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Evaluation Of Deflection Characteristics Of Orthodontic Mini Implants Following Placement- An Ex-Vivo Study

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Abstract

Aim: To Radiographically Evaluate And Compare The Deflection Characteristics Of Self-Drilling Titanium Alloy Mini Implants When Inserted Into Bone Similar To The Human Mandible.
Method: 80 Self Drilling Titanium Alloy Implants Of The Following Sizes Were Used: 1.3mm, 1.4mm, 1.5mm And 1.6mm Diameters And 10mm, 8mm, 7mm And 6mm Lengths. 5 Mini Implants Of Each Of The Possible Combinations Of Lengths And Diameters Were Tested For Study. The Implants Were Inserted Perpendicularly Into Bovine Rib Bone Held In A Custom Made Stand. The Rib Bone Was Made Into Segments 1.5cm Wide Using An Osteotome And Embedded In Autopolymerising Acrylic Resin Blocks With Four Bone Segments In Each Block. Thus A Total Of Twenty Resin Blocks Were Made. Insertion Torque Was Set At 1kgf In The Long Handle Implant Driver With Attached Torque Gauge. Each Resin Block Contained One Implant Per Bone Segment And Individual Blocks Contained Implants Of Identical Lengths But Varying Diameter. The Resin Blocks Were Then Radiographically Exposed And The Deviation Of The Long Axis Of The Implant From A True Vertical Line Drawn Through The Centre Of Entry Of The Implant Into Cortical Bone Was Measured.
Results: There Was An Increase In Deflection Of The Mini Implant With Increase In Length. On The Other Hand, Increase In Diameter Resulted In Decrease In The Amount Of Deflection Observed.
Conclusion: Selecting An Implant Depends On Anatomical Limitations Like Cortical Bone Thickness, Proximity To Adjacent Roots, Or Any Other Vital Structures And Implant Design. For Insertion Into Thicker Bone Such As The Mandible, It Is Preferable To Use A Thicker And Shorter Mini Implants As They Exhibit Lesser Deflection. In Areas Of Lesser Cortical Bone, A Thinner And Longer Mini Implant Can Be Considered As The Resistance Offered By The Bone Will Be Lesser.
Keywords: Mini Implants, Mechanical Properties Of Implant Materials, Deflection, Risk Factor
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Introduction

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The Movement Of Teeth During Orthodontic Therapy Occurs Primarily Through The Application Of Forces. In Order For These Forces To Cause Changes In Tooth Position, Adequate Support Must Be

Available From Which These Forces Can Be Applied. Hence, Ever Since Its Origin, The Field Of Orthodontics And Dentofacial Orthopaedics Has Focussed On The Importance Of Anchorage And The Consequences Of Its Loss. This Anchorage Can Be Derived From Other Teeth, Extraoral Sources Or From Skeletal Structures. But These Forces Also Act Reciprocally On The Anchoring Structures Thereby Causing Undesirable Movement Of Such Structures.

Hence, The Concept Of Skeletal Anchorage Was Introduced To Offer Capabilities For Treatment Unavailable Previously. Various Methods For Obtaining Skeletal Anchorage Like Endosseous Implants, Bone Screws Used For Fixation In Surgery Were Tried Initially And Now Mini Implants Especially Manufactured For Orthodontic Anchorage Are Readily Available. This Helps Forces To Be Applied To Produce Tooth Movement In Any Direction Without Detrimental Reciprocal Forces.

The Possibility Of Skeletal Anchorage Was Explored By Creekmore And Eklund (1983) [1] By Using A Vitallium (Cobalt-Chromium) Screw For Intruding Anterior Teeth In The Maxilla. Kanomi (1997)[2] Clinically Demonstrated The First Successful Use Of Orthodontic Mini Implants With A Diameter Of 1.2mm And 6mm In Length For Mandibular Incisor Intrusion With No Root Resorption Or Periodontal Pathologies.

Numerous Materials Were Used Initially For The Manufacturing Of Mini Screws Before The Widespread Use Of Titanium And Its Alloys Came Into Existence. Some Of The Materials Previously Considered Were Cobalt -Chromium Alloy (Vitallium) And Stainless Steel. Most Present Mini Implants Are Fabricated From Either Commercially Pure Titanium [Cpti / Ti Grade 4] Or Titanium Alloy [Ti-6al-4v / Ti Grade 5]. They Have Excellent Corrosion Resistance And Are Highly Biocompatible. A Protective Surface Oxide Layer Develops When It Comes Into Contact With Oxygen Or Tissue Fluids And Even If It Is Lost, It Is Regenerated Within Milliseconds Due To Its Affinity Towards Oxygen And Nitrogen. Titanium Grade 4 Has Tensile Strength Of 550 Mpa Whereas Titanium Grade 5 Has A Tensile Strength Of 910 Mpa.

Both Have A Similar Young's Modulus Of 100-110 Gpa .Titanium Alloy Offers Greater Strength, More Favourable Surface Condition, Stress-Strain Behaviour And Wear Resistance. Depending On The Method Of Insertion Two Types Of Mini Implants Are Available: Self-Drilling And Self-Tapping. Self Drilling Mini Implants Have A Cutting Tip And Can Be Inserted Directly Into The Bone. Self-Tapping Implants Need Implant Site Preparation With The Use Of A Drill To Make A Pilot Hole Following Which The Implant Is Then Inserted.Self Drilling Implants Offer Numerous Advantages Like Easy Insertion Technique, Increased Tactile Sensation And No Additional Armamentarium Is Necessary.

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Immediately After Insertion, The Retention Of Any Mini-Screw Is Purely Mechanical In Nature And Is Achieved Through A Combination Of Displacement And Compression Of The Adjacent Bone. This Process Is Known As Primary Stability. It Is Independent Of The Implant Material But Is Highly Dependent On The Design Of The Screw, Bone Thickness And Insertion Technique. Primary Stability Relies On The Mechanical Interlocking Of The Threads Of The Screw With Mainly The Cortical Bone, Hence Greater The Bone Quantity, The Better The Primary Stability Will Be. The Minimum Preferred Cortical Bone Thickness For Mini Implants To Be Stable Is Greater Than 1mm.[3]

The Thickness Of The Cortical Bone In The Maxilla Is Generally Lesser Than In The Mandible.
Insertion Torque Is The Result Of Frictional Resistance Between Screw Threads And Bone And Is Reported To Determine Primary Stability. Insertion And Removal Should Be Done At A Slow Steady Rate With A Continuous Force So That The Load On Both The Screw And Bone Will Be Low. All Miniscrews Are Susceptible To Breakage Upon Reaching A Certain Torque Level. However There Is A Range Of Safety Between Recommended Insertion Torque And Maximum Insertion Torque. Mcmanus Et Al[4] Reported That The Mean Maximum Placement Torque In The Maxilla Was 4.6 Newton Centimetres [Ncm] And In The Mandible It Was 8.64 Ncm. Friberg Et Al[5] Described A Positive Correlation Between Mini-Implant Insertion Torque And Bone Density Values, And Concluded That Methods Used To Measure Torque During Mini-Implant Placement Should Be Used Routinely.

When An Implant Is Inserted Into Bone, Due To The Resistance Offered By The Bone, The Implant Is Liable To Undergo Deviation From Its Original Path. This Interaction Between The Implant And Bone Is Dependent On Both The Length And Diameter Of The Implant. Due To Its Size, Despite The Use Of Titanium, The Flexural Strength Of The Mini Implant Is Decreased. Consequently, The Maximum Force Required To Cause Permanent Deformation Also Decreases. This Deflection Or Deformation Can Ultimately Lead To Fracture Or Failure Of The Mini Implant.
Mini Implant Failure Can Involve Factors Related To The Clinician, The Patient And The Screw Itself. According To Kuroda Et Al[6], Root Proximity Is One Of The Major Risk Factors For Failure Of Mini Implants. Placement Of A Mini Screw Too Close To A Root Can Also Result In Insufficient Bone Remodelling Around The Screw And Transmission Of Occlusal Forces Through The Teeth To The Screws Leading To Implant Failure. Considering That Majority Of The Mini Implants For Orthodontic Usage Are Placed In Inter-Dental Areas, A Slight Deflection From The Intended Path Can Thus Affect Their Success.

Hence The Aim Of This In Vitro Study Was To Radiographically Evaluate The Deflection Of Titanium Alloy Self-Drilling Mini Implants From The Intended Path That Occurs During Placement And Also To Compare Effect Of Various Lengths And Diameters On The Quantum Of Deflection.

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Methodology

The Present Study Was Undertaken At The Department Of Orthodontics And Dentofacial Orthopedics, Sri Ramakrishna Dental College And Hospital, Coimbatore And Was Approved By The Ethical Committee Of The Institution. Eighty Absoanchor Self-Drilling, Mini Implants Made Of Titanium- 6aluminium-4vanadium [Ti-6al-4v] Alloy Implants From Dentos® Korea, Of The Following Dimensions Were Used For The Experiment. Sample Size Mentioned In Table 1. Mini Implants Were Conical In Shape And The Head Of The Implant Was Hexagonal With A Small Hole For Passing Threads And Ligature Wires Through It.

Preparation Of Bone Segments:

An Osteotome Was Used To Segment Fresh Bovine Rib Into Pieces 1.5cm Wide. The Segments Were Embedded In Autopolymerising Resin Blocks Of 15cm X 5cm X 2cm. Four Rib Segments Were Embedded In Each Block. To Ensure That The Point Of Insertion Of The Implant Was Truly Horizontal, A Spirit Level Was Placed On The Surface Of Each Of The Rib Segments During Embedding [Fig 1]. Twenty Bone Segment Blocks Were Thus Prepared And Were Segregated For Implant Insertion Such That One Block Had Four Mini Screws Of Similar Length And Varying Diameter.

Bovine Rib Was Used In This Study As Previous Studies By Laurito Et Al[7] Have Shown That Bovine Rib Architecture Is Similar To The Human Mandibular Architecture. Bovine Rib Is One Of The Preferred Human Bone Substitutes In Ex-Vivo Implantology Studies. The Bovine Rib Was Stored In Normal Saline And Kept Moist Till The Time Of Insertion As Done By Chatzigianni Et Al[8.]

Insertion Of Mini Implants:

A Long Handle Implant Driver From Dentos®, Korea With Torque Gauge Fixed At 1kg/Cm [I.E.9.8n] Was Used For The Study. The Torque Force Can Be Adjusted From 0.5kg.Cm To 2kg.Cm. The Driver Emitted A Clicking Noise When The Torque Level Exceeded The Set Value. A Stand Was Custom Fabricated For The Study Using Polymerized Nylon And Chrome Plated Steel [Fig 2]. The Implant, Implant Driver And The Resin Block Were Held Perpendicular To Each Other In The Custom Made Stand. The Stand Was Made With Telescopic Axes To Enable Adjustment Of The Bone Block And Driver Interface In All Three Planes Of Space. The Mini Implant Was Inserted Into The Bone Segment By Slow Continuous Manual Insertion. Likewise, All The Remaining Implants Were Also Inserted One Mini Implant Per Bone Segment.

Radiographic Imaging Of The Bone Block:

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Once The Mini Implants Were Inserted, A Digital Radiograph Was Taken Of Each Of The Blocks Individually. A G.E Discovery Xr656 Digital Radiographic Machine With The X-Ray Source 100cm From The Object Set At 80kv And 292mas Was Used With Radiographic Exposure Time Of 1milli Second. The Bone Blocks Were Placed At The Centre Of The X-Ray Beam Path. A Spirit Level Was Used To Ensure That The Blocks Were Not Inclined.

Image Analysis For Deflection Measurement:

The Radiographic Image Obtained Was Adjusted For Optimum Contrast And Magnification Prior To Obtaining The Mini Implant Deflection Values [Fig 3].A Pictorial Representation Of The Image Analysis Is Shown In Figure 4. In The Image, The Black Line Ab Represents The True Horizontal Line Passing Through The Centre Of Point Of Insertion Of The Implant. The Red Line Xy Represents The Long Axis Of The Mini Implant Passing Through Its Apex And Tip. Ø Is The Angle Between The Two Lines Ab And Xy And Represents The Degree Of Deflection Of The Mini Implant.

Image Analysis Was Done Using The G.E. Media Viewer Software As The Tool For Measuring The Implant Deflection. The Long Axis Of The Mini Implant Was Considered As A Line Joining The Apex And The Tip Of The Implant. A True Vertical Line Passing Through The Centre Of Point Of Insertion Of The Mini Implant Was Used To Obtain The Degree Of Deviation Of Its Long Axis Upon Insertion Into The Bone [Fig. 5]. The Procedure Was Thus Repeated For All The 80 Mini Implants.

A Total Of 80 Mini Implants Were Tested Of Which 2 Mini Implants Of Size 1.6mm X 8mm Fractured And Hence Were Not Included In The Study. The Results Of This In-Vitro Study Using Titanium Alloy Mini Implants In Comparing The Deflection Produced By Implants Of Various Diameters And Length Is Presented As Follows:

Descriptive Statistics For The Measurements Were Computed With Spss Statistical Software Package And The Assumption Of Normality Of The Variables Was Investigated By The Kolmogorov-Smirnov Test. The Mean Deflections Of The Various Dimensions Of Implants Used In The Study Are Shown In Table 1. All Mini Implants Underwent Deflection Upon Insertion With A Maximum Mean Deflection 2.9 Degrees And A Minimum Of 0.6 Degrees. A Test Of Between Subjects' Effects Was Done To Assess The Influence Of Length And Diameter And Also The Combined Effects Of Length And Diameter On Deflection. The Influence Of All Three Parameters Was Found To Be Statistically Significant.

The Individual Effect Of Constant Diameter With Varying Length And Also Constant Length And Varying Diameter Was Assessed Using One Way Analysis Of Variance And Post Hoc Comparisons At 95% Confidence Interval.

Parameters Assessed:

I. Comparison Of The Deflection In Various Diameters Of Varying Length
Ii. Comparison Of The Deflection In Various Lengths Of Varying Diameters

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I. Comparison Of The Deflection In Various Diameters Of Varying Length:

There Was Decrease In The Amount Of Deflection Observed With The Corresponding Decrease In Length.

(A) Comparison Of 1.3mm Diameter Mini Implants Of Lengths 10mm, 8mm, 7mm And 6mm: The 10mm Mini Screws Showed Maximum Deflection Followed By 8mm Then 7mm And The Least Deflection Was Seen In The 6mm Long Screws. This Difference Was Seen To Be Statistically Significant (P <0.05).The Maximum Difference Of 1 Degree Was Seen Between The 10mm And 6mm Screws And A Minimum Difference Of 0.28 Degrees Was Seen Between The 8mm And 7mm Long Screws.

(B) Comparison Of 1.4mm Diameter Mini Implants Of Lengths 10mm, 8mm, 7mm And 6mm: The 10mm Mini Screws Showed Maximum Deflection Followed By 8mm Then 7mm And The Least Deflection Was Seen In The 6mm Long Screws. The Maximum Difference Of 1.08 Degrees Was Seen Between The 10mm And 6mm Screws And A Minimum Difference Of 0.30 Degrees Was Seen Between The 10mm And 8mm Screws And 8mm And 7mm Long Screws. The Difference In The Mean Deflection Observed Was Statistically Significant (P <0.05).

(C) Comparison Of 1.5mm Diameter Mini Implants Of Lengths 10mm, 8mm, 7mm And 6mm: The 10mm Mini Screws Showed Maximum Deflection Followed By 8mm Then 7mm And The Least Deflection Was Seen In The 6mm Long Screws. The Maximum Difference Of 1.30 Degrees Was Seen Between The 10mm And 6mm Screws And A Minimum Difference Of 0.28 Degrees Was Seen Between The 10mm And 8mm Screws. This Difference Was Seen To Be Statistically Significant (P <0.05).

(D) Comparison Of 1.6mm Diameter Mini Implants Of Lengths 10mm, 8mm, 7mm And 6mm: The 10mm Mini Screws Showed Maximum Deflection Followed By 8mm Then 7mm And The Least Deflection Was Seen In The 6mm Long Screws. On Comparison Of Mean Difference Of Deflection, It Was Seen To Be Statistically Significant (P <0.05). The Maximum Difference Of 1.30 Degrees Was Seen Between The 10mm And 6mm Screws And A Minimum Difference Of 0.20 Degrees Was Seen Between The 10mm And 8mm Screws.

Ii. Comparison Of Various Lengths Of Varying Diameter:

There Was An Inverse Relation Seen With Respect To The Effect Of Varying The Diameter Of The Mini Implant.

(A) Comparison Of 10mm Long Implants Of Diameters 1.3mm, 1.4mm, 1.5mm And 1.6mm. The Smaller Diameter I.E. 1.3mm Implants Showed The Greatest Deflection Followed By 1.4mm, 1.5mm And The Least Deflection Was Observed For The 1.6mm Wide Mini Implants. The Maximum Difference Of 1 Degree Was Seen Between The 1.3mm And 1.6mm Diameter Screws And A Minimum Difference Of 0.28 Degrees Was Seen Between The

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1.5mm And 1.6mm Screws. These Discrete Values Were Found To Be Statistically Significant ($P < 0.05$).

(B) Comparison Of 8mm Long Implants Of Diameters 1.3mm, 1.4mm, 1.5mm And 1.6mm. The Smallest Diameter I.E. 1.3mm Implants Showed The Greatest Deflection Followed By 1.4mm, 1.5mm And The Least Deflection Was Observed For The 1.6mm Wide Mini Implants.

The Maximum Difference Of 0.9 Degrees Was Seen Between The 1.3mm And 1.6mm Diameter Screws And A Minimum Difference Of 0.20 Degrees Was Seen Between The 1.5mm And 1.6mm Screws. The Difference In Values Was Found To Be Statistically Significant ($P < 0.05$).

(C) Comparison Of 7mm Long Implants Of Diameters 1.3mm, 1.4mm, 1.5mm And 1.6mm: The Smallest Diameter I.E. 1.3mm Implants Showed The Greatest Deflection Followed By 1.4mm, 1.5mm And The Least Deflection Was Observed For The 1.6mm Wide Mini Implants. The Maximum Difference Of 1.24 Degrees Was Seen Between The 1.3mm And 1.6mm Diameter Screws And A Minimum Difference Of 0.40 Degrees Was Seen Between The 1.4mm And 1.5mm Screws. These Discrete Values Were Found To Be Statistically Significant ($P < 0.05$).

(D) Comparison Of 6mm Long Implants Of Diameters 1.3mm, 1.4mm, 1.5mm And 1.6mm: The 1.3mm Implants Showed The Greatest Deflection Followed By 1.4mm, 1.5mm And The Least Deflection Was Observed For The 1.6mm Wide Mini Implants. A Maximum Difference Of 1.30 Degrees Was Seen Between The 1.3mm And 1.6mm Diameter Screws And A Minimum Difference Of 0.28 Degrees Was Seen Between The 1.4mm And 1.5mm Screws. These Discrete Values Were Found To Be Statistically Significant ($P < 0.05$).

The Overall Comparison Of The Deflection Values Of Mean Of Diameters For Various Lengths Is Represented In Table 2. It Shows A Progressive Decrease In Deflection With Both Increase In Diameter And Also Decrease In Length.

Discussion

Over The Last Decade, The Use Of Mini Implants For The Purpose Orthodontic Anchorage Has Increased Considerably. For An Implant To Achieve Its Goal, The Selection Of A Mini Implant Of Adequate Length And Diameter Best Suited To The Required Area Is Of Prime Importance. Various Authors Like Kyung Et Al[9] And Park Et Al[10] Have Proposed Dimensions Of Implants To Be Used In Different Areas Of The Jaws. Hence In This Study The Commonly Used Dimensions Of Implants Have Been Used For Evaluation And Comparison Of Deflection.

Initially Implants Were Manufactured Using Cobalt-Chromium Alloys, But The Use Of This Material Was Soon Discarded Due To Adverse Bone Reactions Noted. Stainless Steel Implants Are Biocompatible With A High Young's Modulus Of 185gpa[11] And Are Thus Less Prone

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To Bending But Contact Area With Bone Is Reduced And It Also Interferes With Magnetic Resonance Imaging And Computed Tomographic Investigations.

The Biocompatibility And Direct Bone Contact With Pure Titanium Implants Has Been Clearly Demonstrated Previously But It Has A Lower Yield Strength Of 180mpa, Tensile Strength Of 290mpa And Hardness Compared To Titanium Alloys Which Have A Yield Strength Of 830mpa And Tensile Strength Of 900mpa[11]. This Also Permits Filigree Structures Like The Turn Of The Threads To Be Worked Out Solidly. Consequently, Most Orthodontic Mini Implants In Use Currently Are Made Of Grade 5 Titanium (Ti-6al-4v) And Thus This Was The Implant Material Chosen For The Present Study.

Studies Have Shown That The Placement Angle Of The Screw Can Have An Effect On Its Anchor Value And The Stress Transmitted. Woodall Et Al[12] Through Their Finite Element Analysis And Parallel Cadaver Study Clearly Demonstrated That Compared To 30° And 60°, A 90° Insertion Angle To The Bone Surface Showed The Maximum Anchorage Advantage. Jasmine Et Al[13] And Lin Et Al[14] Also Through Their Finite Element Analysis Study Showed That Perpendicular Insertion Of Mini Implant In Bone Reduces The Stress Concentration And Offers More Stability To Orthodontic Loading. Hence The Insertion Angle Was Chosen As 90° For The Present Study.

In The Evaluation Of The Biomechanical Performance Of Screws, Methods Such As Insertional Torque And Axial Pull Out Tests Are The Most Often Used In Orthopedics And Oral And Maxillofacial Surgery. Motoyoshi Et Al[15] Found The Average Torque Measured At Placement To Be Between 8.3 Ncm In The Maxilla And 10 Ncm In The Mandible And Said That Screws Placed With Maximum Torque In The Range Of 5-10 Ncm Had The Highest Rate Of Success. Higher Torque Levels Are Associated With Ischemia And Necrosis Of Surrounding Bone And Low Insertion Torques Are Associated With Inadequate Primary Stability Of Implants. Thus The Optimal Insertion Torque Was Set At 1kgf (I.E 9.8ncm) In This Study.

It Is Thought That The Placement Torque Of Self-Drilling Mini-Implants Can Easily Become Excessive In The Thick, Mandibular Cortical Bone, Which Can Cause The Mini Implant To Loosen And Fracture. When Mini Implants Of Different Diameters Produced By The Same Manufacturer Were Compared By Pithon Et Al[16], It Was Found That Their Torsional Strength Values Increased As Their Diameters Also Increased. This Means That Insertion Torques For Installing Small Diameter Mini-Implants Into High- Density Bones Is Near The Fracture Torque, Thus Requiring More Careful Attention On The Part Of The Orthodontist. Excessive Torque Also Increases Microdamage To Cortical Bone Leading To Cracks In The Cortical Bone Immediately Adjacent To The Implant Surface[17].

Numerous Authors Like Park Et Al[18], Motoyoshi Et Al[15] And Farnsworth Et Al[46] Have Investigated The Cortical Bone Thickness In Various Areas Of The Jaws. Schnelle Et Al[20] And Hu Et Al[21] Have Determined The Availability Of Inter-Radicular Bone For Mini Implant Placement. Bovine Rib Bones Were Chosen For The Study As Other Authors Like Chatzigianni Et Al[8] And Laurito Et Al[7] Have Demonstrated The Similarity Of

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Architecture Of Bovine Rib Bone To Human Mandible. Hounsfield Units Of Cortical Bone In An Average Human Mandible Have Been Observed To Be 1400-1600 With A Medullary Reading Of 400-600 Hounsfield Units. The Cortical Bone In Bovine Ribs Has Demonstrated To Be 1400 Hounsfield Units And Medullary Bone To Be 470 Hounsfield Units.

In Our Study, The Results Of The 80 Samples Were Divided Into 2 Groups:
(A) Effect Of Length On Deflection With Constant Diameter
(B) Effect Of Diameter On Deflection With Constant Length

Irrespective Of The Size, All The Mini Implants Showed Deflection In Varying Degrees Upon Insertion Into The Bone. The Test Between Subjects Showed That Individual Effect Of Varying Length And Diameter And Also The Combined Effect Of Varying Both Diameter And Length On The Degree Of Deflection Was Statistically Significant.

The Overall Comparison Of The First Group Showed That When The Diameter Was Kept Constant, There Was A Statistically Significant Progressive Decrease In Mean Deflection With A Decrease In Length From 10mm, 8mm, 7mm And 6mm Implants. This Phenomenon Was Observed For All The Implants Of Diameters 1.3mm To 1.6mm. In The Second Group, Keeping The Length Constant It Can Be Seen That There Is A Decrease In Mean Deflection With Increase In Diameter From 1.3mm To 1.6mm. This Progressive Decrease In Deflection Was Observed To Be Statistically Significant For All The Various Lengths Of Implants Used In The Study I.E. 10mm, 8mm, 7mm And 6mm.

It Has Been Known That A Change In Length Or Diameter Can Alter The Strength Of A Material. The Strength Of A Material Is Directly Proportional To The Fourth Power Of Its Diameter And Inversely Proportional To The Cube Of Its Length[22]. Thus The Stronger The Implant, The Greater Is Its Ability To Resist Deflection. The Overall Comparison Of Results Of This In Vitro Study Are In Agreement With The Above Principle As The Result Demonstrates That There Is A Direct Relation Of The Deflection Of The Implant On Its Length. In Addition, The Deflection Of The Implant Is Seen To Be Inversely Proportional To Its Diameter. Hence The Greatest Deflection Was Observed For Mini Implants With The Least Diameter And Longest Length I.E. 1.3 X 10mm And The Least Deflection Was Experienced By The Widest And Shortest Mini Implants I.E.1.6 X 6mm.

As Shown In Table 2, Similarities In Deflection Values Can Be Observed For The Various Sizes Of Implants: 1.3 X 6mm, 1.4 X 7mm, 1.5 X 8mm, 1.6 X 10mm. Also 1.3 X 7mm, 1.4 X 8mm And 1.5 X 10mm Mini Implants Are Seen To Exhibit Similar Deflections. Since All The Implants Were Inserted Into Identical Bone With A Constant Insertion Torque And Are All Of The Same Material, The Only Factor Responsible For The Similarities Between Groups Is The Interplay Of Length And Diameter. A Change In The Diameter Of The Implant Is Compensated By The Change In Its Length To Produce Similar Deflections For The Various Sizes Of Implants Used In This Study.

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In A Study Done By Miyajima Et Al[23] The Following Elasticity Coefficients Were Observed For Cortical Bone, Spongy Bone And Titanium Alloy Implants: 1.4 X 10^4mpa, 7.9 X 10^3mpa And 1.1 X 10^4mpa Respectively. Most Of The Stress That Occurs During Insertion Is Absorbed By The Cortical Bone With Minimal Transfer To The Cancellous Bone. Thus, The Difference In Mechanical Properties Between Cortical Bone And Titanium Alloy Is A Factor In Responsible For Deflection Of The Mini Implant Which Is Exhibited In Our Study.

In Our Study Also The Deflection Was Observed At The Point Of Entry Of The Mini Implant Into Bone. Singh Et Al[24] In Their Finite Element Study Observed Deformation Of Titanium Alloy Screws But Not That Of Stainless Steel Screws Under Similar Loading Conditions And Also That The Stress Pattern Was Greatest At The Neck Of Mini Implant In Both Screws. Our Study Is Concurrent With Liu Et Al[25] Also Who Stated That The Point Of Entry Of The Implant Into The Cortical Bone Acts As A Pivot For Its Bending.

Similar To Our Study, Kalra Et Al[26] Also Found Angular Deviation Of Mini Implant From Ideal Path In Their In-Vivo Study. In Addition They Also Found Deviation From The Point Of Entry Of Mini Implants Into Bone. Contrary To Our Study, Meyer Et Al[27] Found Angular Deviation Between Stent Placement Position And Implant After Insertion But Said That This Difference Was Not Significant. However, They Used Prosthetic Implants Which Were Placed In Edentulous Areas And Hence There Were Minimal Chances Of Contact With Adjacent Teeth.

Having Evaluated The Deflection Characteristics Of Various Implants Used In The Study, The Clinical Implications Of The Same Can Be Considered. Prior To Implant Placement, Numerous Factors Liken The Amount Of Available Bone In The Particular Area, The Presence Of Sinus, Nerve Canal And Proximity To Roots Of Adjacent Teeth Is Examined. This Is Done Using Investigative Tools Like Radiographs Or Computed Tomographic Techniques. Although, It Is Seen That Choosing A Wider Diameter Implant Would Be Beneficial In Terms Of Ensuring A Higher Success Rate [18] And A Lesser Degree Of Deflection As Seen By Our Study, Selecting An Implant For A Particular Area Is Largely Dependent On The Amount Of Available Bone In That Region. Poggio Et Al[3] And Alrbata Et Al[28] Have Proposed That A Minimum Of 1mm Bone Thickness Surrounding The Mini Implant Is Necessary To Ensure Its Stability. Hence In Areas Where Inter Radicular Bone Availability Is Less Mini Implants Of Smaller Diameter Can Be Chosen.

This Will Also Decrease The Failure Rates Of Mini Implants As Kuroda Et Al[6] Have Proven That Root Proximity Is One Of The Major Risk Factors. However It Must Be Borne In Mind That A Decrease In Diameter Will Lead To An Increase In Deflection As Shown By Our Study And Also Weaken The Implant. Few Studies Concluded That The Risk Of Mini Implant Fracture Should Be Borne In Mind At The Time Of Insertion Especially If Mini Implants Of Small Diameters Are Employed.

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In Areas Where Cortical Bone Is Thick, Reducing The Length Of The Mini Implant Will Help Reduce Chances Of Failure By Decreasing The Amount Of Deflection As Exhibited By This Study. Longer And Thinner Implants Are Also Seen To Be More Prone To Bending And Breakage. This Is A Factor In Preferring Shorter Length Implants Predominantly In The Mandible Where The Cortical Bone Thickness Is Inherently Thicker Than The Maxilla. In Our Study Also, Longer Mini Implants Showed Greater Deflection When Compared To The Shorter Mini Implants. Another Alternative As Proposed By Melsen[29] Is That Even With The Use Of Self-Drilling Screws, Pilot Drilling May Be Required If Cortical Bone Thickness Is Greater Than 2mm As The Dense Bone Can Bend The Fine Tip Of The Screw.

Two Mini Implants Fractured During The Study During Insertion. This Was Due To Over Tightening Of The Screw During Placement. The Insertion Torque Exceeded The Set Value Of 1kgf. Hence Caution And Care Is Advised During Implant Insertion To Decrease Fracture Rates Of Mini Implants.

Before Placement Of Mini Implant, The Behaviour Of The Implant Due To Its Interaction With Bone Even Prior To Loading Needs To Be Considered. The Importance Of The Biomechanical Behaviour Of Various Lengths And Diameters Of Mini Implants Used In The Study Has Been Evaluated. The Above Study Highlights The Fact That When An Implant Is Being Placed Into Bone With Increased Cortical Thickness Such As The Mandible, A Shorter And Wider Implant Needs To Be Used. Both The Mechanical Properties Of The Material In Use As Well As Anatomical Constraints In Choice Of Implant To Withstand The Load Applied Are Of Prime Importance. Hence, This Study Will Enable The Practitioner To Select A Proper Mini Implant From His/Her Available Armamentarium For The Right Anatomical Location. However, The Above Study Is An In Vitro Study Hence The Exact Clinical Scenario Cannot Be Simulated. Further Studies On A Larger Sample Scale May Be Needed To Validate The Results Obtained.

Conclusion

The Present Study Considered The Phenomenon Of Deviation Of The Mini Implant Due To Its Interaction With Cortical Bone. On The Basis Of The Results, When An Implant Is Inserted Into A Bone Of Increased Cortical Thickness, The Following Inferences Can Be Obtained:

- Deflection Of The Mini Implant Does Occur Upon Insertion.
- Increasing The Diameter Of The Implant Decreases The Amount Of Deflection.
- Decreasing The Length Of The Mini Implant Causes A Decrease In Deflection.
- Similarities In Deflections Of Mini Implants Are Caused Due To The Interplay Between Length And Diameter Of The Mini Implant.

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When An Implant Is Planned For Insertion Into Thicker Bone Such As The Mandible, It Is Preferable To Use A Thicker And Shorter Mini Implants As They Exhibit Lesser Deflection. In Areas Of Lesser Cortical Bone, A Thinner And Longer Mini Implant Can Be Considered As The Resistance Offered By The Bone Will Be Lesser.

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Figure 1 Bone Block Surface Checked With Bubble Level

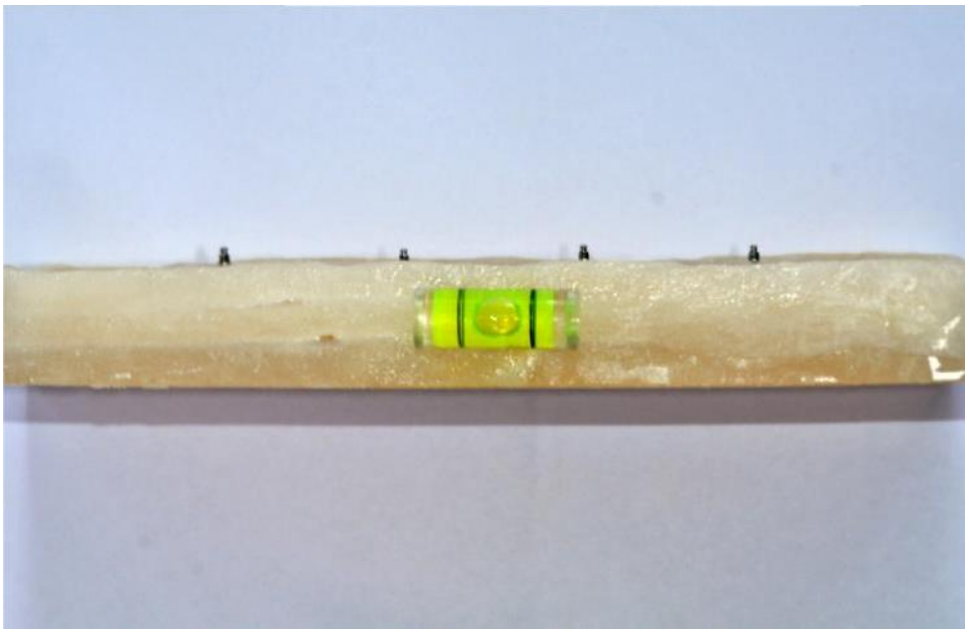

Figure 2 Miniscrew Insertion Stand With Embedded Bone

Figure 3 Radiographic Image Obtained Of A Bone Block

Figure 4 Pictorial Representation Of The Image Analysis

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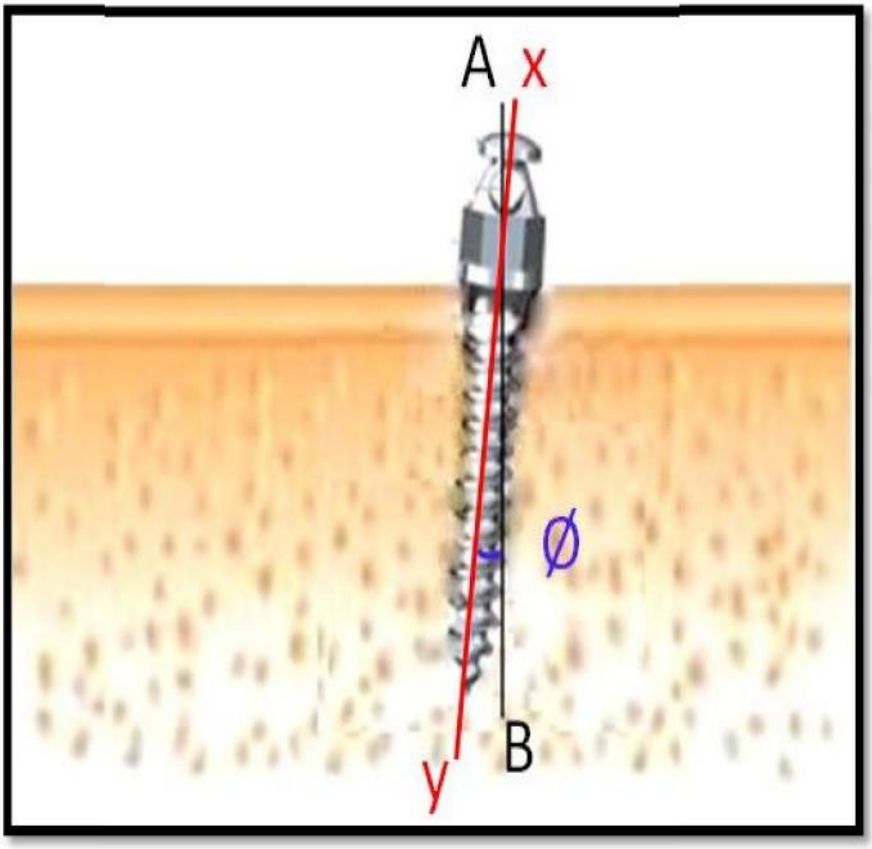

Figure 5 Analysis Of Image Using G.E. Media Viewer Software

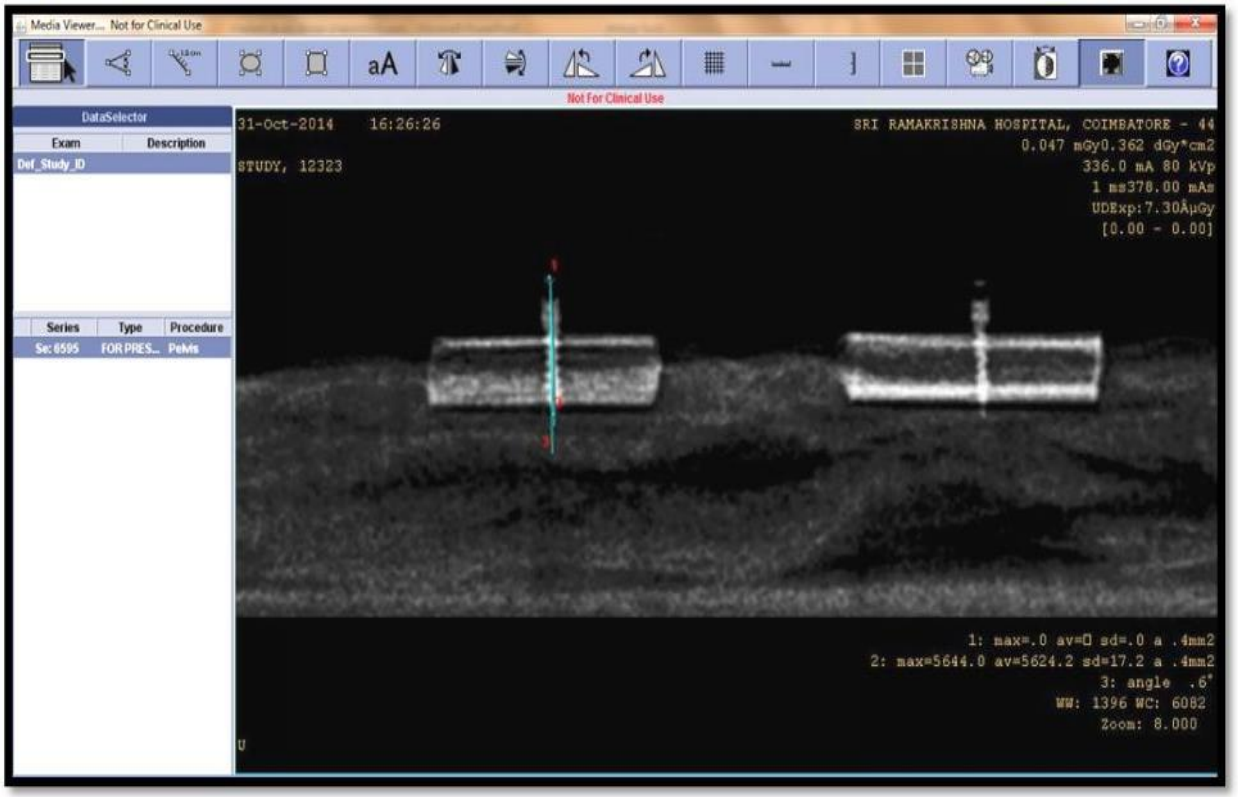

Table 1 Miniscrew Sample Size Evaluated In The Stuady

Length 6mm With Diameters: 1.3mm, 1.4mm, 1.5mm And 1.6mm	5 Screws Of Each Dimension Total 20 Mini Implants
Length 7mm With Diameters: 1.3mm, 1.4mm, 1.5mm And 1.6mm	5 Screws Of Each Dimension Total 20 Mini Implants
Length 8mm With Diameters: 1.3mm, 1.4mm, 1.5mm And 1.6mm	5 Screws Of Each Dimension Total 20 Mini Implants
Length 10mm With Diameters: 1.3mm, 1.4mm, 1.5mm And 1.6mm	5 Screws Of Each Dimension Total 20 Mini Implants

Table 2 Overall Comparison Of Deflection Of Mini Implants