REV BRAS ORTOP. 2017;xxx(xx):xxx–xxx

SBOT
SOCIEDADE BRASILEIRA DE ORTOPEDIA E TRAUMATOLOGIA

RBO
REVISTA BRASILEIRA DE ORTOPEDIA
www.rbo.org.br

Technical Note

Finite element analysis of the equivalent stress distribution in Schanz screws during the use of a femoral fracture distractor☆

Vincenzo Giordano[a,*], Alexandre Leme Godoy-Santos[b], William Dias Belangero[c], Robinson Esteves Santos Pires[d], Pedro José Labronici[e], Hilton Augusto Koch[f]

[a] Hospital Municipal Miguel Couto, Serviço de Ortopedia e Traumatologia Prof. Nova Monteiro, Rio de Janeiro, RJ, Brazil
[b] Universidade de São Paulo, Faculdade de Medicina, Hospital das Clínicas, São Paulo, SP, Brazil
[c] Universidade Estadual de Campinas, Disciplina de Ortopedia e Traumatologia, Campinas, SP, Brazil
[d] Universidade Federal de Minas Gerais, Departamento do Aparelho Locomotor, Belo Horizonte, MG, Brazil
[e] Universidade Federal Fluminense, Departamento de Ortopedia e Traumatologia, Niterói, RJ, Brazil
[f] Universidade Federal do Rio de Janeiro, Faculdade de Medicina, Departamento de Radiologia, Rio de Janeiro, RJ, Brazil

ARTICLE INFO

Article history:
Received 16 June 2016
Accepted 20 June 2016
Available online xxx

Keywords:
Finite element analysis
Bone nails
Femoral fractures
External fixators
Treatment outcome

ABSTRACT

To evaluate the mechanical stress and elastic deformation exercised in the thread/shaft transition of Schanz screws in assemblies with different screw anchorage distances in the entrance to the bone cortex, through the distribution and location of tension in the samples.

An analysis of 3D finite elements was performed to evaluate the distribution of the equivalent stress (triple stress state) in a Schanz screw fixed bicortically and orthogonally to a tubular bone, using two mounting patterns: (1) thread/shaft transition located 20 mm from the anchorage of the Schanz screws in the entrance to the bone cortex and (2) thread/shaft transition located 3 mm from the anchorage of the Schanz screws in entrance to the bone cortex. The simulations were performed maintaining the same direction of loading and the same distance from the force vector in relation to the center of the hypothetical bone. The load applied, its direction, and the distance to the center of the bone were constant during the simulations in order to maintain the moment of flexion equally constant. The present calculations demonstrated linear behavior during the experiment. It was found that the model with a distance of 20 mm between the Schanz screws anchorage in the entrance to the bone cortex and the thread/shaft transition reduces the risk of breakage or fatigue of the material during the application of constant static loads; in this model, the maximum forces observed were higher (350 MPa). The distance between the Schanz screws anchorage at the entrance to the bone cortex and the smooth thread/shaft transition of the screws used in a femoral distractor during acute distraction of a fracture must be farther from the

☆ Study conducted at the Departamento de Ortopedia, Hospital Miguel Couto, Rio de Janeiro, RJ, Brazil, and at the Departamento de Ortopedia e Traumatologia, Faculdade de Medicina, Universidade de São Paulo, São Paulo, Brazil.

* *Corresponding author.*
E-mail: v_giordano@me.com (V. Giordano).

http://dx.doi.org/10.1016/j.rboe.2017.07.003

entrance to the bone cortex, allowing greater degree of elastic deformation of the material, lower mechanical stress in the thread/shaft transition, and minimized breakage or fatigue. The suggested distance is 20 mm.

Análise de elementos finitos da distribuição de tensões equivalentes nos pinos de Schanz durante o uso do distrator femoral de fraturas

RESUMO

Avaliar o comportamento do estresse mecânico e da deformação elástica exercida na transição rosca-talo liso dos pinos de Schanz do distrator femoral de fraturas em montagens com diferentes distâncias de ancoragem dos pinos na cortical óssea de entrada através de estudo da distribuição e da localização de tensões no corpo de prova.

Feita análise de elementos finitos 3D para a avaliação da distribuição das tensões equivalentes em um pino de Schanz fixado de modo bicortical e ortogonal a um osso tubular, em dois padrões de montagem: (1) transição rosca-talo liso distante 20 mm da ancoragem dos pinos de Schanz na cortical de entrada e (2) transição rosca-talo liso distante 3 mm da ancoragem dos pinos de Schanz na cortical de entrada. Foram feitas simulações e manteve-se a mesma direção da carga e a mesma distância do vetor força em relação ao centro do osso hipotético. A carga aplicada, sua direção e a distância ao centro do osso foram constantes durante as simulações para manter o momento fletor igualmente constante. Os cálculos apresentados demonstraram comportamento linear durante todo o experimento. Verificou-se que o modelo com uma distância de 20 mm entre a ancoragem dos pinos de Schanz na cortical óssea de entrada e a transição rosca-talo liso reduziu o risco de ruptura ou fadiga do material durante a aplicação de cargas estáticas constantes. Nesse modelo, as forças máximas observadas foram superiores (350 MPa). A análise do comportamento do estresse mecânico e da deformação elástica exercida na transição rosca-talo liso dos pinos de Schanz do distrator femoral de fraturas mostrou que distâncias maiores entre a ancoragem dos pinos na cortical óssea de entrada e a transição rosca-talo liso dos pinos de Schanz permitem menor estresse mecânico na transição rosca-talo liso e maior grau de deformação elástica do material e minimizam quebra ou fadiga. A distância sugerida é de 20 mm.

Palavras-chave:
Análise de elementos finitos
Pinos ortopédicos
Fraturas do fêmur
Fixadores externos
Resultado do tratamento

Introduction

In the management of various orthopedic situations related to trauma, such as diaphyseal fractures of long bones of the lower limbs and consolidation disorders, the use of indirect reduction tools such as femoral fracture distractor, developed by the AO Group[1] to be used as an adjuvant tool for fracture alignment, is an important advantage during surgery. Its applicability goes beyond the gain of length during surgery; it is possible to make simultaneous or isolated angular and rotational corrections. After the desired adjustments, it serves to maintain the bone fragments in position until definitive osteosynthesis is achieved. Several studies have demonstrated its application in highly varied situations of orthopedic trauma.[2,3]

According to the technique used, the fixation of Schanz screws – one in the main proximal fragment and another in the main distal fragment, perpendicularly to the long axis of the operated bone – allows the distractor's threaded body to be positioned parallel to the bone. Protective sleeves are slid over the screws for both biological and mechanical protection at the soft tissue-pin-bone interface. During distraction of the fracture line, pseudoarthrosis, or osteotomy, the highest stress is observed in the cortical adjacent to the entry site of the pins, which is also the area of greater frequency of failure and loosening.[4]

Numerous factors have been studied to understand the best way to improve bone anchorage of Schanz screws, in order to reduce rates of complications in the pin-bone interface.[5–7] Nonetheless, no studies that evaluated the mechanical stress in the smooth thread/shaft transition of Schanz screws at different distances between the anchorage of screws in the entrance into cortical bone and the smooth thread/shaft transition were retrieved. The greatest concentration of forces is observed precisely in this transition, mainly due to compression and shear loads.[1,8] In the more classical technique descriptions from clinical or experimental trials, the screws

Please cite this article in press as: Giordano V, et al. Finite element analysis of the equivalent stress distribution in Schanz screws during the use of a femoral fracture distractor. Rev Bras Ortop. 2017. http://dx.doi.org/10.1016/j.rboe.2017.07.003