



# Surgical & Radiographic Parameters to Guide Timing of Implant Loading: *POSTERIOR MANDIBLE*

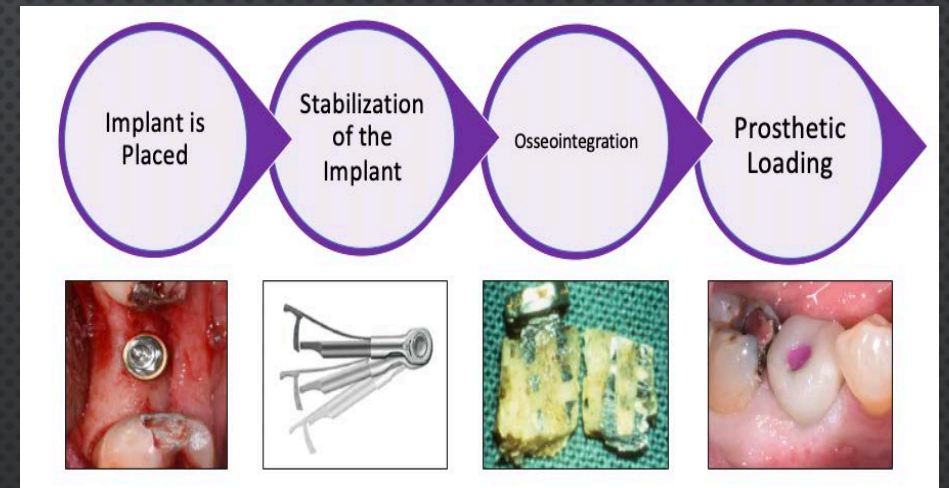
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# Disclosure:

The views expressed are those of the author and do not reflect the official views or policy of the Department of Defense or its Components. The voluntary, fully informed consent of the subjects used in this research was obtained as required by 32 CFR 219 and DODI 3216.02\_AFI 40-402.

# When is the Best Time to Load an Implant?

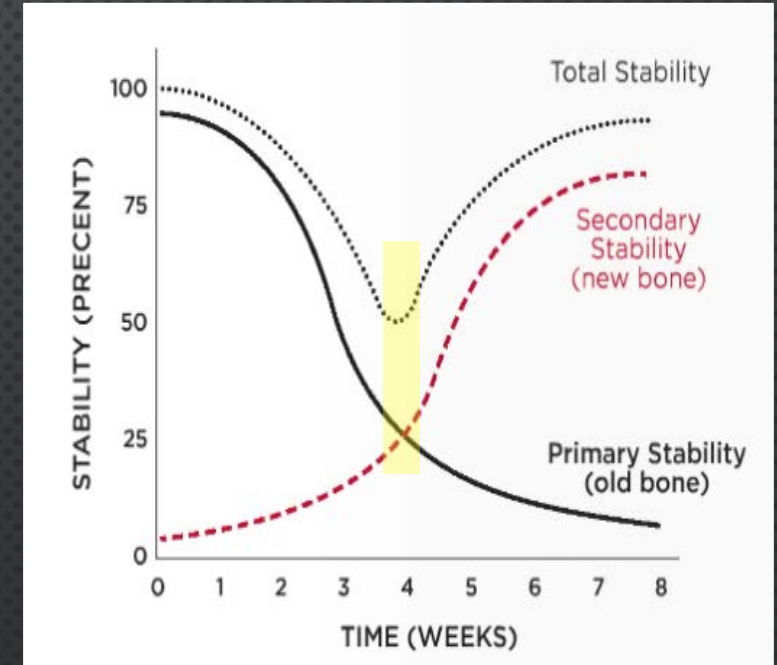
- 1970's: 'One-size fits all' loading
  - I. Conventional: 3-6 months
- Today: **Options** for loading
  - I. Immediate: 1 week
  - II. Early: 1 week – 2 months
  - III. Conventional: 3 – 6 months



# Implant Stability:

- **Primary (Mechanical) Stability:** Absence of mobility in the bone bed after placement
- **Secondary (Biologic) Stability:** Related to biologic events at the bone-to-implant interface
- **Total Stability:** primary + secondary
- Primary stability changes to secondary stability at point of osseointegration
  - Implant at highest risk of failure

## Implant Stability Over Time



# Modalities for Assessing Implant Stability:

## 1. Insertion Torque (IT):

- Measures shear force/ frictional resistance (N/cm)
- Typically sole objective measurement of implant stability
- **Problems:** subjective measurement, can be manipulated, requires calibration



Greenstein et al, 2017

*"The measurement of the resistance that the implant encounters during its advancement in the apical direction by means of a rotating movement on its axis"*

# Modalities for Assessing Implant Stability:

## 2. Reverse Torque Test (RTT):

- Earliest definitive verification of osseointegration
- Measures surface-related stability (+/-)
- Applies counterclockwise force to implant
- **Problems:** Invasive & potentially destructive; dichotomous results



## 3. Percussion Test (PT):

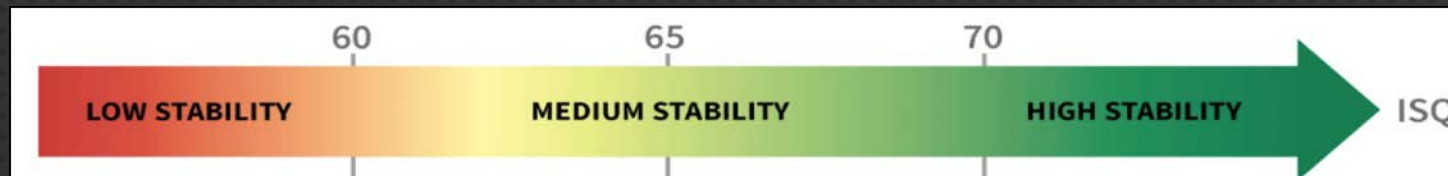
- Measures inflammation (+/-)
- Tap implant abutment with mirror handle
- **Problems:** dichotomous results



# Modalities for Assessing Implant Stability:

## 4. Implant Stability Quotient (ISQ):

- Non-invasive, non-destructive, clinical tool
- Measured via resonance frequency analysis
- Provides early assessment of:
  - Axial stability / quality of bone to implant contact
  - Changes in healing of peri-implant bone consistent with osseous healing



# Purpose / Research Questions:

- I. Is the success of early implant loading **equal** to conventional loading in the posterior mandible?
  
- II. Can early osseointegration be **predicted**, based on a patient's clinical presentation?

# Hypothesis & Specific Aims:

- I. There is a subset of patients for whom early implant loading can be achieved with **success equal** to that of conventional loading.
- II. Early osseointegration **can be predicted**, and all clinical & radiographic parameters will be equally prognostic.

# Methods & Materials:

## INCLUSION CRITERIA:

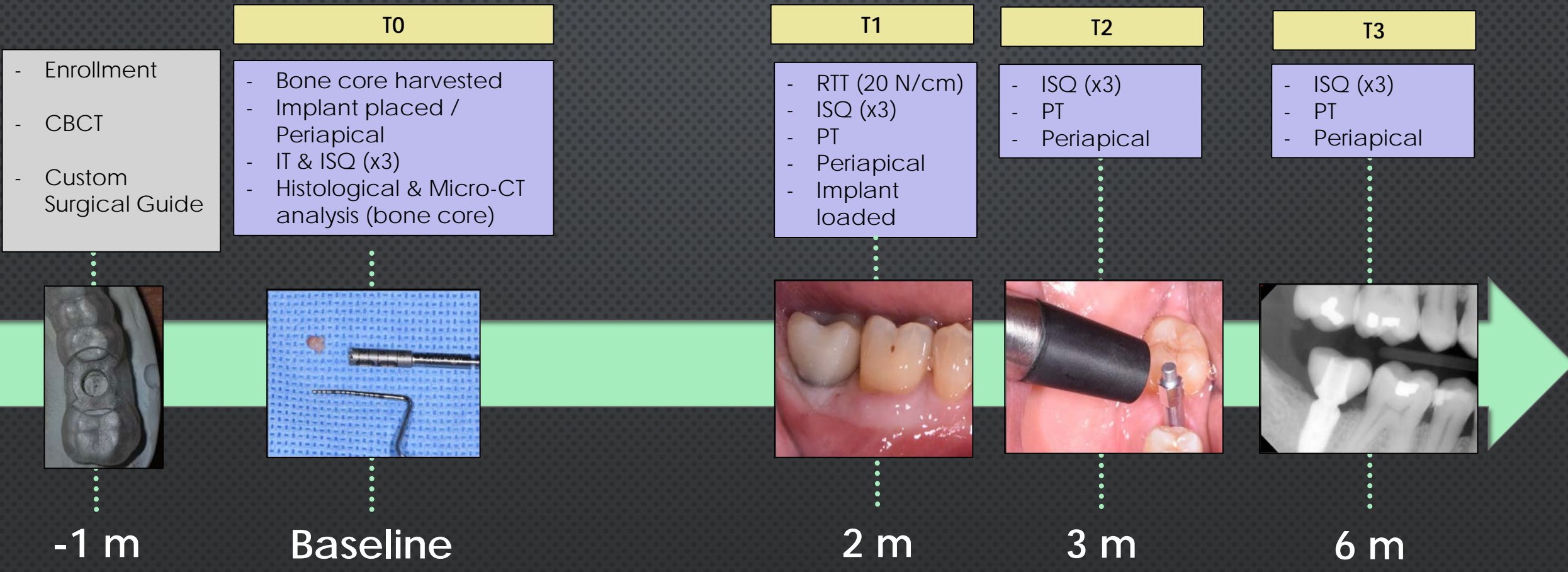
- >21 years old; Male & Female
- ASA I and II
- Planned for implant in **posterior mandible** (TiUnite)
- Single or multiple implants
  - Independent of restoration
- Adequate bone volume & Oral hygiene
- Documentation of a restorative provider

## EXCLUSION CRITERIA:

- History of IV bisphosphonates / Head & Neck Radiation
- HBA1C >7.0; Pregnant; Heavy smokers (>10 cigarettes per day)
- Augmentation / extraction within **6 months**
- Require grafting at the time of placement to augment stability

Requirement:  $IT \geq 35$  N/cm and  $ISQ \geq 55$

# Methods & Materials:



## Study Design:

- Posterior mandible; prospective cohort study
  - 21 subjects; 22 implants

# Methods & Materials:

## Micro-Computed Tomography (Micro-CT):

Images scanned  $180^\circ \rightarrow$  3D image

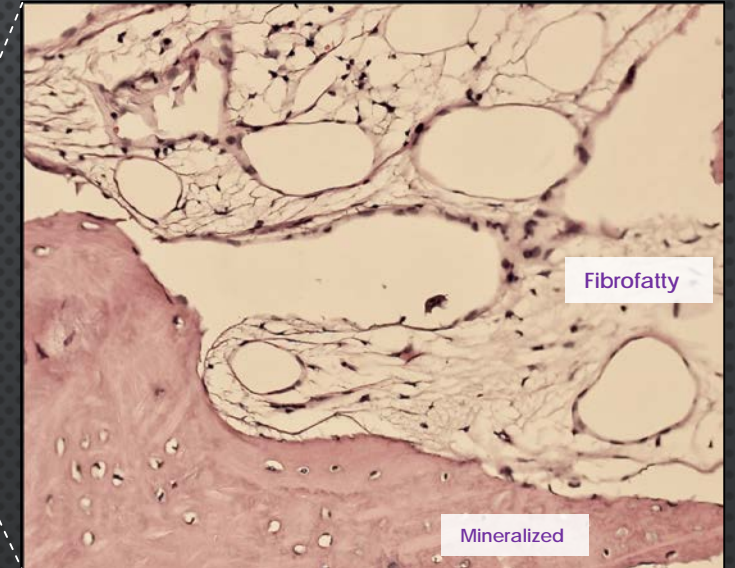
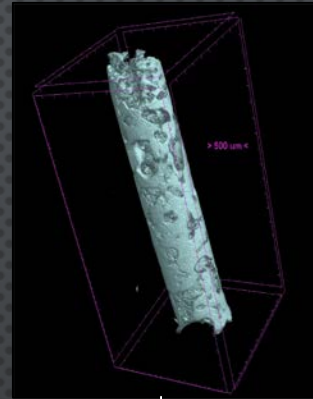
510 projections/ specimen

Voxel size:  $9.83 \mu\text{m}$

Bone volume density calculated

CTAn v-1.18.9.0+ image software

Trabecular thickness, separation & number



## Histological Analysis:

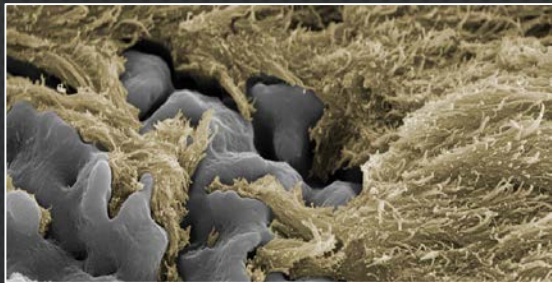
1. 10% neutral buffered formalin (72 hours)
2. 10% EDTA
3. Embedded in paraffin & sectioned
4. Stained with **Hematoxylin Eosin**
5. Light microscopy (4X-40X)
6. % of mineralized/fibrofatty tissue determined



# Methods & Materials:

## CRITERIA FOR OSSEOINTEGRATION

- (-) RTT
- (-) PT
- (-) Symptoms
- Crestal bone loss  $<0.2\text{mm}$



## STATISTICAL ANALYSIS:

- ANOVA test with repeated measurements to determine **significance of timeframes**
- Correlations between **IT, ISQ, %BV/TV** using descriptive statistics
- Regression curve (bone density over time) calculated using JMP software

# Results:

- Mean age of subjects: **62** years old
- **62%** Male, **38%** Female
- Incidence of Early Osseointegration: **95%**
- Marginal Bone loss over study:  **$0.1 \pm 0.05$  mm**
- Bone density: **29-82% mineralized tissue** (initial)



# Results:

- IT as predictor of early osseointegration:

- Sensitivity: 64.3%

- Specificity: 50%

- PPV: 69%

- NPV: 44%

- PT & RTT correctly identified early osseointegration 100% of the time

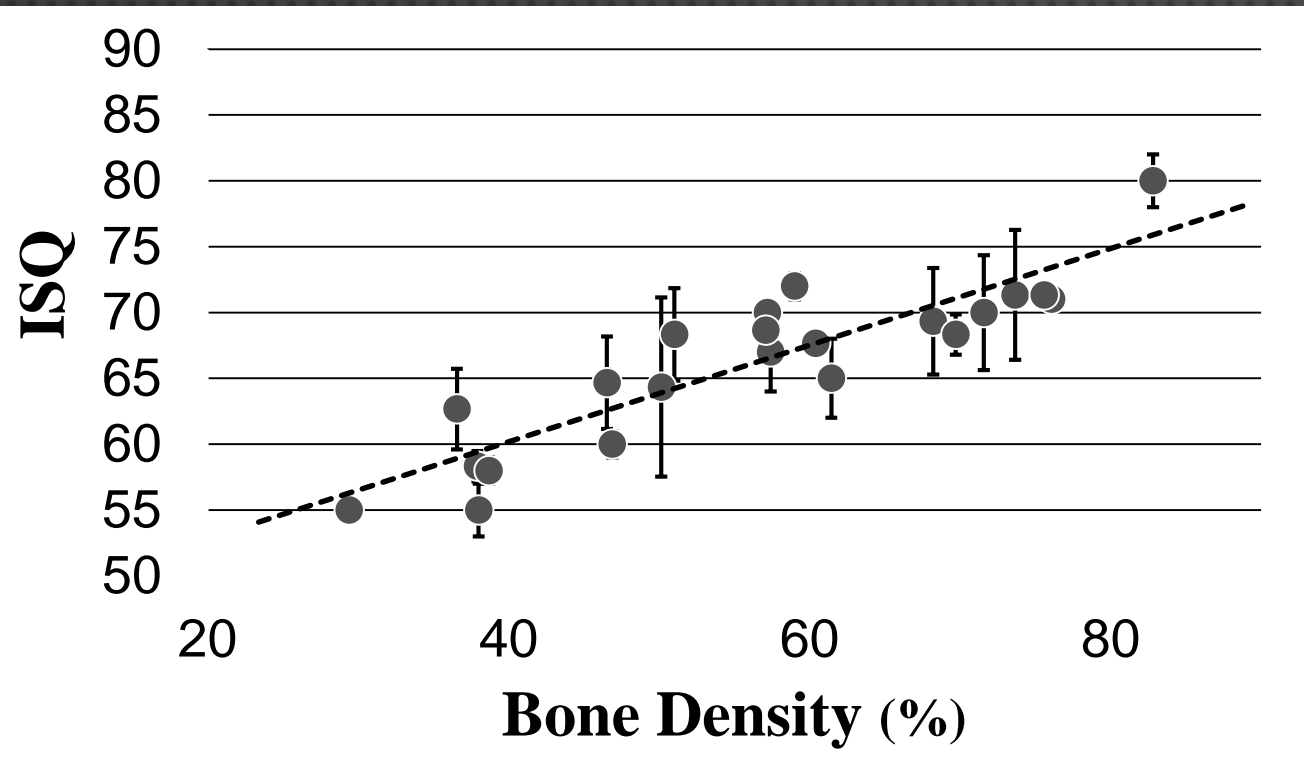
- 4.7% of implants had abnormal response to RTT and PT

	High BV BV/TV $\geq$ 56% Or ISQ $\geq$ 66	Low BV BV/TV < 56% Or ISQ < 66
High Initial Torque (40 or 50 N cm)	9 True Positive	4 False Positive
Low Initial Torque (35 N cm)	5 False Negative	4 True Negative

	-- Response (Normal)	+ Response (Abnormal)
Percussion	21	1
Reverse Torque	21	1

# Results:

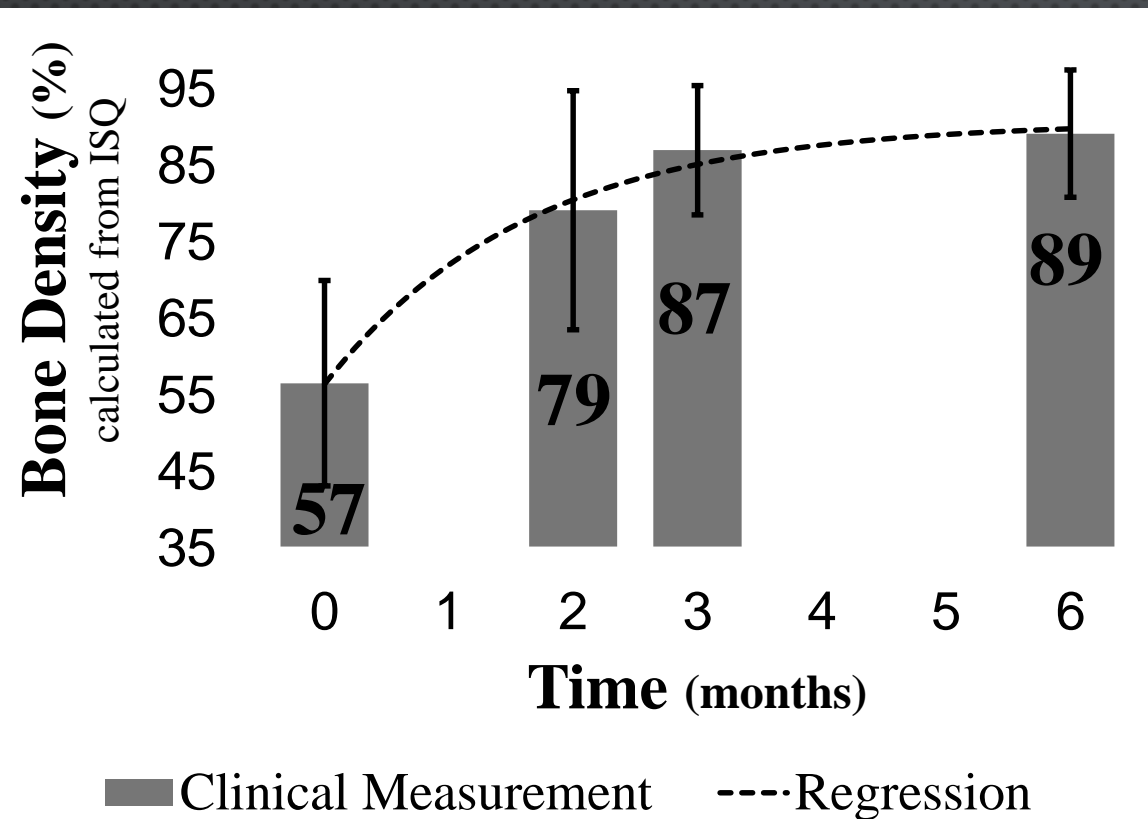
The Relationship Between Bone Volume Density & ISQ



- 1:1 relationship between Bone density (Micro-CT & Histological Analysis)
- Coefficient of determination ( $R^2$ ) between bone density & initial ISQ: **0.8**

# Results:

## Bone Volume Density Over Time



- T0 - T1 was the only statistically significant time point
- Findings correspond to stability graph

# Discussion – the first two months:

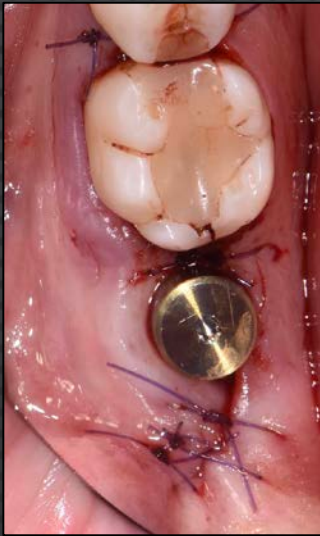
- Most healing occurs within first **2 months**
- Implants with initial ISQ closer to 55 =  $\uparrow$  bone growth over first 2 months
- Stability **plateau** seen at 2 months
  - - Peri-implant bone = dense & uniform
- **Downward** trajectory of ISQ values at 2 months = problematic
- Regardless of IT, same **asymptotic** healing pattern observed

# Discussion – the outliers:

T0



T1



T2



- IT: 35 N/cm
- Initial ISQ: 55
- ISQ at T2: 50



T0



T1



T2



- IT: 50 N/cm
- Initial ISQ: 80
- ISQ at T2: 87



# Conclusion:

Loading at 2 months **CAN** be as successful as conventional loading.

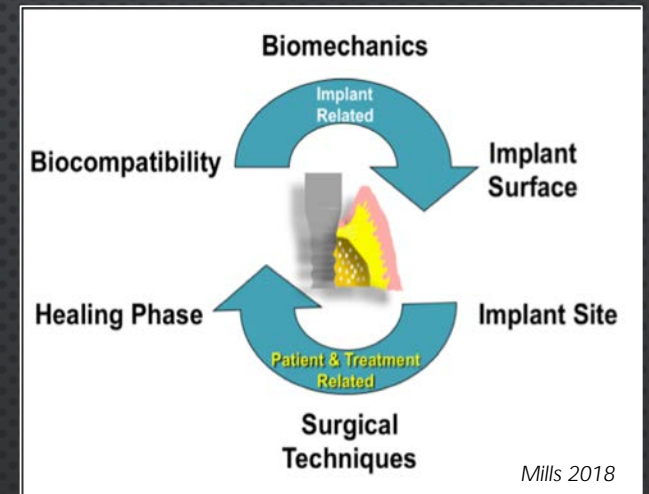
A personalized approach, accounting for **patient**, **site**, and **implant-related factors** should be used.

**ISQ** is the most prognostic predictor of **bone density / implant stability**

**IT** should be used to evaluate stability only in conjunction with **ISQ**

Osseointegration at 2 months can be predicted if the following present:

1. **ISQ  $\geq 66 \pm IT \geq 35$  N/cm**
2. **(-) RTT; (-) Percussion**



# Future Research:

- Updates to current study:
  - Continue enrolling subjects
  - Add **4 week** follow-up
  - Further assess outcomes of patient's with initial **ISQ <55** and **IT <35**
- New study:
  - Evaluate same principles in **other quadrants**

