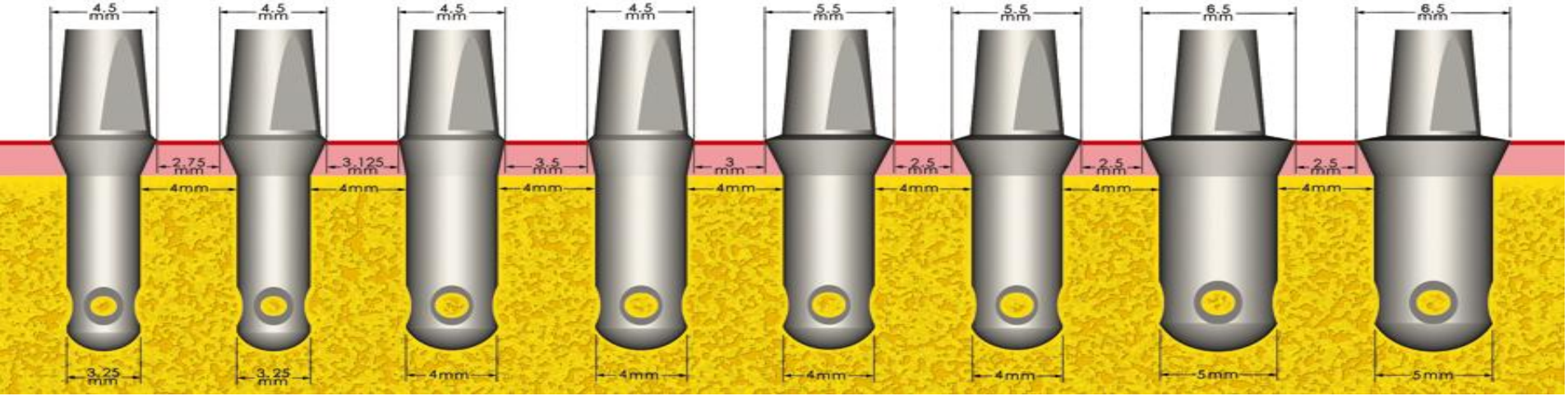

R
L
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
4.5mm
5.5mm
6.5mm

Biomechanical Considerations for Prosthetic Design

- Provide surgical templates to achieve ideal position
- Avoid cantilevers
- Use adequate number of largest, longest implants
- Space implants for best support
- Identify “weak link” or other negative factors
- Decrease occlusal width of posterior restorations to help prevent non-axial loading
- Accurate fit to allow optimum force transfer

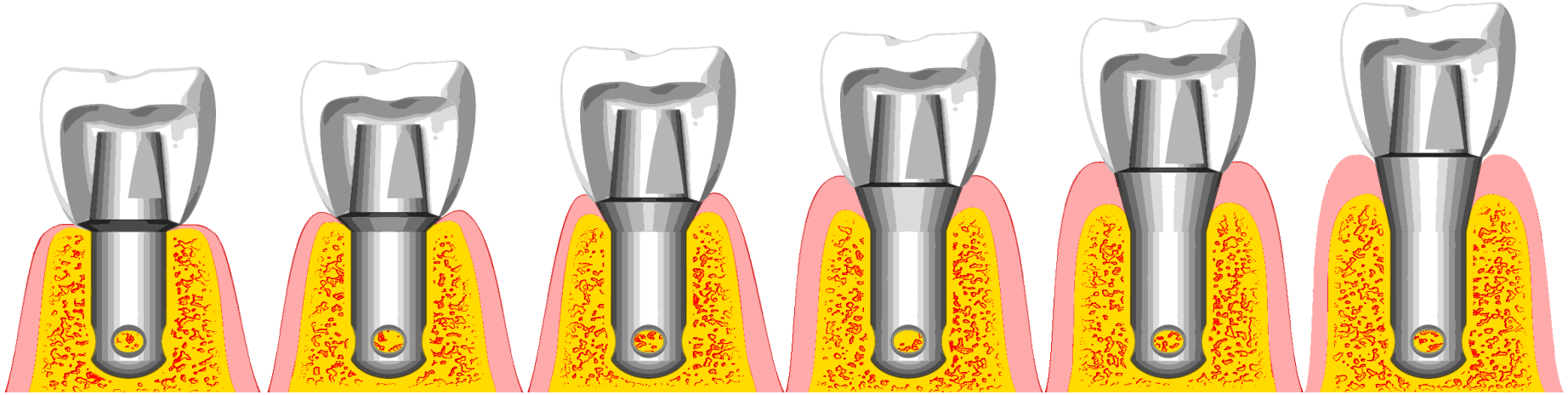
Implant Placement

- A minimum of 4-6mm is needed between implants (depending on the type of restoration)
- This provides adequate blood supply to maintain the bone
- Also provides adequate spacing to develop an anatomically flared emergence profile


4.5 mm
4.5 mm
4.5 mm
4.5 mm
5.5 mm
5.5 mm
6.5 mm
6.5 mm
2.75 mm
3.125 mm
3.5 mm
3 mm
2.5 mm
2.5 mm
2.5 mm
4mm
4mm
4mm
4mm
4mm
4mm
4mm
4mm
3.25 mm
3.25 mm
4mm
4mm
4mm
4mm
5mm
5mm

Soft Tissue Considerations

- Restorative Options Available in a Variety of Cuff Heights
- Fixed
- Shouldered Abutment
- Gold Coping



Root Surface Area of the Teeth

Tooth	Maxillary (mm^2)	Mandibular (mm^2)
Lateral	179	168
Central	204	154
Second Premolar	220	207
First Premolar	234	180
Canine	273	268
Second Molar	431	426
First Molar	433	426

Data on file.

Spline Implant Body Surface Area

	8mm	10mm	13mm	15mm	18mm
3.25mm	**88.4**	**109.7**	**140.3**	**169.6**	**192.2**
3.75mm	**110.1**	**137.1**	**177.7**	**206.8**	**249.6**
4.0mm	**112.9**	**138.1**	**174.8**	**200.0**	**238.7**
5.0mm Cylinder	**148.3**	**181.9**	**229.1**	**260.6**	
5.0mm Screw	**170.4**	**217.7**	**286.5**	**331.3**	

Data on file.

Factors That Influence Implant Success or Failure

- Patient selection
- Efficacy of system
- Surgical protocol
- Prosthetic design
- Hygiene

Patient Selection

- Bone quality
- Bone quantity
- Systemic health
- Patient habits
  - Hygiene
  - Smoking
  - Bruxing
  - Substance abuse

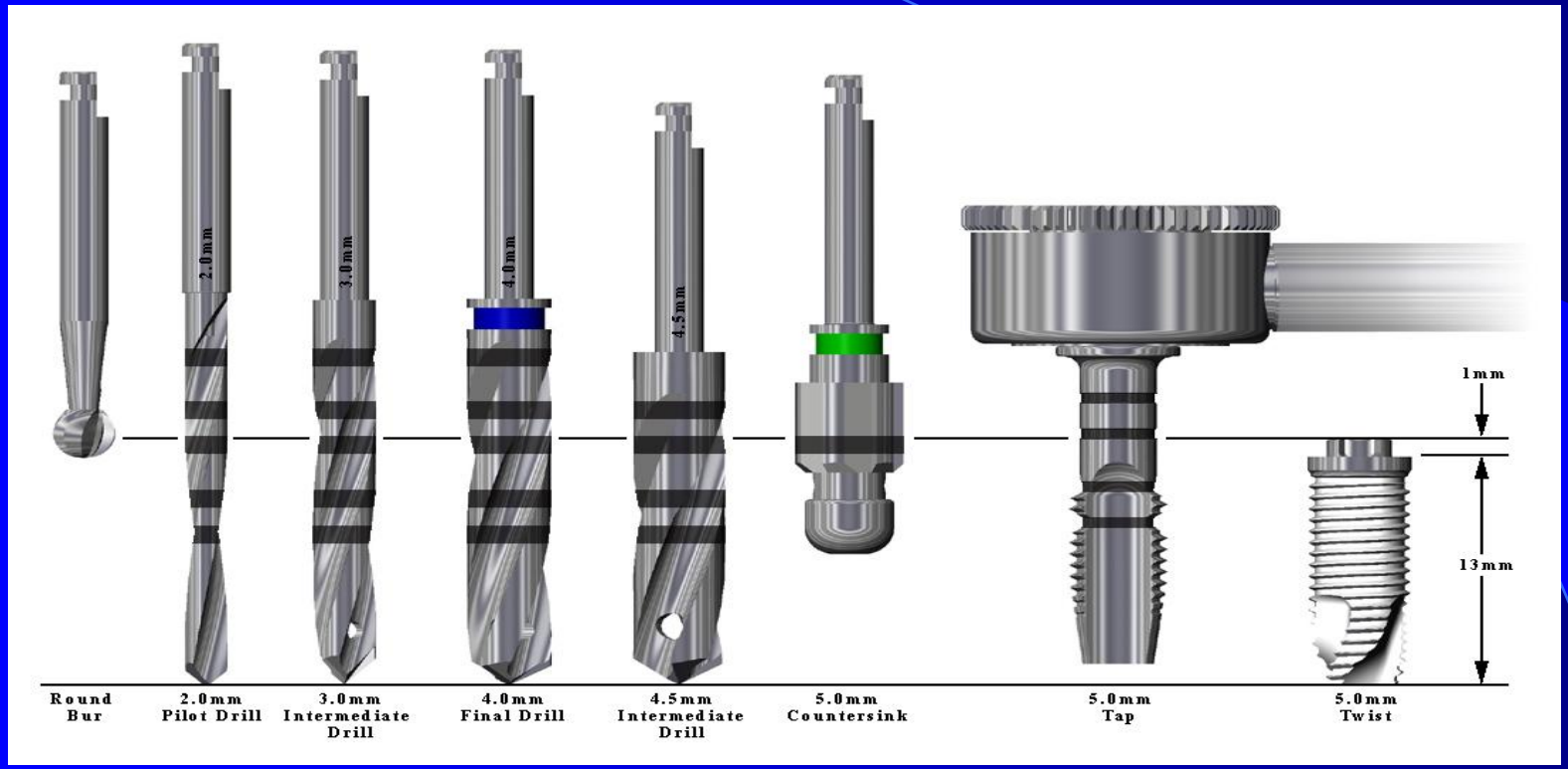
Triangle of Success

Surgical:
- Clinical evaluation
- Diagnosis
- Surgery

Restorative:
- Clinical evaluation
- Diagnosis
- Restoration

Laboratory:
- Fabrication of temporary and final prostheses

5.0mm Drill Sequence - Twist Implants




Pilot
8–18
MM
8–18
MM
8–18
MM
Long

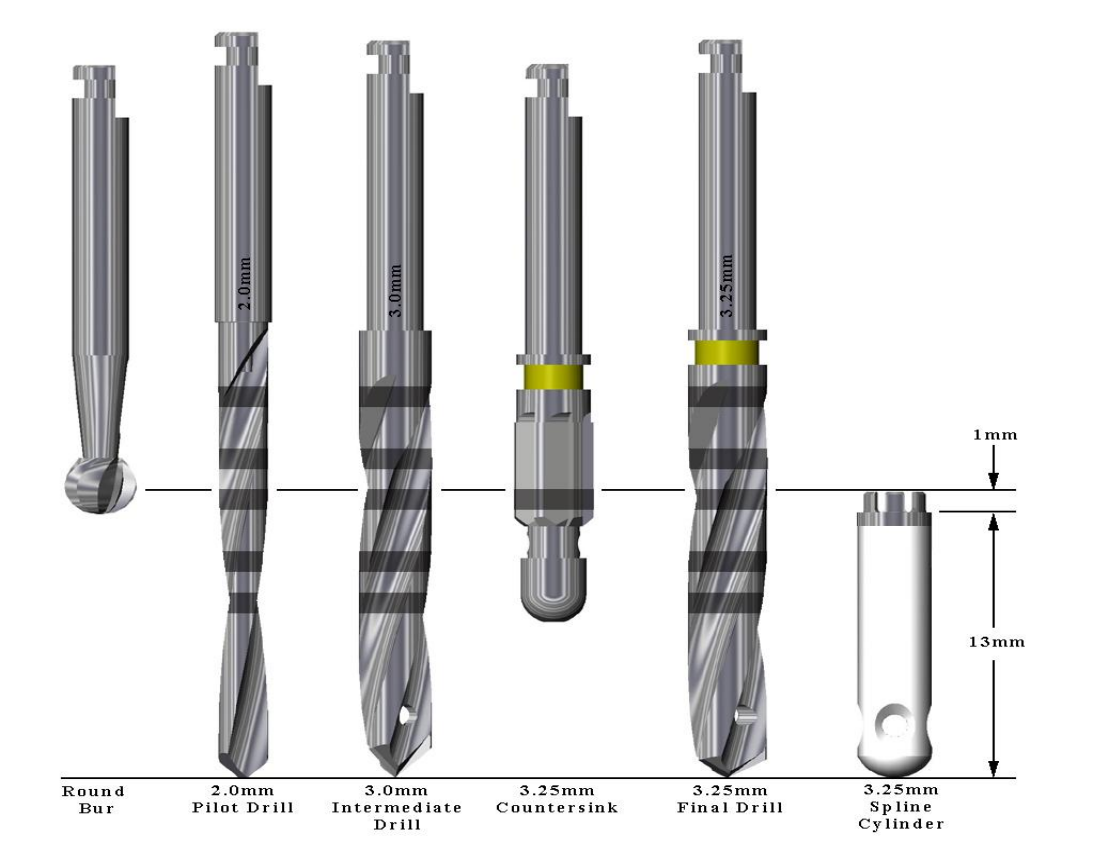

Pilot
8–18
MM
8–18
MM
8–18
MM
Long


8–18
MM
8–18
MM

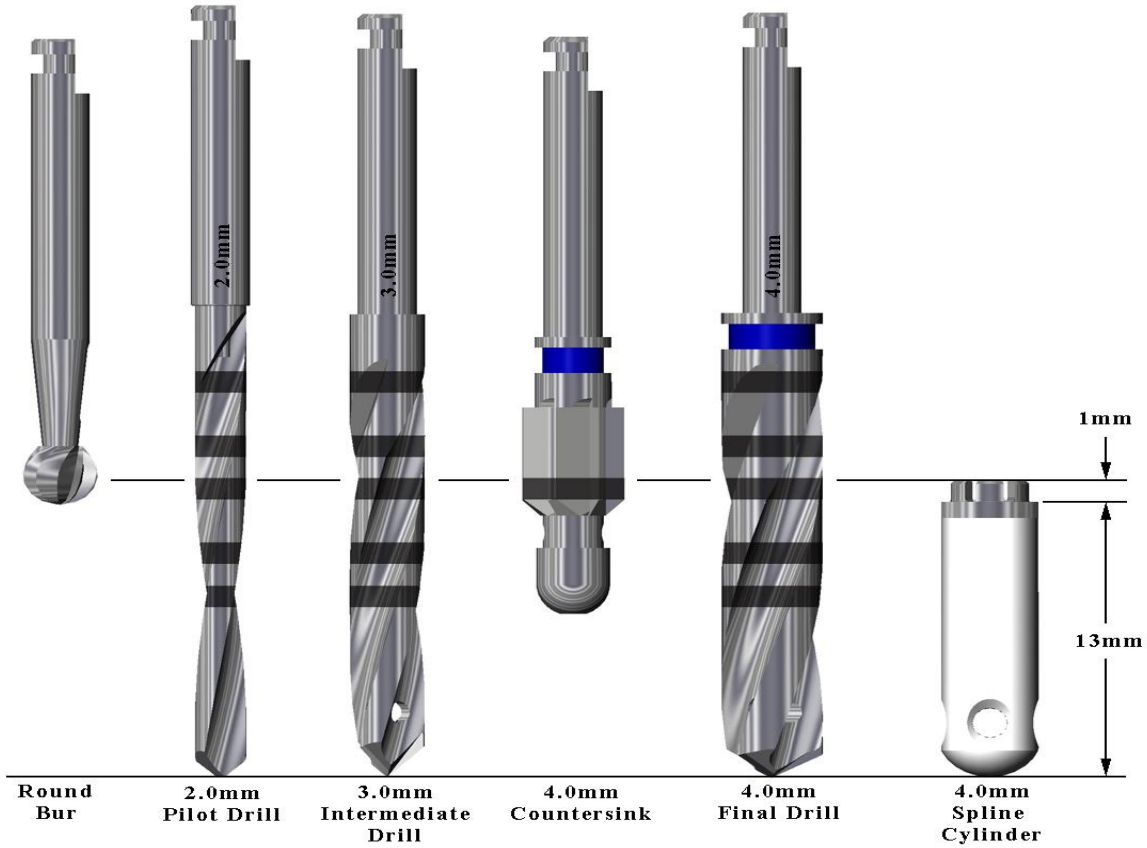

8–18
MM
8–18
MM


8–18
MM

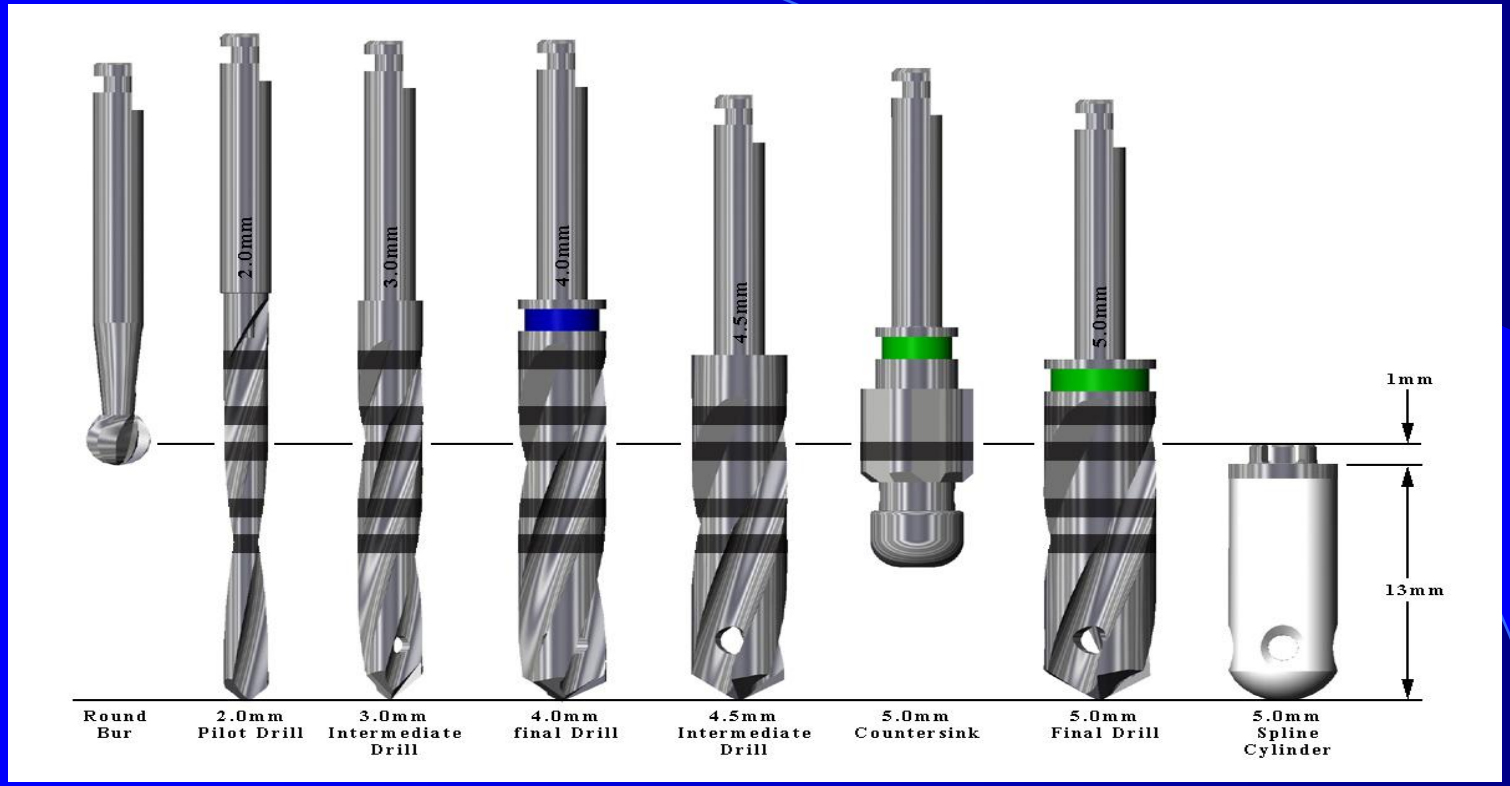
3.25mm Drill Sequence - Cylinder Implants



4.0mm Drill Sequence - Cylinder Implants



5.0mm Drill Sequence - Cylinder Implants



Components of an implant restoration

- Screw retained implant restorations consist of three components.

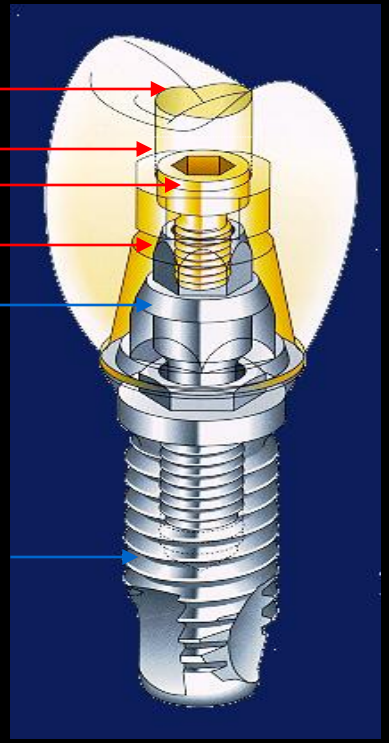
  (a) implant fixture

  (b) abutment

  (c) restoration

- the abutment screw secures the abutment to the fixture

- the prosthetic retention screw secures the prosthesis to the



Abutment

(Screw retained restoration)

- can be either parallel (standard) or conical (estheticone) in shape.

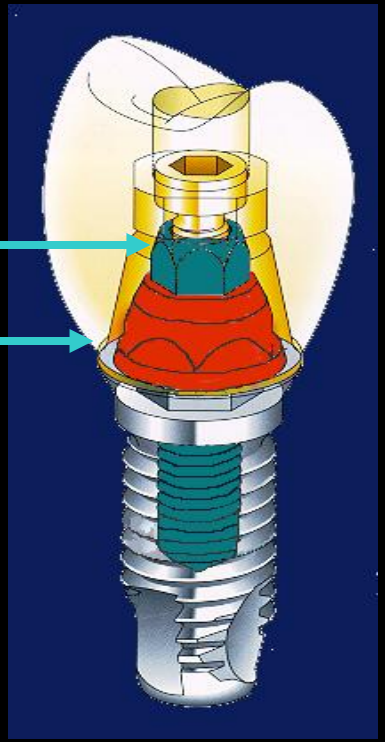
- are secured with an abutment screw that is tightened to 20 Ncm.

Abutment

(Cemented restoration)

- Cera One abutment

- secured with a square head screw tightened to 32 Ncm.



Prosthetic retaining screw

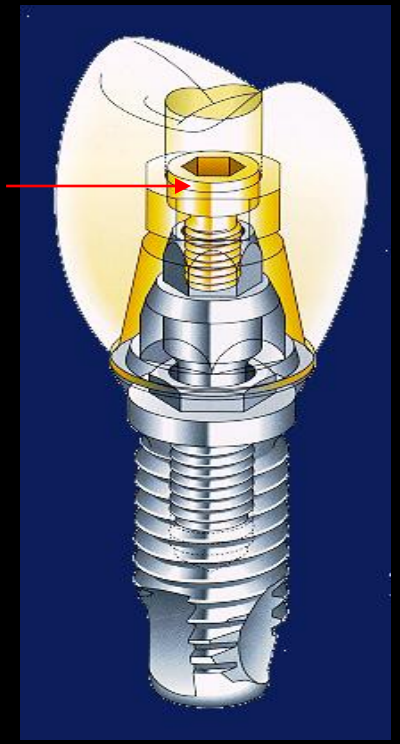
- can have a slot or hex head

- access is usually covered by a combination of gutta percha and composite.

- used to retain the prosthesis to the abutment.

- tightened to 10 Ncm.

Retaining screw



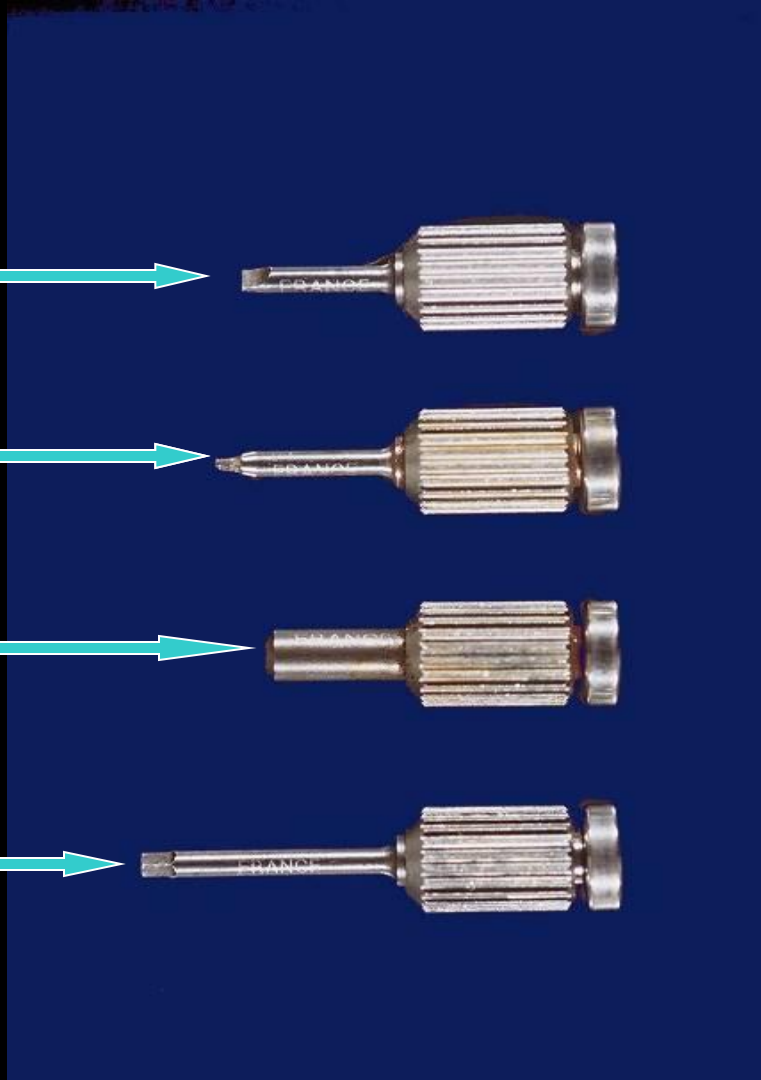
Hand Screw Drivers

Prosthetic retention slot screw driver

Prosthetic retention hex screw driver

Hex Abutment driver
Standard and conical (estheticone)

Square abutment driver
Cera One or square abutment screws



Implant Body Analog

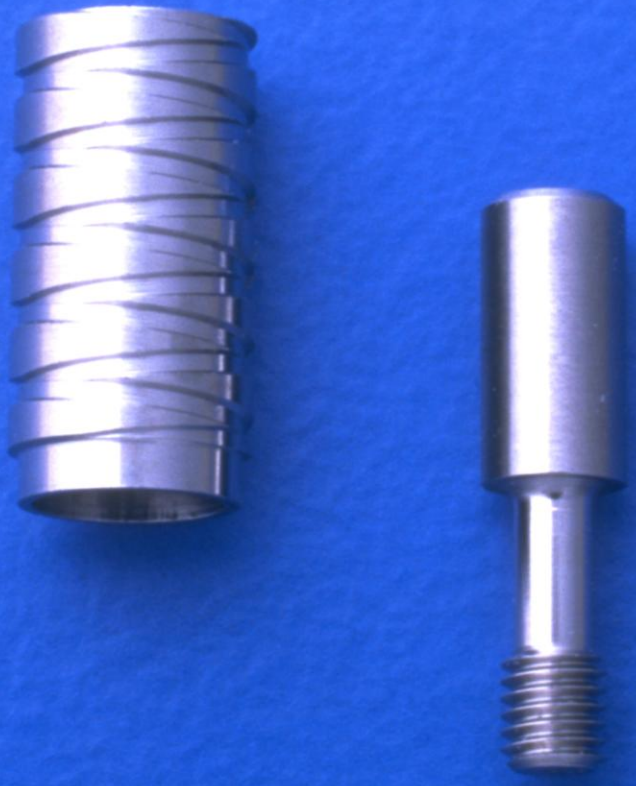
Implant Body Analog and Impression Post

Color Coded Impression Post, Gingival Cuff and Implant Body Analog

Fixed Abutment

Preangled 15° Fixed Abutment

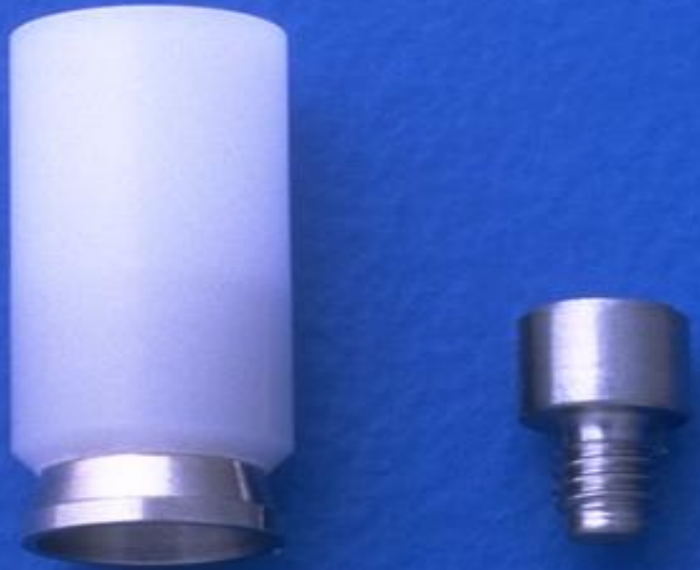
Temporary Abutment



Direct Gold Coping with Waxing Sleeve

Shouldered Abutment

Shouldered Abutment Gold Coping with Waxing Sleeve



Comfort Cap

Shouldered Abutment Transfer Coping

Shouldered Abutment Analog

Shouldered Abutment Seating Tool

O-Ring Attachment with O-Ring Retainer

O-Ring Attachment/Retainer and O-Ring Seating Tool

O-Ring Analog

Spline ERA® Straight Abutment

Spline ERA® 5°, 11° and 17° Preangled Abutment

ERA® Overdenture Males

Prosthetic Torque System