

Master track Medical Imaging and Intervention

Treat necrotic bone and cartilage in a joint: A solution using putty bone void filler and a hydrogel scaffold containing mesenchymal stem cell

Groep casus Saris 1; Frank Baan, Bsc; Paula Bos, Bsc; Bram Bakhuizen, Bsc

Abstract:

Keywords: non-Hodgkin lymphoma, bone necrosis, tissue engineering, biomaterials, bone regeneration, bone substitute, cartilage regeneration, cartilage scaffold, hydrogel, mesenchymal stem cells. In this paper is a case described of a young women, who suffered from non-Hodgkin lymphoma. After she was cured, severe bone necrosis developed in her knee. The necrosis is very likely caused by the treatment of non-Hodgkin lymphoma; prednisone, chemotherapy and radiation. The necrotic bone was treated in first instance, but this failed. Important in the treatment of necrosis is a correct combination of bone and cartilage repair mechanisms. Several methods for bone generation are discussed: bone grafts, prostheses, biomaterials, tissue engineering and combinations of these methods. Because this paper describes a case with the knee joint, regeneration of cartilage is also of high importance. Scaffolds can be used in the regeneration, solid and hydrogel scaffolds are discussed. The most promising method for the case seems to be the combination of a putty bone substitute material or bone void filler combined with a hydrogel scaffold containing cells of the patient

A novel design for an unicondylar hemiarthroplasty implant with a plug and play solution

Groep casus Saris 2; Thijs van den Broek, Bruce Boti, Sander Brinkhof

Abstract:

Introduction: A 23 year old patient suffered from several symptoms in her knee leading to functional disability. She was diagnosed with post-chemo osteonecrosis which leads to bone and cartilage degeneration. The challenge is to come up with a design for a suitable implant.

Materials: Several materials are being used in medical orthopedic implants and they need to possess certain mechanical and biomaterial properties. This study focusses on polymers (PEEK) and ceramics (Zc-YTP). **Design:** Multiple types of implants were researched as well as different polymers and ceramics. Based on this research an implant was designed and the fixation in the bone was studied.

Conclusion: A novel design was made for an unicondylar hemiarthroplasty implant that uses polymers and ceramics in a plug and play solution. This allows easy access and replacement of the important parts of the implant.

Autologous reconstruction of a knee in deteriorated condition with a combination of sca olds, hydrogel and mesenchymal stem cells

Groep casus Saris 3: Suzan Brouwer de Koning, Robin Bruggink, Rob van Doremalen

Abstract:

Background case: A 23 year old patient suffered in former times from Non Hodgkin Lymphoma (NHL). Due to the prednisone medication, chemo- and radiation therapy she fully recovered from the NHL. However, the treatment for NHL caused a deteriorated condition of the bone and cartilage tissue, resulting in osteochondral defects in her right knee. Because of the bad quality of her bone, pieces of bone are released and defects of cartilage occur.

Method: To find a proper treatment for the osteochondral defects a literature study is done. Multiple methods for cartilage and bone reconstruction are evaluated.

Results: By combining plural methods a composed treatment is developed as solution for this case. A combination of the imaging techniques QCT and dGEMRIC results in an exact determination of the defect. With this information the dimensions of an implantable scaffold can be determined. This scaffold consists of three layers: an underlying subchondral bone, a compact layer and a cartilage layer. The three layers will be implanted separately. MSCs containing hydrogel will be administered in both the subchondral scaffold and the cartilage scaffold, in which they will differentiate in respectively the desired osteoblasts and chondrocytes.

Conclusion: A treatment is found that combines the characteristics of multiple methods to meet certain requirements.

Keywords: Non Hodgkin Lymphoma, QCT, dGEMRIC, Osteochondral defect, Osteoporosis, Bone reconstruction, Cartilage Reconstruction

Multilayer scaffolds in combination with mesenchymal stem cells for regeneration of articular cartilage and subchondral bone in bone defects

Groep casus Saris 4; Onno Mennes, Seline Goudeketting, Roy van den Ende

Abstracts

Introduction: In this report the outcome of a case study will be described. The case of a 23 year old woman with a complex knee injury is examined. She has suffered from Non-Hodgkin lymphoma and was treated for this. The treatment consisted of chemotherapy, corticosteroids and radiation therapy. She was fully cured, however, she developed symptoms in her knee for which her knee was examined. Hydrops was found in the knee without infection or traumatic characteristics. Provocation of the lateral compartment is sensitive, movement is normal, but with extreme flexion the knee is very sensitive. An X-ray showed spots on the right condyle accompanied with some round calcifications intercondylair and posterolateral of the condyle. She received an autologous bone graft but it was rejected due to compromised bone health. The purpose of this study is to find a solution for this patient.

Methods: After the probability diagnosis for the cause of this complex bone defect was determined, a literature case study has been done to look for solutions. Possible solutions were sought in the direction of regenerative medicine. Since bone growth is induced by proteins in the transforming growth factor- β -superfamily, this was the subject of choice.

Results: Bone morphogenetic protein-2 and transforming growth factor- β 1 were the best choice for inducing the regeneration of subchondral bone and articular cartilage, respectively. The delivery of these growth factors was done by using a multilayer scaffold which was seeded with mesenchymal stem cells. Each growth factor was placed in their respective layers, inducing osteoblast differentiation of the mesenchymal stem cells in the bone morphogenetic protein layer and chondrocyte differentiation of the mesenchymal stem cells in the transforming growth factor- β 1 layer.

Conclusion: The multilayer scaffold is a promising strategy for simultaneous regeneration of multiple tissue types, by combining a biomimetic and multi-phasic scaffold design, a spatially controlled and localized gene delivery system and mesenchymal stem cells which differentiate into osteoblasts and chondrocytes.

An image guided surgery system during TEVAR

Groep casus Geelkerken 1; Jan Heidkamp, Kay van der Hoogt, Daphne Huizing

Patients with a thoracic aneurysm can be treated with thoracic endovascular aortic repair (TEVAR). This is an endoprosthesis placed in the thoracic part of aorta. During the procedure the surgeon has to control and visualise the position of the endoprosthesis using fluoroscopy, especially with regard to the fixation and landing zone. The fluoroscopy time during the procedure can be several minutes and radiation could cause tissue damage, thus fluoroscopy time should be minimized. This could be achieved using a C-arm in combination with an additional tool that gives the surgeon real time information about the orientation and position of the instruments and prosthesis. In this review article electromagnetic (EM)-tracking in combination with 4D CT-model, which is based on pre-operative CT-imaging, is analysed as an Image Guided Surgery (IGS)-system. Because of the dynamic behaviour of the aorta a 4D CT-model containing temporal information is coupled to the patient's ECG-signal and is implemented into this IGS-system. This will result in a more accurate placement of the endoprosthesis as well as reduction of the radiation time.

Fluid dynamics: A novel solution for aortic zone 0 endovascular stent graft fixation?

Groep casus Geelkerken 2; Guido de Jong, Leon de Jong, Lisanne Karbaat

Abstract

Introduction: The placement of a thoracic endovascular stent graft in the treatment of aortic aneurysms can be very hard. Problems in the placement arise due to the lack of space, anatomical variations, crucial side branches, irregular shapes and difficulty in intraoperative imaging. The most frequent complication during and after surgery are endoleaks.

Problem: Current endovascular stent grafts require a fixation site of at least 2 cm and improper placement of the stent can lead to endoleaks. Current techniques often fail in zone 0 aortic endovascular stent graft placement. Our goal is to develop a novel endovascular stent graft with shorter fixation sites and less frequent occurring endoleaks aimed at zone 0 in the aorta.

Methods: Using the Venturi effect and pressure conducting canals along with the aortic elastic recoil properties, an additional fixation method, and a possible endoleak resolving endovascular stent graft is designed. The Venturi effect in this prosthesis should result in a blood velocity mediated self-sealing effect due to a local pressure drop and the aortic elastic properties. The prosthesis variables that are used for this Venturi effect are determined by parameters found in literature studies and calculations. These parameters are the aortic diameter at zone 0, the average peak velocity of the blood at zone 0, the stenosis of the prosthesis and the pressure-diameter relation of the aorta. Based on these parameters a model will be made to determine the variables of a theoretical prosthesis that could be used in patients.

Results: Based on a healthy piece of aorta as a landing site for the prosthesis, a pressure-diameter relation of 20 mmHg=mm is found with an average diameter of 2.26 cm. During systole a peak velocity ranging from 0.75 m/s to about 1.00 m/s are normal in rest while mild activity could already create a blood velocity elevation to 1.50 m/s. The elastic recoil of the aorta due to the pressure drop have been determined for a broad range of natural occurring parameters as well as prosthesis diameters. Using a peak velocity of 1.00 m/s along with the found pressure-diameter relation and the average aortic diameter along with a venturi of 1.13 cm in diameter, a pressure drop of 59.63 mmHg can be found. This would result in an elastic recoil of 3 mm in diameter. However this would give a surface area of 1cm² and is considered a severe to moderate stenosis. When using a stenosis of 1.5 cm² maximum, a pressure drop of 24.62 mmHg can be found which results in an elastic recoil of 1.23 mm in diameter.

Conclusion: In theory this is a solution that looks promising for a range of patients. Before this stent graft can be placed, the relevant parameters of each individual patient have to be evaluated with the model to determine the variables and the possibilities of the prosthesis. Expected is that a fixation site shorter than 2cm is not possible with this solution. The practical prevention of endoleaks as well as the in situ behaviour of the prosthesis is yet to be determined.

The Click 'n Go - A BRANCHED STENT-GRAFT DESIGN FOR THORACIC ANEURYSM REPAIR

Groep casus Geelkerken 3; Timen ten Harkel, Eva Leemans, Daphne Lobeek

Abstract

Thoracic Aortic Aneurysms (TAAs) have an estimated worldwide incidence of 10.4 cases per 100.000 person-years. Patients with an aortic diameter above 5.5 cm or high expansion rates have an increased risk of rupture and need surgical intervention. Today, the preferred treatment option is endovascular repair. However, only a few stent-grafts are available for TAAs, and the survival of these treatments is low. Five challenges stand out when developing stent-grafts for TAAs: a short procedure time is required, it should handle bifurcations, it should be patient-specific, prevent endoleaks and have a good fixation. In this report, the anatomical variances are taken into account to create a patient-specific stent-graft device. A function and requirement analysis is performed and three concept designs are made: the straw method, the chimney method and the connector method. The connector method met the three requirements (a fast, adequate and efficient/functional procedure) the best. This concept is elaborated in detail and recommendations are given. However, more research is needed to determine the exact dimensions and materials of the stent-graft and connector. Thereafter a concept design should be produced and tested on a phantom for weaknesses to improve the current design.

Sac-anchoring Endoprosthesis for Treatment of Thoracic Aortic Aneurysm

Groep casus Geelkerken 4; Daan van den Oever, Robert Poel, Thijs ter Mors

Abstract

Aortic aneurysm is a commonly seen pathology. The possible effects of an aneurysm can be very drastic and often deathly. When an aneurysm is diagnosed, an intervention has to take place to prevent rupture of the weakened arterial wall. A stent graft is placed to bypass the aneurysm internally. This procedure can take place with open surgery however lately endovascular procedures show satisfactory results in abdominal aortic aneurysm repairs. This endovascular approach is also gaining popularity in thoracic aortic aneurysm repair. However, the large amount of important branches and the diversity in anatomy make this a very difficult procedure. Nellix endosac prosthesis are a recent development in the endovascular approach with promising results in the abdominal aortic aneurysm repair. This technique possesses some specific advantages that lead to a more rigid placement and less endoleaks leading to a more reliable intervention. The object of this study is to investigate if the principles of the Nellix technique could be used in a novel design for thoracic aortic aneurysm repair in order to make the procedure more applicable and successful. First a thorough analysis of the thoracic aortic aneurysms, the problems arising during interventions and the current limitations of repair are made. Based on this information a conceptual endoprosthesis design consisting the Nellix principles is conceived. This design, however, is not usable in practice because it leaves a lot of unresolved questions. It is not sure whether the design can actually be manufactured or if the technical possibilities are advanced enough to perform the required procedure. Additionally a lot of complications could arise in practice. In conclusion, we can say that our design is, for now, too sophisticated to be executed. This is more due to the complicated anatomy of the anatomic arch than to the implementation of the Nellix principle, which is worth further investigation.

Keywords: Aortic Aneurysm, Aortic Arch, EVAR, Endoprosthesis, Nellix, Design, Sac-anchoring, Hydrogel.

FEES '13: A new designed endo-echo workstation

Groep casus Broeders 1; Trudy van Ruiten, Wendelien Sanderink, Inge Slouwerhof

Abstract

Flexible endoscopy has undergone a change from a pure diagnostic medium to a combined diagnostic and therapeutic environment where more and more complex interventions take place. This supports the need of a new workstation in medical practice. The goals for designing a new endo-echo workstation are that the new workstation has to improve the efficiency, precision and safety of the procedure while maintaining the degrees of freedom of the current endoscopic procedure. Thereby, the system should be flexible and compact, while easy transition from diagnostics to interventions can be realized. At last, it is preferable to improve the ergonomics of the endoscopist as much as possible. The new designed Flexible Endo Echo Workstation (FEES'13) meets these requirements. Regarding this new design, improvement of the endo-echo procedure could be achieved.

Endoscopic Room and Information management

Groep casus Broeders 2; Arico Verhulst, Luuk Voskuilen, Bas de Vries

Abstract

A commonly used method for looking inside the body for medical reasons is endoscopy. Unlike other diagnostic applications endoscopy has the advantage of the possibility of direct intervention when a lesion is detected. Thus endoscopy can be used for investigation of symptoms, confirming a diagnosis, and it can also be used for treatment.

Flexible interventional endoscopic procedures can spare patients from having to undergo major surgeries and the complications that accompany them. But to perform interventional endoscopy the endoscopist must handle the endoscope and also the instruments. It is impossible in the current clinical practice to control all these variables, thus the endoscopist needs a telemanipulator and workstation that can lock the endoscope into position, so the endoscopist is able to navigate the instruments while still being able to slightly adjust the position.

The creation of this workstation is in progress and the proof of concept has been delivered. To use the new workstation and work efficiently, there also need to be a good room arrangement of the endoscopic chamber for colonoscopic and gastroscopic interventions. There are a lot of important parameters that have to be taken into account for example safety of both patient and medical staff and the involvement of other imaging modalities like endoscopic ultrasound.

Ultimately, a low-end and a high-end design of the endoscopic chamber have been created in which the robotic endoscopy system is incorporated into the clinic.

Development and design of an Ergonomic Endoscopic Workstation

Groep casus Broeders 3; Ali Zada, Bryan Wermelink

Abstract

Introduction:	Endoscopy in medicine is both for diagnostic and therapeutic uses indispensable. As the value of scar-less surgery increases, the demand for endoscopic surgery procedures also increases. Novel techniques are developed and improved but they all have the same bottleneck. This bottleneck is the conventional use of the endoscope. This article discusses a workstation where novel techniques are implemented that improves endoscopic procedures.
The workstation:	The workstation will consist of three major parts. The three major parts are the stabilizing platform, a joystick operated endoscope and a workstation in which all is combined. Furthermore the best position of the workstation in the endoscopic room is researched and the walking routes related to the place of the workstation are compared.
Ergonomics:	In the design of the workstation also the ergonomics is fully researched. This ensures the best posture during procedures performed on the workstation and opposed to the current execution of endoscopic procedures. Parts of the workstation that are being evaluated are the monitor, the chair, the armrests, the feet rest and the placement of the working channel.
The design:	This article is not only the description of such an endoscopy workstation but also the first prototype is visualized.
Conclusion:	The combination of all the information collected from the literature lead to an ergonomic well designed workstation with all the functions required for a good implementation in endoscopic procedures.