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(54) **DEVICE FOR MEASURING BLOOD FLOW IN THE BONE AFTER A FRACTURE**

VORRICHTUNG ZUR MESSUNG DES BLUTFLUSSES IM KNOCHEN NACH EINER FRAKTUR

DISPOSITIF POUR MESURER L'ECOULEMENT SANGUIN DANS L'OS APRES UNE FRACTURE

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US-A- 4 756 304 **US-A- 6 086 542**
US-A1- 2004 068 226

- **DATABASE BIOSIS [Online] BIOSCIENCES INFORMATION SERVICE, PHILADELPHIA, PA, US; 1991, HARPER W M ET AL: "FEMORAL HEAD BLOOD FLOW IN FEMORAL NECK FRACTURES AN ANALYSIS USING INTRA-OSSEOUS PRESSURE MEASUREMENT" XP002493918 Database accession no. PREV199191081352 & JOURNAL OF BONE AND JOINT SURGERY BRITISH VOLUME, vol. 73, no. 1, 1991, pages 73-75, ISSN: 0301-620X**

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Description

BACKGROUND OF THE INVENTION

[0001] The invention relates to a device for measuring blood flow in the bone after a fracture, typically a femoral neck fracture.

[0002] The following description includes information that may be useful in understanding the present invention. It is not an admission that any of the information provided herein is prior art or relevant to the presently claimed invention, or that any publication specifically or implicitly referenced is prior art.

[0003] Often the circulation of the bone, mainly the femoral head is destroyed at a dislocated bone fracture, typically at a femoral neck fracture. If there is inadequate circulation, a necrosis of the femoral head will develop and prosthesis implantation is the most likely course of treatment. Inadequate blood flow in the neck of the femur may lead to inadequate healing of the femoral head after a fracture, as well as cause osteonecrosis, a disease that results from loss of blood supply to the bone where the bone tissue dies and may eventually collapse. If a bone involved in osteonecrosis is near a joint, such as in the case of the femoral head, it often leads to the collapse of the joint surface. Conversely, if there is adequate circulation of the femoral head, the femoral head remains alive and in this way the fracture is capable of healing. In this instance, the most likely surgical solution is to perform osteosynthesis. Thus, the determination of whether there is adequate circulation is an important step in the overall treatment regimen.

[0004] Presently, the two most widely used methods for evaluating circulation are angiographic and isotopic methods. However, neither method is effective as the isotope or contrast material flows out of the head of the femur and into the fracture gap. Because the material covers the site to be examined, the examination can only be performed two weeks after the neck fracture. Abnormal blood flow patterns in the bone within a few weeks of a fracture may provide early warning of delayed union or nonunion of the fracture (Ashroft, et al.; "Measurement of Blood Flow in Tibial Fracture Patients Using Positron Emission Tomography," J Bone Joint Surg [Br] 1992; 74-8:673-677).

[0005] A method for measuring blood flow in the bone before surgery will impact treatment selection, which will likely result in improvement of clinical outcome, minimization of cost and prevention of long term disability (Research Study, "Fracture healing - measuring blood in bone using MRI." Department of Orthopaedics, MEMO, Department of Clinical Radiology at Bristol Infirmary, and Department of Cardiovascular Medicine, John Radcliffe, Oxford). Furthermore, accurate measurement of blood flow is important for orthopaedic research due to close correlation of the flow with bone formation and mineral deposition. Accurate measurements may also allow secondary predictions of bone activity in other bone disoeders.

[0006] Bone imaging techniques, including scintigraphy and magnetic resonance imaging, have also been employed by some investigators to determine the blood supply available to the femoral head prior to surgery, these techniques have not been successful.

[0007] Watanabe Y, Terashima Y, Takenaka N, Kobayashi M and Matsushita T suggested to measure the intramedullary oxygen tension of the proximal femur after a femoral neck fracture and to evaluate the usefulness of that monitoring for prediction of subsequent avascular necrosis (J Orthop Trauma. 2007 Aug;21(7):456-61).

[0008] Cho MR, Lee SW, Shin DK, Kim SK, Kim SY, Ko SB, Kwun KW used 7.0 mm cannulated screws for fracture fixation to monitor bleeding (J Orthop Trauma. 2007 Mar;21(3):158-64).

[0009] A 2.0-millimeter drill was used to assess the presence and character of bleeding from the femoral head at open reduction and internal fixation of a femoral neck fracture, according to Gill TJ, Sledge JB, Ekkemkamp A, Ganz R (Orthop Trauma. 1998 Sep-Oct;12(7):474-8).

[0010] These techniques, however, often do not provide as detailed and accurate information as the intraoperative techniques, which albeit invasive have been preferred and employed recently. A major limitation of the intraoperative invasive techniques, however, is that assessment of vascularity in the femoral head is often not sufficiently quantitative for routine clinical use.

[0011] Thus, there is presently a great need for a method and instrument that can give an accurate and more immediate determination of circulation flow.

SUMMARY OF THE INVENTION

[0012] In accordance with this invention a device to measure blood flow in the bone after a femoral neck fracture is disclosed, which includes a metal sleeve to be inserted into a bore drilled in the fractured bone; the optics of an osteoscope to be inserted into said metal sleeve and connected to a visual display; a reservoir with physiological solution connected to the metal sleeve; means for controlling the pressure of the solution; a manometer for monitoring the pressure of the solution; and a manometer for measuring the blood pressure of the patient. The metal sleeve has preferably a flow in connection and a flow out connection to the reservoir with physiological solution and the device is provided with a flushing fluid pump and a flushing fluid collection container as well. Document US 6 086 542 which represents the closest prior art to the present invention discloses the preamble of claim 1.

[0013] According to a preferred embodiment, a first drill is provided with an external diameter approximately the same size as the external diameter of the sleeve and a second drill is provided with an external diameter approximately the same size as the internal diameter of the sleeve, wherein the drills are provided with end sections

having smaller diameter, than the internal diameter of the sleeve. The end section is at least 1 mm long.

[0014] The osteoscope applied in the device according to the invention is preferably an osteoscope with 0° optics and is at least 150 mm long, preferably 450 mm long and most preferably 550 mm long.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Exemplary embodiments are illustrated in referenced figures. It is intended that the embodiments and figures disclosed herein are to be considered illustrative rather than restrictive.

Figure 1 (prior art) depicts the blood supply of the femoral head. The arteries and veins are running on the surface of the femoral neck, as depicted by the arrows.

Figure 2 (prior art) depicts the femoral neck. In cases of dislocated femoral neck fracture the vessels are destroyed. The line depicts the line of a fracture.

Figure 3 (prior art) depicts the femoral neck fracture as classified by the Garden classification as used in clinical practice. In the cases of Garden I and II (as depicted by "1" and "2", respectively), there is no dislocation and the circulation is intact. In the cases of Garden III and IV (as depicted by "3" and "4", respectively), there is dislocation and the circulation may or may not be destroyed.

Figure 4 (prior art) depicts X-ray pictures of the femur head under two different treatment scenarios. As depicted in (a), if the circulation of the head is intact after the neck fracture, the surgical method used is the preservation of the head (osteosynthesis). As depicted in (b), if the circulation of the head is destroyed after the neck fracture, the surgical method used is head replacement (prosthesis implantation).

Figure 5 depicts steps of osteoscopy and the surgical intervention of the femoral neck fracture in acute cases, as outlined in figure (a) - (m), chronologically in accordance with various embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0016] As disclosed herein, the invention relates to a device for the measurement of blood flow in the bone.

[0017] Unless defined otherwise, technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs.

[0018] One skilled in the art will recognize many methods and materials similar or equivalent to those described herein, which could be used in the practice of the present invention. Indeed, the present invention is in no way limited to the methods and materials described.

[0019] As depicted in Fig. 5 (a), the first step of the method acording to the invention is to repose the fracture. In step (b), a Kirschner wire is inserted into the femoral head, and in (c) a second Kirschner wire is inserted into the femoral head. The insertion of the Kirschner wires fix the femoral head. In step (d), a hole is drilled into the femoral head. The Kirschner-wire is used as a guide for drilling. Then, a thread is cut into the hole that has been created (e), and a screw is driven into the hole for the fixation of the fracture (f). After the fracture is fixed by one screw, a second hole is drilled through the neck of the femur into the head, parallel with the neck axis, in the former place of the Kirschner wire that has been removed (g). A "thicker" drill bit B1, that is used for that, has an external diameter D1 approximately of the same size as the external diameter of the sleeve of the osteoscope, and the end of the drill is of a thinner diameter D2. The metal sleeve 2 of the osteoscope is then inserted into the hole (h). A "thinner" drill B2 is applied through the tube of the sleeve (i). The diameter D3 of the drill is aproximately the same as the internal diameter of the sleeve 2 of the osteoscope, and the end of the drill B2 is of a thinner diameter D2. This "thinner" drill B2 is 1.5 mm longer than the sleeve of the osteoscope. The use of the "thinner" drill allows the removal of the small bone fragments from the sheath. The end of the drill excavates a small cavity into the bone. The shape and measurements at the end of the drills are the same for both the thicker and thinner drills.

[0020] The optics 1 of the osteoscope is inserted into the sleeve, as depicted in Fig 5 (j and k). The small hole is in the focus of the optics. The surface of the small part of the cavity is at least 30 mm^2, preferably at least 35 mm^2, most preferably at least 40 mm^2.

[0021] The system is filled up with physiological solution and the blood is rinsed out of the visual scope. The pressure of the physiological solution is increased above the systolic blood pressure. While the small hole is being observed through the osteoscope, the pressure is being decreased continuously, and at the commencement of bleeding, the pressure in the system is measured.

[0022] If the circulation is acceptable, the difference between the systolic pressure and the pressure in the head is less than 60 Hg mm, and the surgical intervention is osteosynthesis (ie the femoral head preservation).

[0023] In this instance, the second screw is inserted to fix the fracture (l and m). The final result in this scenario is the fracture fixed with screws.

[0024] The external diameter of one drill is approximately the same size as the external diameter of the metal sleeve; the external diameter of the second drill is approximately the same size as the inner diameter of the metal sleeve. The end sections of the drills are thinner, enabling them to create a small cavity in the bone, as shown in Figs 5j and k. The length of the end sections is preferably at least 1 mm.

[0025] A commercially available endoscope with 0° optics can be used for purposes described herein. The optics of the osteoscope should be at least 400 mm long, preferably 450 mm long and most preferably 500 mm

long.

[0026] The metal sleeve has two connections and a reservoir with physiological solution. The pressure of the solution is controlled by a manometer.

[0027] Returning to Fig 5 (k), one can see, that the device includes an osteoscope, the optics 1 of which is inserted into a metal sleeve 2 well known in the art. The metal sleeve 2 has two connections: flow in connection 3 and flow out connection 4. Through these connections the device is connected to reservoir 5 with physiological solution. The device is provided with means for producing and a manometer for measuring pressure in the system. It should preferably contain a flushing fluid pump and a flushing fluid collection container as well.

[0028] The optics 1 is inserted into the sleeve 2 to be about 2 mm shorter, than the sleeve, as shown in Fig 5 (k). At the other end, the optics is connected to a display 6 showing the inside of the small cavity in the bone. The display unit also contains screen 7 for the manometer showing the pressure of the physiological solution.

[0029] The device is further provided with a cuff 8 for monitoring the blood pressure of the patient. Screen 9 in the display unit shows the value of the blood pressure. It is advantadeous if the device contains a computer unit for controlling the system and for recording the results.

[0030] Acceptable circulation is when the difference between the systolic pressure and the measured pressure is less than 60 mm Hg. If the difference in the pressure is more than 60 mm Hg, the surgical intervention may be the implantation of a prosthesis. If this is not the case, the surgical intervention may be femoral head preservation.

[0031] It will be readily apparent to those of skilled in the art that the inventive devices and methods can be used to measure blood pressure in any number of bones. The invention is by no means limited to the measurement of blood flow in the femur.

[0032] One skilled in the art will recognize many and materials similar or equivalent to those described herein, which could be used in the practice of the present invention. Indeed, the present invention is in no way limited to the methods and materials described. For purposes of the present invention, the following terms are defined below.

EXAMPLES

[0033] The following examples are provided to better illustrate the claimed invention and are not to be interpreted as limiting the scope of the invention. To the extent that specific materials are mentioned, it is merely for purposes of illustration and is not intended to limit the invention. One skilled in the art may develop equivalent means or reactants without the exercise of inventive capacity and without departing from the scope of the invention.

Example 1

Steps of Osteoscopy

[0034]

(1) Repose the fracture. (2) Insert a Kirschner wire into the femoral head. (3) Insert a second Kirschner wire into the femoral head. The insertion of the Kirschner wires fix the femoral head. (4) Drill a hole into the femoral head. The Kirschner-wire is used as a guide for the drilling. (5) Cut a thread into the hole that has been created. (6) Drive a screw into the hole for the fixation of the fracture. (7) After the fracture is fixed by one screw, drill a second hole through the neck of the femur into the head, parallel with the neck axis, in the former place of the Kirschner wire that has been removed. Here a "thicker" drill is used, where the external diameter of the drill bit is of the same size as the external diameter of the sleeve of the osteoscope, and the end of the drill is a thinner diameter. (8) Insert a metal sleeve of a osteoscope into the hole. The "thinner" drill is applied through the tube of the sleeve so that in this way, bone fragments are removed. Here a "thinner" drill is used, which is 1.5 mm longer than the sleeve. The end of the drill excavates a small cavity into the bone. (9) Insert the optics of anosteoscope into the sleeve, so that the small cavity previously created is in the focus of the osteoscope. (10) Fill up the system with physiological solution and rinse blood out of the visual scope. (11) Increase the pressure of the physiological solution so that it is above the systolic blood pressure. While the small hole is being observed through the osteoscope, the pressure is being decreased continuously, and at the commencement of bleeding, the pressure in the system is measured.

Example 2

Determining Circulation Conditions from Differences in Pressure

[0035] The inventors determine excellent circulation of a femoral head if the difference between systolic pressure and the pressure in the head is lower than 30 hg mm. Average circulation of a femoral head is determined if the difference between the systolic pressure and the pressure in the head is lower than 60 hg mm but 30 hg mm or higher. Minimal circulation of a femoral head is determined if the difference between systolic pressure and the pressure in the head is 60 hg mm or higher.

Example 3

Surgical Intervention of a Femoral Neck Fracture

[0036] If the circulation is acceptable, the surgical in-

tervention is osteosynthesis (ie the femoral head preservation). In this instance, a second screw is inserted to fix the fracture. If there is no circulation or the circulation is minimal, the screw and the femoral head are removed and prosthesis is implanted.

[0037] While the description above refers to particular embodiments of the present invention, it should be readily apparent to people of ordinary skill in the art that a number of modifications may be made without departing from the scope claimed. Preferably, the device is provided with means (e.g. computer unit) for controlling and monitoring the method, as well as for storing and processing the data obtained during the use of the device. The presently disclosed embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

Claims

1. A device to measure blood flow in the bone after a fracture, preferably femoral neck fracture, comprising

   • a metal sleeve (2) of an osteoscope to be inserted into a bore drilled in the fractured bone;
   • an optics (1) of an osteoscope to be inserted into said metal sleeve (2) and connected to a visual display (6) of the osteoscope;
   • a reservoir (5) with physiological solution connected to the metal sleeve (2);
   • means for controlling the pressure of the solution;
   • a manometer for monitoring the pressure of the solution; **characterised in that** it further comprises a manometer for measuring the blood pressure of the patient.

2. The device as claimed in claim 1, **characterized in that** the metal sleeve (2) has a flow in connection (3) and a flow out connection (4) to the reservoir (5) with physiological solution.

3. The device as claimed in claim 1 or 2, **characterized in that** a drill (B1) is provided with an external diameter (D1) approximately the same size as the external diameter of the sleeve (2).

4. The device as claimed in any of claims 1 to 3, **characterized in that** a drill (B2) is provided with an external diameter (D3) approximately the same size as the internal diameter of the sleeve (2).

5. The device as claimed in claim 2 and 3, **characterized in that** the drills (B1, B2) are provided with an end section having smaller diameter (D2), than the internal diameter (D3) of the sleeve (2).

6. The device as claimed in claim 4, **characterized in that** the end section is at least 1 mm long.

7. The device as claimed in any of claims 1 to 5, **characterized in that** the osteoscope is an osteoscope with 0° optics (1).

8. The device as claimed in any of claims 1 to 6, **characterized in that** the optics (1) is at least 150 mm long, preferably 450 mm long and most preferably 550 mm long.

9. The device as claimed in any of claims 1 to 8, **characterized in that** it contains a flushing fluid pump and a flushing fluid collection container.

Patentansprüche

1. Vorrichtung zur Messung des Blutflusses im Knochen nach einem Knochenbruch, insbesondere nach einem Schenkelhalsbruch, umfassend

   - eine Metallhülse (2) eines Osteoskops, die in eine in den gebrochenen Knochen hineingebohrte Bohrung einzusetzen ist;
   - eine Optik (1) eines Osteoskops, die in die Metallhülse (2) einzusetzen ist und mit einer optischen Anzeige (6) des Osteoskops verbunden ist;
   - ein Behälter (5) mit einer physiologischen Lösung, das mit der Metallhülse (2) verbunden ist;
   - Mittel zur Steuerung des Druckes der Lösung;
   - ein Manometer für die Überwachung des Druckes der Lösung,

   dadurch gekennzeichnet, dass die Vorrichtung auch ein Manometer zur Messung des Blutdruckes des Patienten umfasst.

2. Vorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Metallhülse (2) einen Einströmanschluß (3) und einen Ausströmanschluß (4) zum Behälter (5) mit der physiologischen Lösung aufweist.

3. Vorrichtung nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** ein Bohrer (B1) vorgesehen ist, dessen Außendurchmesser (D1) annähernd die gleiche Größe wie der Außendurchmesser der Metallhülse (2) hat.

4. Vorrichtung nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** ein Bohrer (B2) vorgesehen ist, dessen Außendurchmesser (D3) annähernd die gleiche Größe wie der Innendurchmesser der Metallhülse (2) hat.

5. Vorrichtung nach Anspruch 2 und 3, **dadurch gekennzeichnet, dass** die Bohrer (B1, B2) mit einem Endabschnitt versehen sind, dessen Durchmesser (2) kleiner ist, als der Innendurchmesser (D3) der Metallhülse (2).

6. Vorrichtung nach Anspruch 4, **dadurch gekennzeichnet, dass** der Endabschnitt mindestens 1 mm lang ist.

7. Vorrichtung nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** der Osteoskop ein Osteoskop mit einer Optik (1) von 0 ist.

8. Vorrichtung nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die Optik (1) mindestens 150 mm lang, vorteilhafter 450 mm und noch vorteilhafter 550 mm ist.

9. Vorrichtung nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** sie eine Spülflüssigkeitspumpe und einen Spülflüssigkeit-Sammelbehälter enthält.

Revendications

1. Dispositif pour mesurer l'écoulement sanguin dans l'os après une fracture, notamment après une fracture du col du fémur, comprenant

   - une douille métallique (2) d'un ostéoscope à insérer dans un alésage foré dans l'os fracturé;
   - une optique (1) d'un ostéoscope à insérer dans la douille métallique (2), cette optique étant raccordée à un affichage visuel (6) de l'ostéoscope;
   - un réservoir (5) avec de la solution physiologique, le réservoir étant raccordé à la douille métallique (2);
   - moyens à régler la pression de la solution;
   - un manomètre pour surveiller la pression de la solution,

   caractérisé en ce qu'il comprend aussi un manomètre pour mesurer la pression artérielle du patient.

2. Dispositif selon la revendication 1, **caractérisé en ce que** la douille métallique (2) a un raccord d'entrée (3) et un raccord de sortie (4) au réservoir (5) avec de la solution physiologique.

3. Dispositif selon la revendication 1 ou 2, **caractérisé en ce qu**'un foret (B1) est prévu avec un diamètre extérieur (D1) approximativement de même grandeur que le diamètre intérieur de la douille (2).

4. Dispositif selon l'une quelconque des revendications 1 à 3, **caractérisé en ce qu**'un foret (B2) est prévu avec un diamètre extérieur (D3) approximativement de même grandeur que le diamètre intérieur de la douille (2).

5. Dispositif selon les revendications 2 et 3, **caractérisé en ce que** les forets (B1, B2) sont ménagés avec une section d'extrémité dont le diameter (D2) est plus petit que le diamètre (D3) intérieur de la douille (2).

6. Dispositif selon la revendication 4, **caractérisé en ce que** la section d'extrémité a une longueur d'un millimètre.

7. Dispositif selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** l'ostéoscope est un ostéoscope avec une optique (1) à 0°.

8. Dispositif selon l'une quelconque des revendications 1 à 6, **caractérisé en ce que** l'optique (1) a une longueur de 150 mm, avantageusement une longueur de 450 mm et la plus avantageusement une longueur de 550 mm.

9. Dispositif selon l'une quelconque des revendications 1 à 8, **caractérisé en ce qu'**il contient une pompe à fluide de rinçage et un recipient-collecteur pour le fluide de rinçage.

Figure 1.

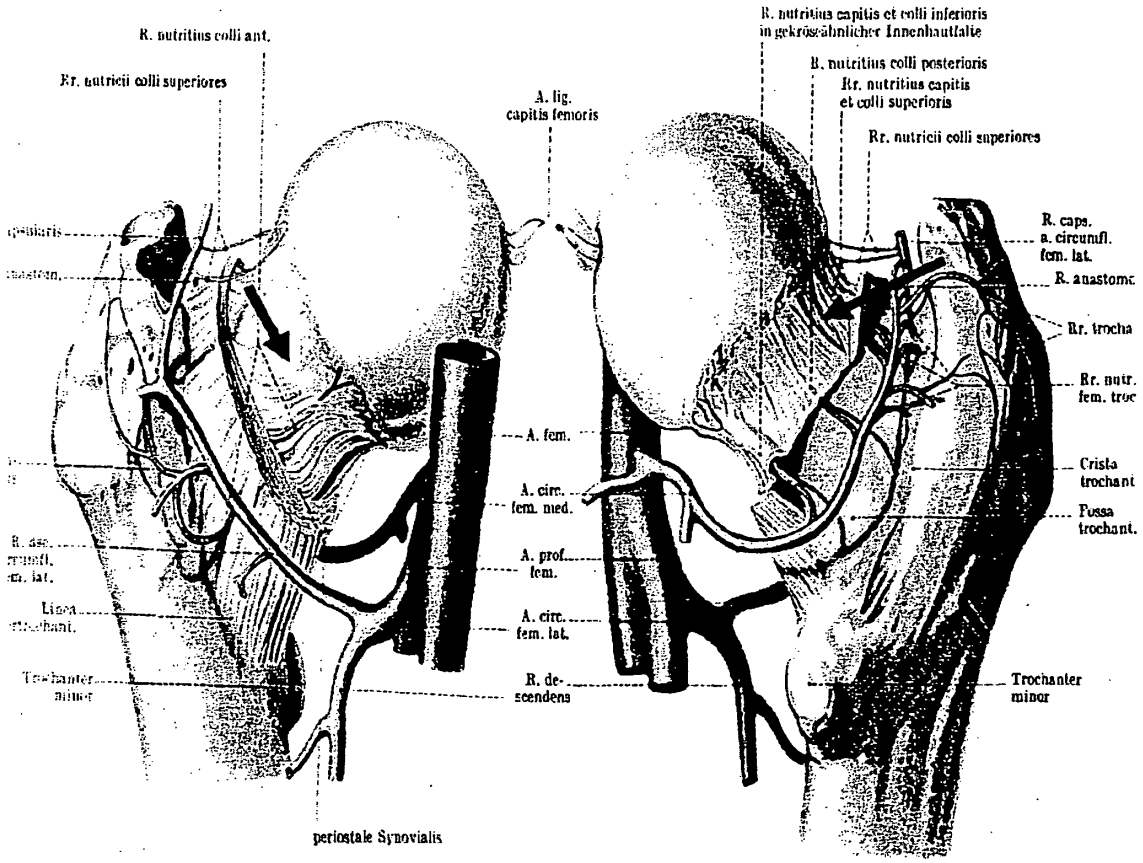

R. nutritius colli ant.
Rr. nutricii colli superiores
A. lig.
capitis femoris
R. nutritius capitis et colli inferioris
in gekröseähnlicher Innenhautfalte
R. nutritius colli posterioris
Rr. nutritius capitis
et colli superioris
Rr. nutricii colli superiores
R. caps.
a. circumfl.
fem. lat.
R. anastomc
Rr. trocha
Rr. nutr.
fem. troc
Crista
trochant
Fossa
trochant.
A. fem.
A. circ.
fem. med.
A. prof.
fem.
A. circ.
fem. lat.
R. de-
scendens
Trochanter
minor
periostale Synovialis
a) von ventral
b) von dorsal

Figure 2.

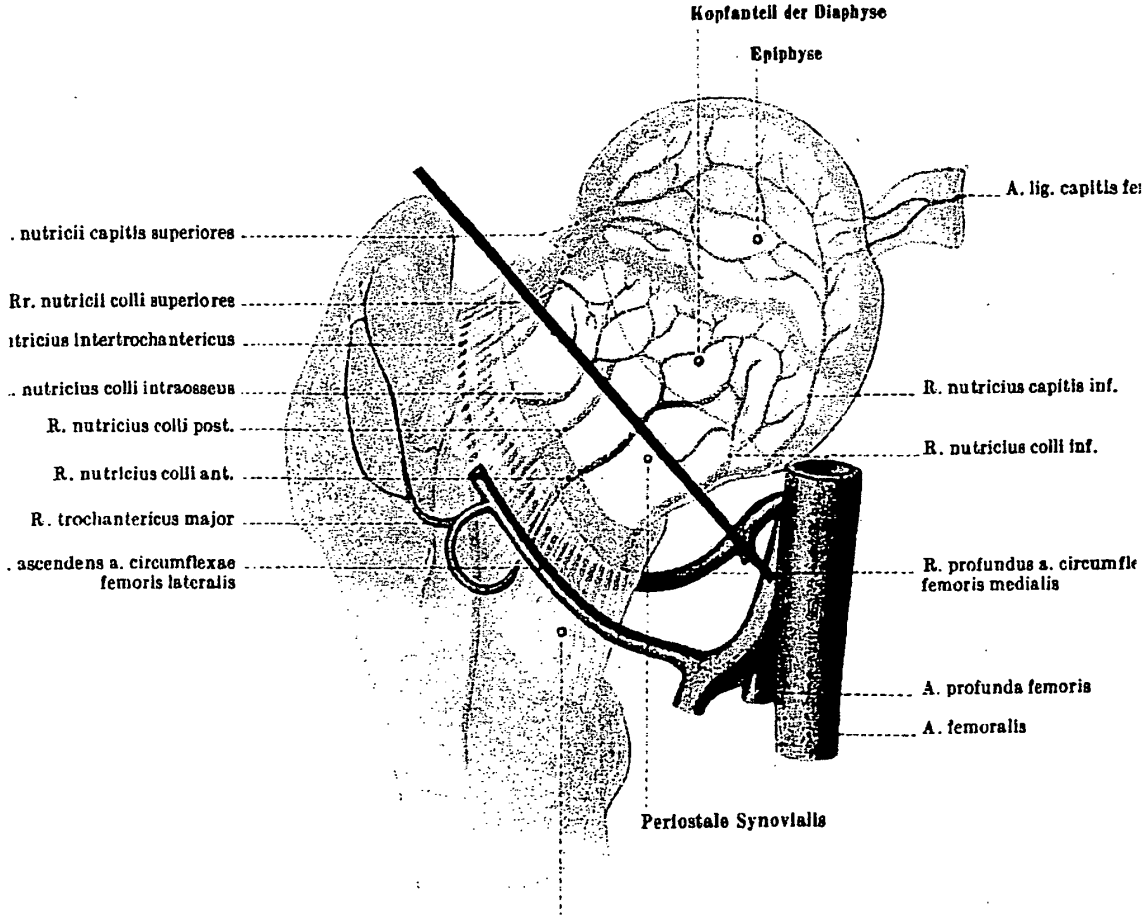

Kopfanteil der Diaphyse
Epiphyse
A. lig. capitis fe
. nutricii capitis superiores
Rr. nutricii colli superiores
ıtricius intertrochantericus
.. nutricius colli intraosseus
R. nutricius colli post.
R. nutricius colli ant.
R. trochantericus major
. ascendens a. circumflexae femoris lateralis
R. nutricius capitis inf.
R. nutricius colli inf.
R. profundus a. circumfle femoris medialis
A. profunda femoris
A. femoralis
Periostale Synovialis

Figure 3.

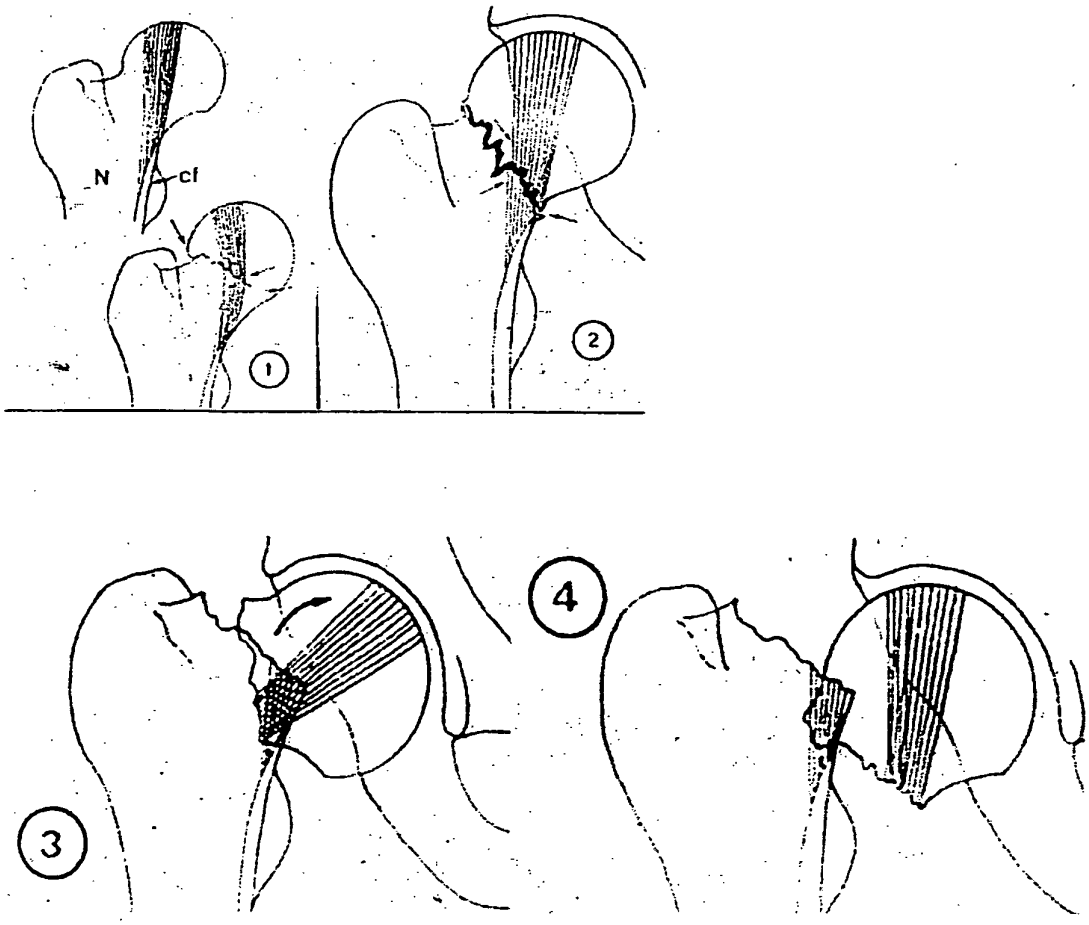
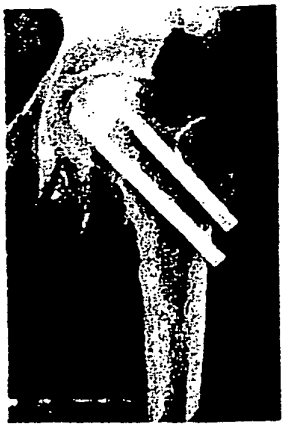


Figure 4 (a) – (b)

(a)

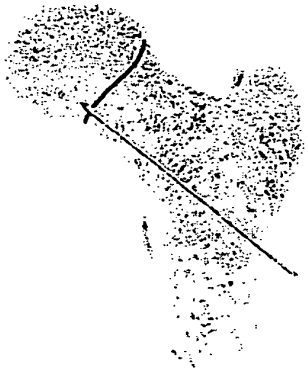


(b)

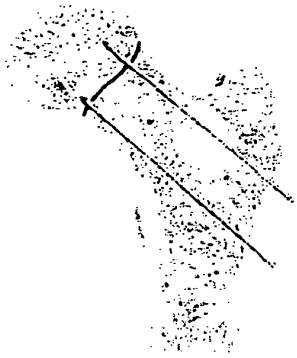
Figure 5 (a) – (m).

(a)

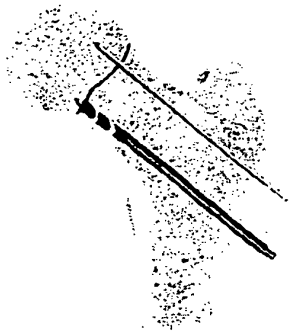
(b)



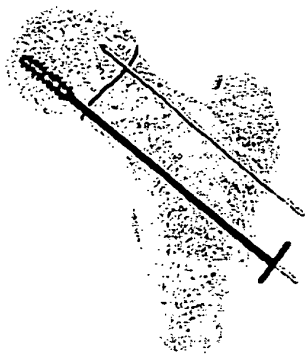
(c)



(d)

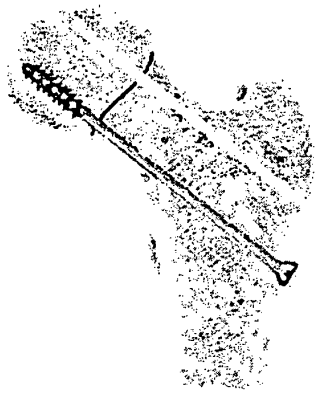


(e)

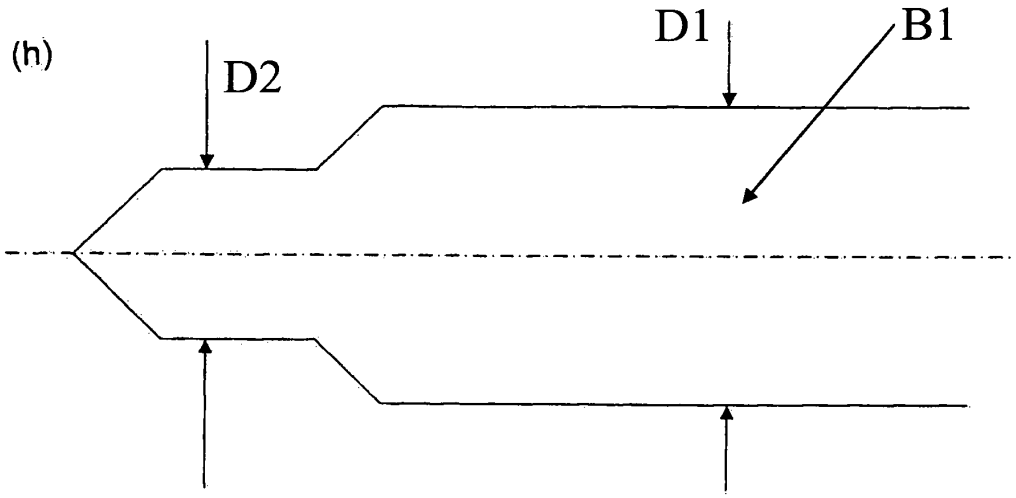


(f)

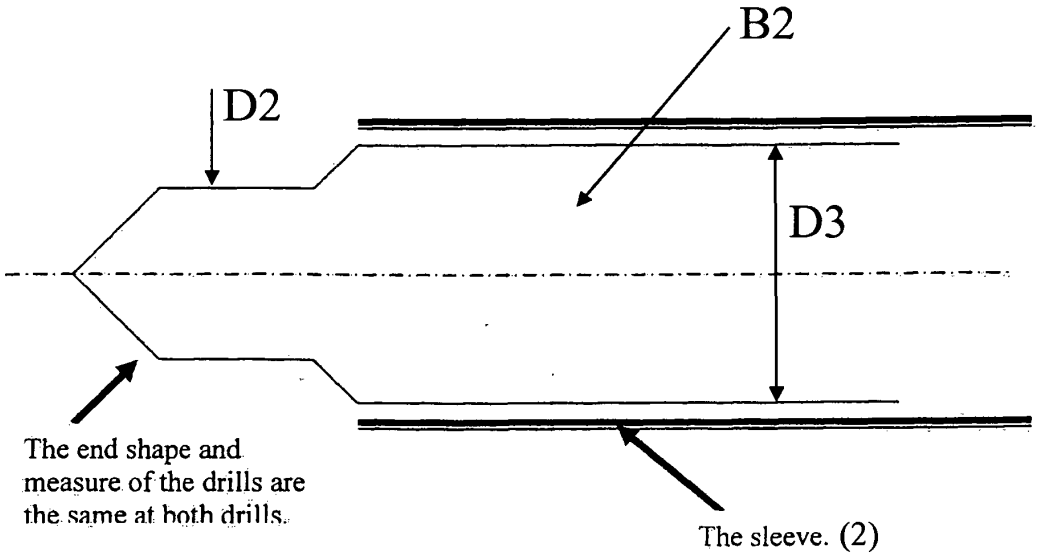
(g)



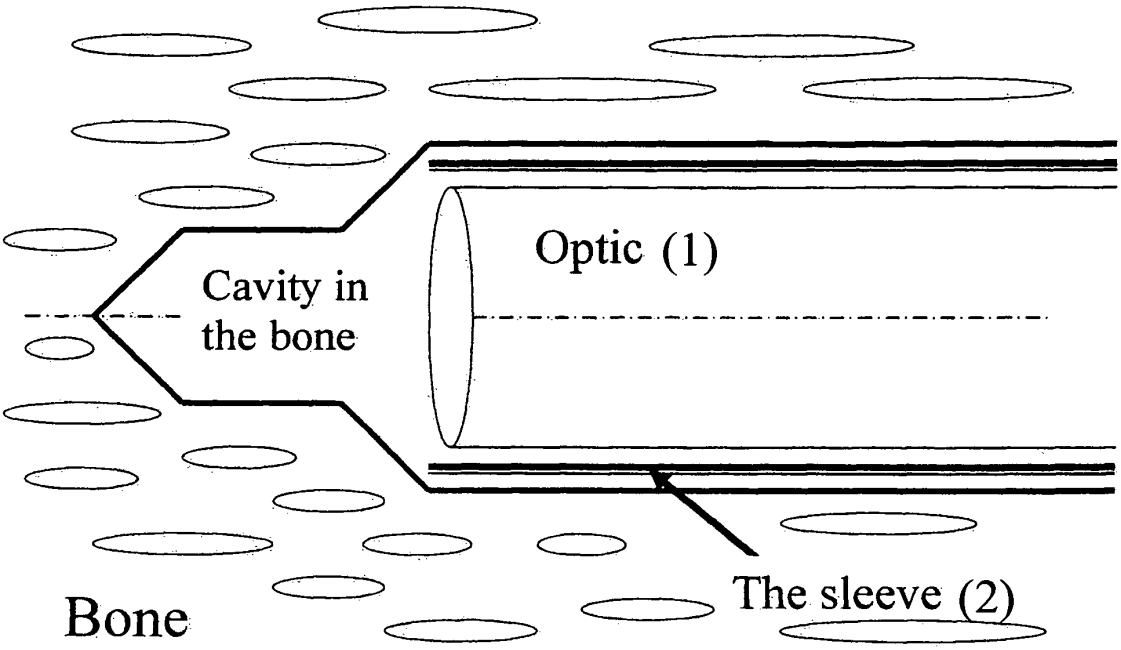
(h)


D1
B1
D2

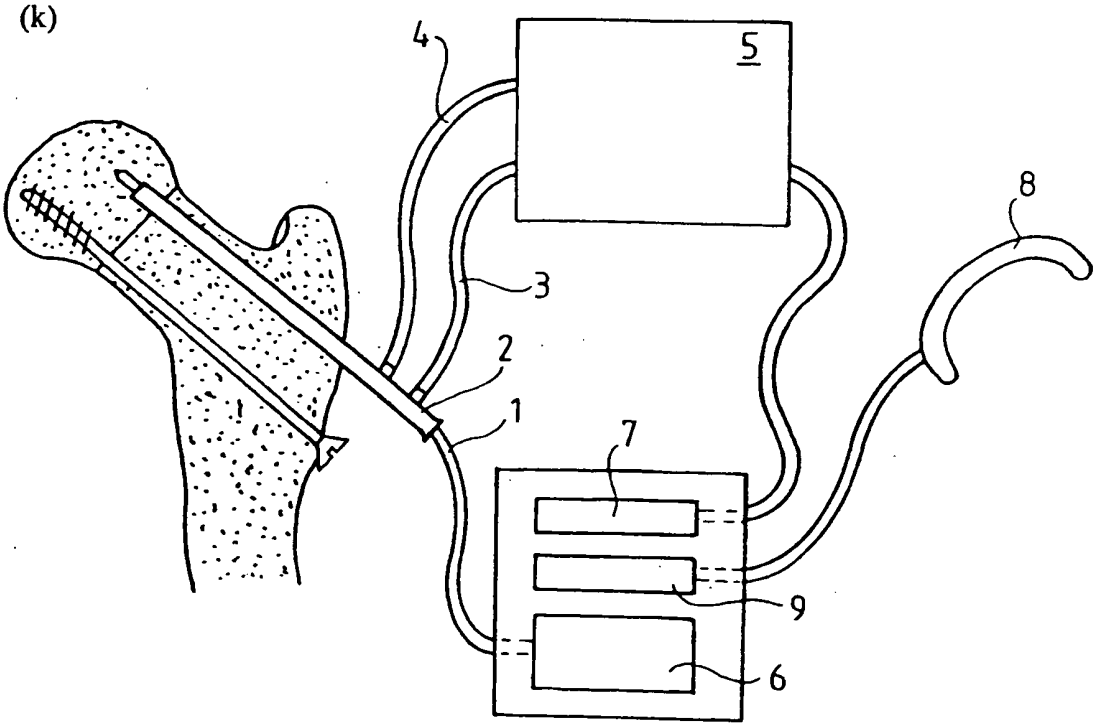
(i)


B2
D2
D3
The end shape and measure of the drills are the same at both drills.
The sleeve. (2)

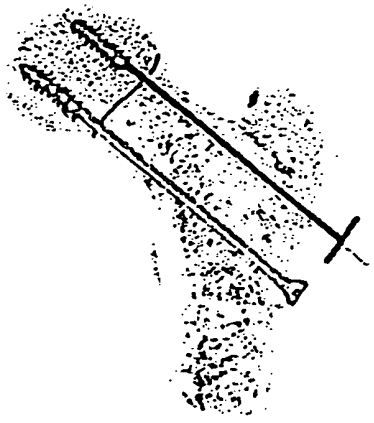
(j)



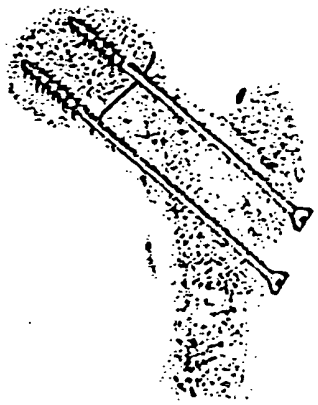
(k)



(l)



(m)



REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	用于测量骨折后骨中血流量的装置		
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申请(专利权)人(译)	Mediolan LTD.		
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优先权	60/915885 2007-05-03 US		
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外部链接	Espacenet		

摘要(译)

本发明涉及一种用于测量骨折（主要是股骨颈骨折）后骨中血流的方法和装置，其中在骨中钻一个孔，优选通过股骨颈进入股骨头。该方法包括将骨镜的金属套管插入孔中的步骤;插入一个整形器的光学器件插入金属套管中并聚焦在由钻头产生的空腔上;用生理溶液填充装置和腔体，使溶液的压力高于收缩压;在通过骨镜观察腔体的同时降低溶液的压力，并在出血开始时记录系统中的压力。该装置包括一个骨科镜的金属套管（2），该金属套管插入骨折骨中钻出的孔中。一个骨科镜的光学系统（1），插入所述金属套管（2）并连接到骨镜的视觉显示器（6）;储存器（5），其生理溶液连接到金属套管（2）;用于控制溶液压力的装置;用于监测溶液压力的压力计;和用于测量患者血压的压力计。