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THE EFFECT OF INNOVATIVE SCREW ANGLED MINI-PLATES ON BIOMECHANICAL STABILITY OF MONO-CORTICAL FIXATION: AN *IN VITRO* MODEL

by

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Dedication:

I dedicate this PhD to the following inspirational people:

my dearest wife, Erica, my children, Marilize, Julius, Erica and Gerhard

Parents Fred and Sophia

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by

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Degree: PhD

SUMMARY

There is no evidence in the literature of biomechanical stability characteristics comparing conventional rectangular screw placement with that of an angled mono-cortical screw plating system where standard 2mm diameter screws are applied at angles more acute than conventional 90° screws, through plate holes machined (cut) for a definite specific screw angle placement.

Angled screws will have an obvious clinical advantage of direct line of vision insertion, through an intra-oral route without the disadvantage of trans-buccal (cutaneous) approach required for conventional 90° rectangular screw application.

Angled screw application will result in the prevention of possible, less post-operative swelling, nerve fall out (motor and/or sensory), haematoma, false aneurysm and scarring as unwanted clinical complications associated with trans-buccal extra-oral surgical technique. Intra-oral angled screw application will result in definitive cost saving due to less operating time required. Post-treatment removal of angled screws is uncomplicated, requiring only intra-oral surgical approach, without trochar use or skin incisions for screwdriver application.

By determining angle displacement values at certain clinical relevant force values for both compression/tension and torsion, preference can be established for ideal angle(s) of screw application in a plating system. An own unique, designed and manufactured, jig and inclined screw insertion (ISI) plates were implemented during the biomechanical evaluation of stability at different screw angle applications in a Zwick machine. For the purpose of this biomechanical comparative investigation an inclined screw insertion (ISI) plate was manufactured with 90°, 75°, 60° and 45° angled

plate holes orientated in line with the long-axis (quadrant 3) of the distal section of the plates and diagonal across (quadrant 1) in the proximal section of the plates. Screws with an ISI angle of 30° in any quadrant application resulted in lifting the plate from the bone surface and caused cortical bone destruction during pilot drilling.

The results for mono-cortical 7mm screw placement proved superior in biomechanical stability during tension/compression - forces for screw insertion angles of 60° and 45°, when compared to conventional 90° rectangular screw placement. Screws inserted at an angle of 75° demonstrated no improvement in compression/tension stability when compared with 90°.Torsion force stability for all of the 75°, 60° and 45° inclined screw insertion (ISI) systems proved more stable compared to conventional 90° screw angle plates. It is concluded that angled mono-cortical screw placement between angles 60° and 45° has clinical significance as far as stability, intra-oral surgical technique and time-cost factor is concerned.

The results of this biomechanical behaviour investigation of ISI, evolved new terminology such as screw-tip shifting, screw-tip travel, lag potential and clinical significance for the range of screw angle placement. Angled orientation to the plate design and plate geometry is also defined in terms of tension line distribution in the anatomical region for application in the mandible. An unique quadrant description for ISI is described for future communication.

An international patent, based on the ISI principle, has been registered for mono-cortical six-hole plates of firstly different geometric designs to conform to specific anatomical topographic sites in the mandible and secondly specific screw plate-holes angled at 60° in different orientation to the plate (Patent:PCT/EP 2006/006365), (Addendum 6). A specific L-shaped, mandibular angle plate with screw holes at a 60° angle where orientation shifts from in-line with the long-axis of the plate in the distal three plate holes to diagonal orientation in the proximal section of the plate, is designed and manufactured by Stryker/Leibinger as an example of such a patent plate.

It is recommended that a smart-lock plate with plate holes at 55° angles be manufactured to allow screw angle placements of 65° - 45° in different angle orientations. Pilot hole drilling and ISI can be performed without the use of a drill-guide.

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DIE EFFEK VAN INNOVERENDE MINIPLATE MET GE-ANGULEERDE SKROEWE OP DIE BIOMEGANIESE STABILITEIT VAN MONO-KORTIKALE FIKSASIE, 'N *IN VITRO* MODEL

deur

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Graad: PhD

SAMEVATTING

Daar is geen literatuur beskikbaar aangaande biomeganiese stabiliteitsgedrag van 'n ge-anguleerde mono-kortikale plaat sisteem soos hier beskryf. Die 2mm diameter skroewe, aangewend teen hoeke kleiner as die konvensionele 90°, deur skroefgate, wat spesiaal vervaardig (gemasjineer) is teen 'n spesifieke hoek, is met konvensionele 90° skroef plasing vergelyk.

Deur eksperimentele bepaling van verplasing teenoor kragtoepassing by sekere klinies relevante Newton ladingswaardes vir kompressie, tensie en torsie kan voorkeur vir 'n spesifieke skroefangulasie(s) bepaal word. Die aanwending van 'n unieke eie ontwerpte en vervaardigde monterings-apparaat in 'n Zwick masjien maak dit moontlik om verplasing teenoor spesifieke krag toepassing in Newton deur die komper te registreer.

Die resultate vir mono-kortikale 7mm lank skroewe het vir geanguleerde plasing teen 60° en 45° biomeganies deurgans beter stabiliteit gedemonstreer in vergelyking tot konvensionele 90° 7mm skroef plasing 'n aanwendingshoek van 75° vir mono-kortikale 7mm skroewe het nie biomeganies betekenisvol verskil van 'n 90° skroefaanwending nie, terwyl 'n aanwendingshoeke van 30° vir 'n mono-kortikale skroef nie klinies moontlik is nie. Vanuit die resultate van hierdie biomeganies geanguleerde skroefplasing studie is nuwe terme gedefinieer soos skroefpunt verskuiwing, skroefpunt verlenging, lag-potensiaal en kliniese relevansie vir die angulasie reikwydte van skroefplasing. Angulasie oriëntasie tot die skroefplaat geometrie is ook gedefinieer.

Vir die doel van hierdie biomeganies vergelykende stabiliteit studie is spesiale geanguleerde skroefgat plate met skroefgat angulasies van onderskeidelik 90°, 75°,

60° & 45° deur Stryker/Leibinger vervaardig waar die angulasie orientasie van alle skroefgate in lyn met die langas in die distale segment en koronaal teenoor die proksimale segment van die plaat was. Die spesiale plate is as die inklineerde skroef inplasing (ISI) sisteem benoem.

Die resultate van hierdie biomeganiese analise het nuwe terminilogie gevestig soos skroefpunt verskywing, skroefpunt verlenging en die potensiaal van ‘n skroef om die fraktuur lyn te oorbrug indien geplaas teen ‘n spesifiek angulasie. Die skroefgat angulasie en plaat geometrie is ook ten opsigte van tensie lyne en anatomiese plasing gedefinieer. ‘n Unieke kwadrant beskrywing vir skroefgat angulasie is omskryf om toekomstige eenvormige kommunikasie te verseker.

‘n Internasionaal geregistreerde patent is gebaseer op die resultaat van hierdie studie as (1) 60° ses-skroefgat mono-kortikale plate van (2) verskillende geometriese forme vir intra-orale chirurgiese tegniek en aanwending in verskillende anatomiese posisies in die mandibula (Patent: PCT/EP2006/006365), (Addendum 1). Die L-vormige ses-gat, mono-kortikale kaakhoek plaat met 60° skroefgat angulasie het oriëntasie in die langas van die plaat in die distale segment en die oriëntasie koronaal (dwars) tot die plaat in die proksimale segment, en is n voorbeeld van die “ISI”-sisteem (Inklineerde Skroef Inplasing) spesifiek ontwerp vir aanwending in die kaakhoek van die mandibula en geometries ontwerp om ooreen te stem met die ideale stress-lyne vir fiksasie op die ventrale aspek van die eksterne skuinsrif.

‘n Aanbeveling word gemaak dat ‘n “smart-lock” universele 10° variasie geanguleerde skroefgat, ontwerp vir skroefplasing teen 55°, vervaardig word wat skroefangulasieplasing tussen 65° en 45° klinies moontlik sal maak deur dieselfde skroefgat. Geen boorgids sal nodig wees nie en die inklineerde skroefangulasie sal moontlik wees in verskillende kwadrant oriënterings.

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