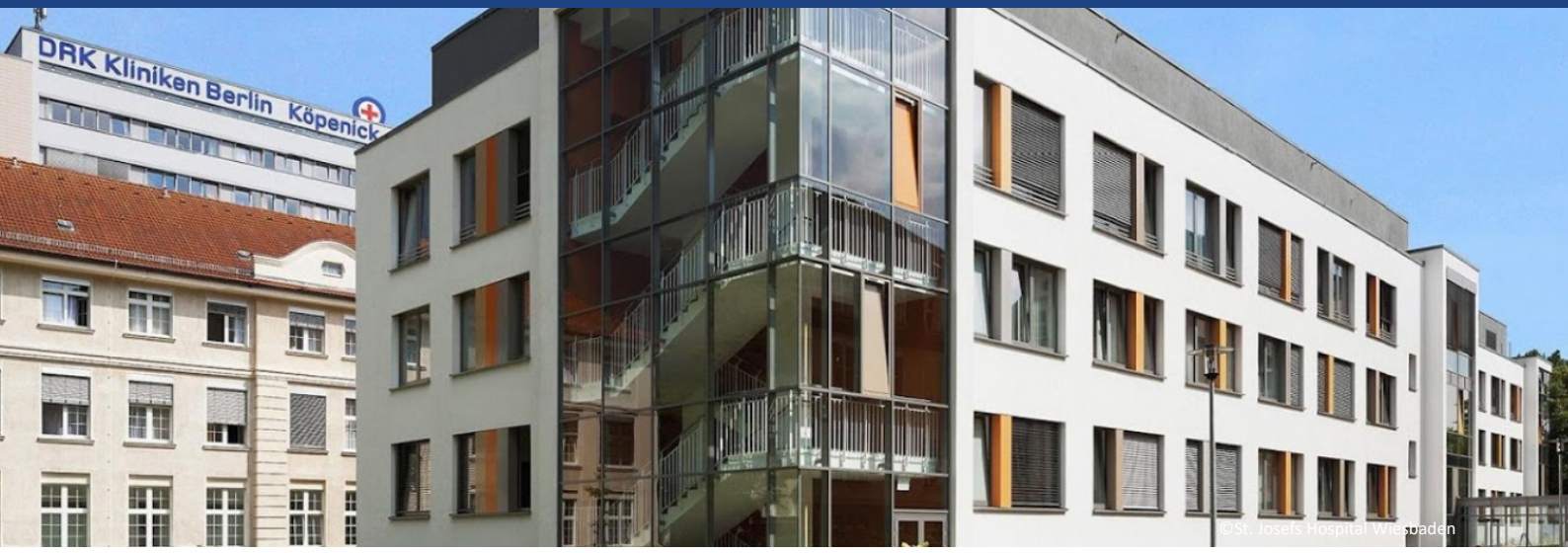
3D Planning in Shoulder Endoprosthetics

An upgrade in preoperative planning



DRK clinics Berlin Köpenick

mediCAD®

The Orthopedic Solution

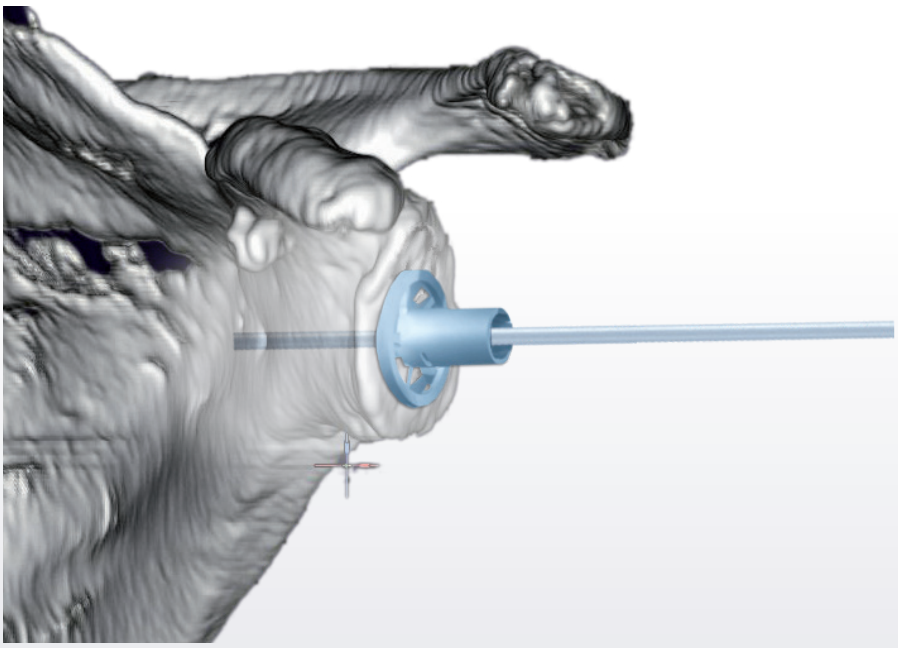
Software Bundesverband IT-Mittelstand Made in Germany

100% Service Quality Future

3D planning as road to success in shoulder endoprosthetics

The 3D planning is taking the preparation and implementation of shoulder prosthetics up to the next level. Even though a preoperative CT-Scan is demanded and used routinely by surgeons, these rely on their own experience level with regards to the viewing of deformities and the positioning of implants, combined with a restricted view during the intervention. These preoperatively received information frequently served the purpose of deciding which sort of prosthesis should be used and which correction requirements had to be transfered from the planning to the intervention, for example at a retroversion of the acetabulum.

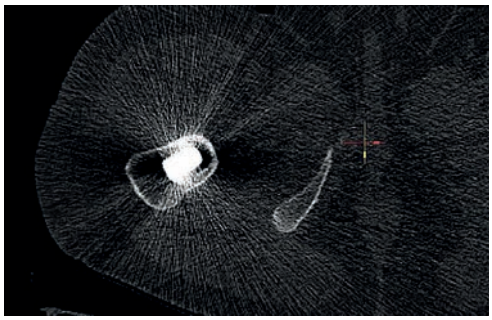
In recent years, the number of planning software has strongly increased. Especially manufacturers and providers of shoulder prosthetics have intensified the development of planning software in order to offer these specifically for the sale of their implants. There are different approaches to the intervention.



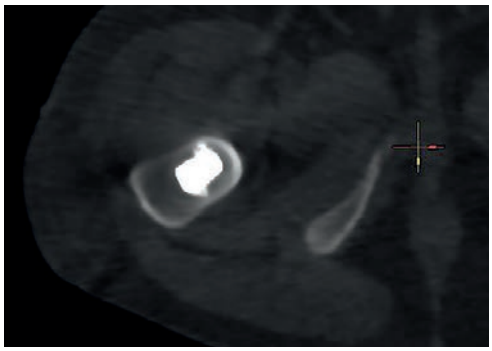
After the 3D prosthesis planning has taken place, the possibility of a customised instrumentation (PSI) is frequently offered. Therefore, a 3D model of a drilling template is created and used as a steril guide wire. For cost reasons, this seems difficult to realize because it is not offset by the refinancing system (DRG). Therefore, the implementation is often reserved to deformities which are intraoperatively difficult to see as well as secondary deformities.

The preoperative 3D planning at bigger osseous defects particularly in the area of the glenoid is almost obligatory, while at mostly anatomic conditions the necessity of a planning for the implantation of shoulder prostheses have not yet beet sufficiently evaluated and implemented.

The main problem is currently to eliminate the metal artefacts of existing and inset implants so far as a planning is at all possible. This applies particularly to patients who have been preoperated on multiple times with metal implants or spacers of bone cement.



Especially for these cases it is very important to measure not only the size and type of the defect, but also to determine the possible anchoring of the implant in the native bone and to integrate this into the planning software. The application of osseous augmentations as autogenous or allogenic bone blocks or of metal superstructures or wedges onto the baseplate (so-called full-wedge metallic reconstructions) may be necessary.



The 3D plannings help with the preoperative measurement of potential corrections of asymmetric defects or needed lateralisation of the glenoid component. The size and type of a bone block can be preoperatively planned and intraoperatively implemented as well.

The next challenge is the transfer of the planning results into the surgery. First of all, it is important to view all deformities and osseous defects as detailed as possible. It is up to the surgeon and the existing technical requirements whether a CAS (Computer Assisted Surgery) with navigation or an intraoperative imaging with anterior-posterior and axial radiation is preferred.

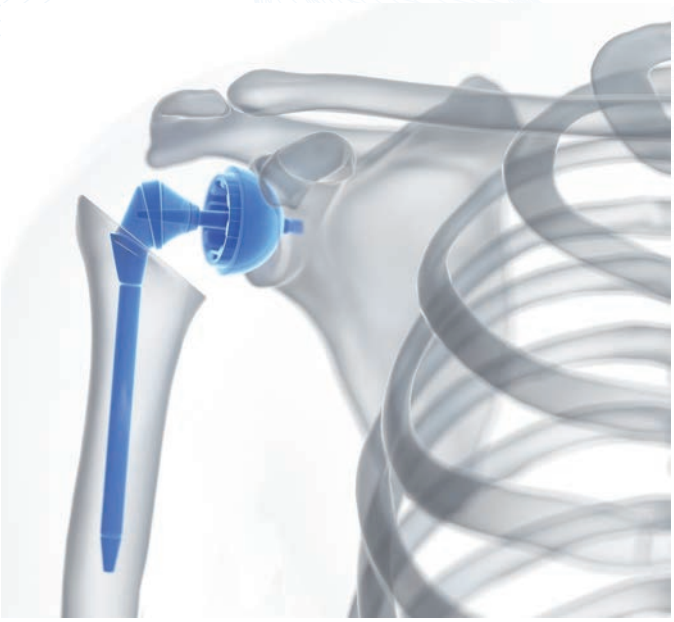
By using PSI, higher costs, a longer surgery time and reduced precision have to be considered when it comes to technical operating problems or for example osteophytes.

A further advantage is the testing option of the planning software for the range of movement which enables the correction of components if the shoulder cannot be moved in a satisfactory way. Nevertheless, other impacts like the condition of soft parts have to be considered.

In any case, during the planning it should be tried to calculate at least a 80% osseous contact of the base plate to the native glenoid.

A virtually notching-free movement can be achieved by an appropriate choice of articulating triological pairing, glenosphere and humerusinlay.

The notching of the scapular, in long-term course due to progressive bone resorpion, is responsible for the survival and revision rate, after all.



Precondition for a widespread use of preoperative 3D planning in shoulder endoprosthetics is an easy to use software which automatically takes the essential steps.

This includes:

- Centering of the glenoid cranio-caudal und anterior-posterior as standard settings
- Precise automatic measurement to determine the inclination and version of the glenoid
- Segmentation of the glenoid and the humeral head (automatically and manually)
- Application for a large number of suppliers with the same planning module
- Hiding of metal artefacts and bone cement
- File export for the production of 3D models and PSI

In the future, preoperative planning will be a basic tool for surgeons and play an increasing role at certifications, as it is already the case for hip and knee prosthetics.
The earlier and the more intensive each shoulder surgeon meets these demands, the easier succeeds the introduction into the clinical routine.

Dr. med. Falk Reuther is chief physician at the clinic for trauma surgery and orthopaedics DRK clinics Berlin Köpenick, Germany. He completed fellowships in several countries, such as Australia, Austria and Germany. His focus is on shoulder surgery, mainly on arthroscopical reconstructive interventions. He is an expert for the implantation of shoulder joint prostheses after fractures or consequences of fractures, for patients with degenerative joint diseases and for revision surgery.

In 2012, Dr. Reuther was together with Prof. Markus Scheibel the president of the German annual conference of shoulder and elbow surgery (DVSE). Since 2000, Dr. Reuther has been working as a medical consultant for the company Mathys (Bettlach, Switzerland) and was involved in the development of a modular fracture-hemiprosthesis, an inverse fracture prosthesis and an inverse prosthesis as well as in the improvement of surgery techniques.
Dr. Reuther is member of many German and international expert associations, such as the European Society for Shoulder and Elbow Surgery (SECEC-ESSSE).

The Interview

mediCAD®:

Dr. Reuther, you use the software planning tool mediCAD® 3D Shoulder for your work. Since when do you use it?

Dr. med. Falk Reuther:

We use the 3D module for two years but we have been working with mediCAD® for some time. For years, we have been planning with the aid of mediCAD® 2D software, for hip and knee joint prostheses as well as implants for osteosyntheses, and we are very satisfied.

mediCAD®:

You chose directly the animated three-dimensional planning software, wouldn‘t it have been sufficient to use a two-dimensional one?

Dr. med. Falk Reuther:

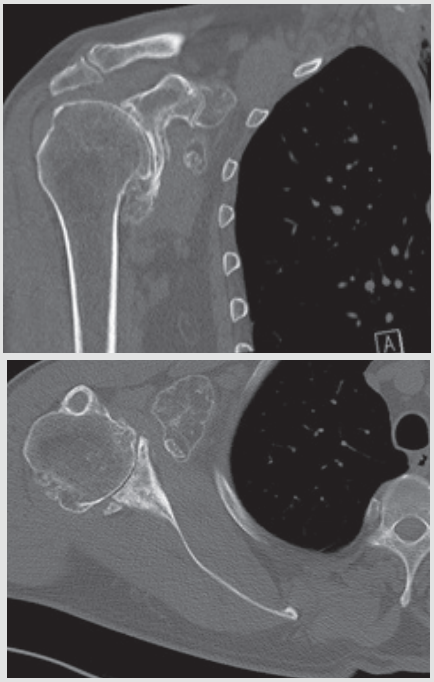
We decided based on a much better visualisation of the 3D tool. Especially for the shoulder joint, the viewing in 3D in order to really understand the anatomy - and in particular with regards to recurrent osseous deformities and defect situations - is decisive for the choice of the operational action.

Case 1

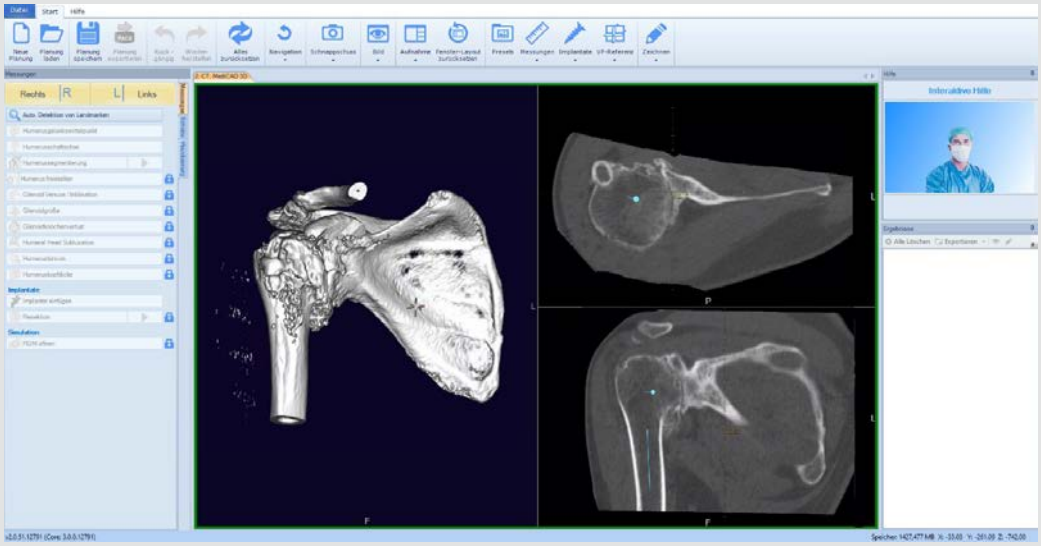
Background

A patient, age 69, with reduced, very painful mobility for years (Flex 90°, Abd 70°, AR1 20°). After a shoulder arthroscopy in 2015 with arthroscopic subacromial decompression, no real improvement was reached.

Omarthrose level III by Samilson with annulus osteophytes.



CT shows a central acetabular reduction with posterior decentration of the humeras head at B3 glenoid by Walch, with retroversion of the glenoid to 20°.



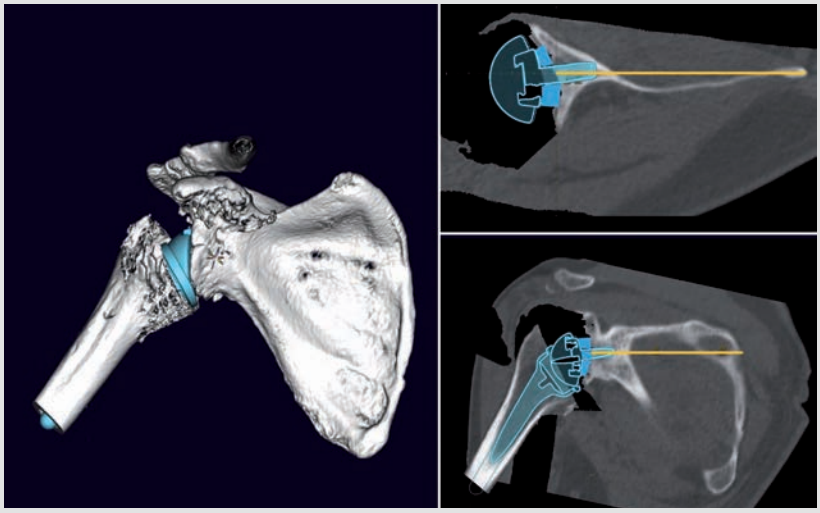
mediCAD® Shoulder 3D planning module with automised 3D view of the shoulder joint.

Case 1

Planning

Implantation of an inverse total endoprosthesis with a cement-free stem. For lateralisation, an osseous building of the glenoid is intended, with autograft of the humerus head (BIO RSA).

We use a Metaglene CP with central post of 25mm length and prepare the bone block asymmetrically in order to compensate posterior bone loss.



Care

Implementation of the planning with intraoperative control of the guide wire and of the position of the bone block in axial radiation.

Postoperative x-ray check of the shoulder joint with regular implant position and appropriate joint position.

mediCAD®:

You consider yourself a “perfectionist“. Is this one of the reasons why you decided for a digital surgery planning even though it hasn‘t been prescribed by law so far?

Dr. med. Falk Reuther:

If perfectionist or “just user“, this doesn‘t make any difference. The digital planning has a decisive advantage. The surgery can be virtually planned and implemented. Especially under the current situation, we have all learned to meet in a digital setting and we achieve stunninly efficient results. This is what we all want in surgery: an almost 100% result of our previously chosen shoulder prothesis at the end of the intervention. This won‘t be always possible due to unpredictable difficulties, such as they may occur at revision interventions, which affect our result. We can examine the soft parts preoperatively and estimate how they affect the result but to which extent can only be seen during the intervention. This is why it is particularly important to choose the right implant for the patient and to test it virtually in advance.

Crucial aspects to avoid risks of incorrect implantation or a premature implant malfunction, are an improved reconstruction of the glenoid anatomy, minimisation of bone substance loss at the glenoid, protection of the joint line and opimisation of positioning and fixing of the implants.*

mediCAD®:

The supply of planning software has risen during the last years, why did you choose the software of mediCAD®?

Dr. med. Falk Reuther:

A big advantage is the vendor-independent plannning software because almost all big implant manufacturers provide the necessary data in the form of implant catalogues. I can also mention the individual possibility to use automised steps at the bone processing like the segmentation of humerus and glenoid, or the individually refined implementation of these steps which help at recurrent overlaps of osseous structures that exist at advanced omarthroses or defect arthropathies. Sometimes the software can‘t crarry out these steps automatically. In these special cases, such as revisions with enclosed osteosynthesis material or endoprosthetics, individual steps for the detection of osseous landmarks are necessary.

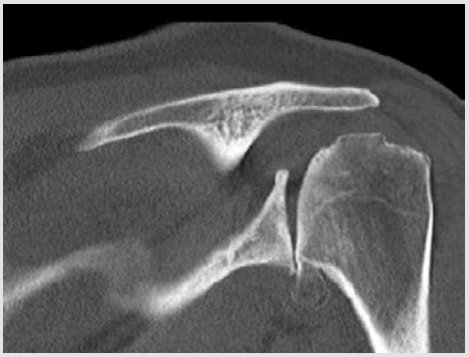
*Schmalzl, J., Gerhardt, C. & Lehmann, L.J. Dreidimensionale Planung und Verwendung patientenspezifischer Instrumentierung (PSI) in der Schultertotalendoprothetik. Obere Extremität 15, 179–186 (2020). https://doi.org/10.1007/s11678-020-00580-2

Case 2

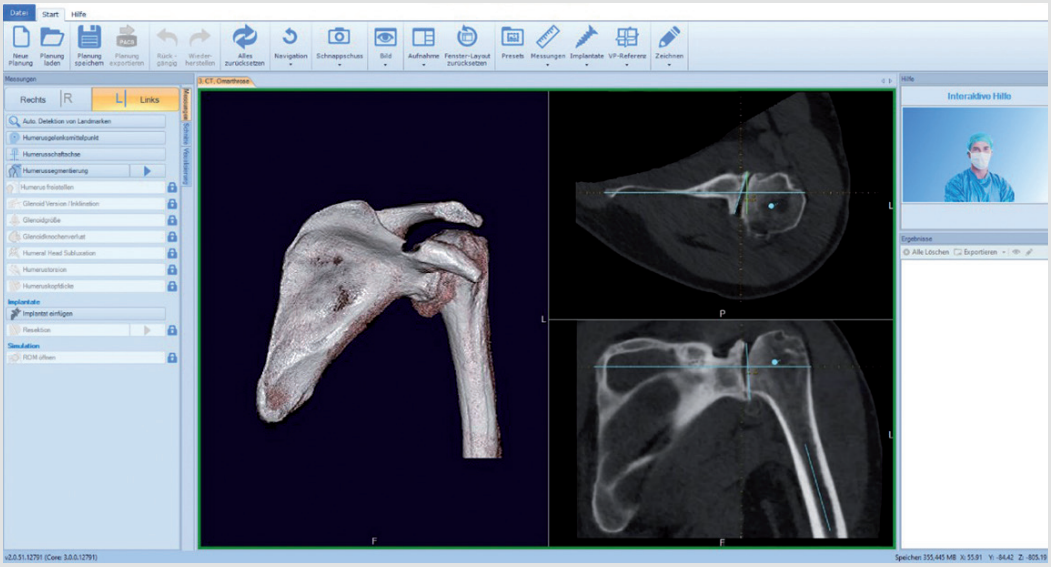
Background

A male patient, age 51, for three years with increasingly reduced mobilisation of his left shoulder joint (Flex 100, Abd 60, AR1 0°).

Omarthrose Samilson III at B3-Glenoid by Walch.



CT, Retroversion of the glenoid ca. 15°.

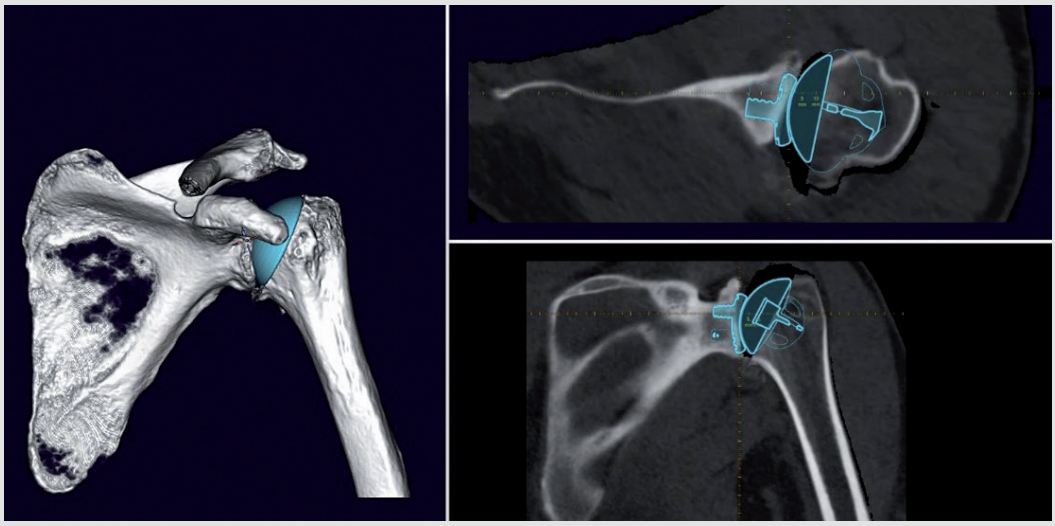


Automatic segmentation of the humerus head and scapula in the 3D tool of mediCAD® 3D Shoulder with usage of the Friedman`s Line.

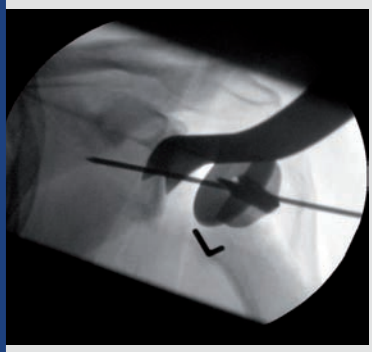
Case 2

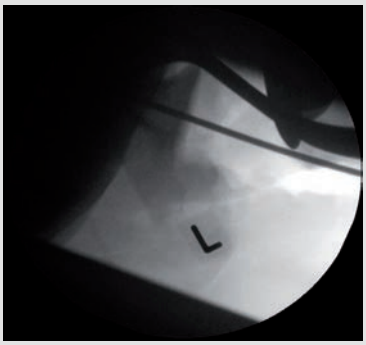
Planning

The 3D planning enables a precise determination of the requested retroversion of the glenoid component or of its correction. Here, a virtually increased bone resection (correction max. 10°) can be planned, without compromising the stability of the glenoid component. In any case, during the planning has to be decided whether an intact rotator cuff still indicates an anatomically stem-free total endoprosthesis or if we should implant an inverse TEP.

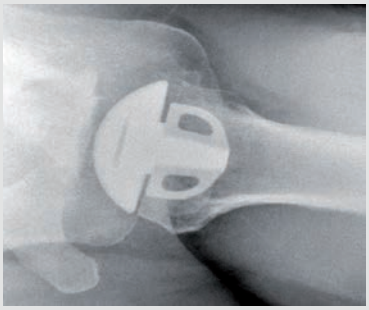


Care





Intraoperative BV-control of the positioning of the guide wire at both levels. Screening of the retroversion correcti-on of ca. 10° by use of axial radiation before working on the glenoid.



X-ray records in the true ap and axial level with centering of the humerus head.

mediCAD®:

The digital preoperative planning is legally required for hip and knee endoprosthetics at EndoProtheticsCentres. Not so at shoulder endoprosthetics. What do you think is the reason, and do you believe a compulsory planning would positively affect surgery success?

Dr. med. Falk Reuther:

I cannot really answer the question why legal anchoring lasts so long because the decision is often taken by various committees. Certainly, the considerably smaller amount of implanted shoulder prostheses in comparison with hip and knee joint endoprosthetics plays a role. Additionally, the costs of a planning software shouldn‘t be underestimated. An automatically improven quality and a higher survival rate of the implants can be assumed but not yet validated. In this context we also have to see the discussion about minimum quantities which will certainly rise for shoulder joint endoprosthetics in the coming years.

mediCAD®:

You have been using mediCAD® 3D Shoulder for two years now. Do you plan each endoprosthetic intervention with mediCAD® 3D or are there cases where you work with the classic template?

Dr. med. Falk Reuther:

I believe that for each surgery a CT-Scan is essential. For easy osseous situations, without strong deformities or defects, we plan mostly in order to determine the size of implants, to avoid surprises at critical situations, for example, the glenoid (inclination of the metaglene, size und form of the pegs) or the stem (size, cemented or cement-free). For me, the advantage can be mainly seen with complex osseous deformities and revisions. Also, the usage of osseous auto- or allografts or metal augmentation material can be decided very well digitally.

mediCAD®:

You have had the possibility to extensively test the software - where do you see potential for improvement of mediCAD® 3D Shoulder? Which functions are not yet included in mediCAD® which you would consider essential for an optimal planning?

Dr. med. Falk Reuther:

A software must be easy and intuitively to use. Regular usage will make it easier each time. In this way, planning duration can be shortened and quality can be increased. Only if you plan all easy cases, you will succeed in difficult osseous situations. Additionally, all doctors who are directly affected by the surgery must get to know the software in order to understand the principle, get to know the implant and "virtually practise" the steps of the intervention in advance. Only those who have planned themselves are entitled to operate themselves in the future.

Further possibilities for improvement are the automatisation of planning steps, simplified sementation and the possibility of virtual movement analysis after completion of the planning. In the future, procedures for better visualisation at enclosed metal artefacts and at strong osseous deformities have to be developed. In addition to that, producers of endoprostheses should transfer all implants into the database in a timely manner, so that we can add these in the planning. A further objective is the transfer of the planning results into the operating room. This concerns not only the implant sizes but for example also the detailed positioning of the guide wire and the aiming wire in terms of inclination and version as well as the determination of the cutting depth at the glenoid for optimal anchoring of the components. Today, there are PSI or intraoperatively navigating systems on the market which are sometimes cost-intensive and can't be offset by the payers. Currently, many companies sell auxiliary planning software and customised PSI only for their own products. This is one of the reasons why we think very seriously about how to develop easy economical procedures which simplify these steps and how we may implement them in the future.

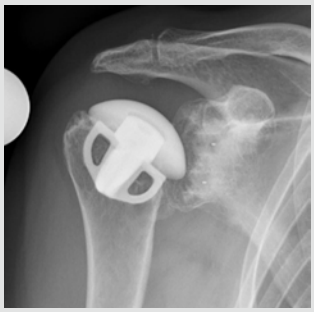
Case 3

Background

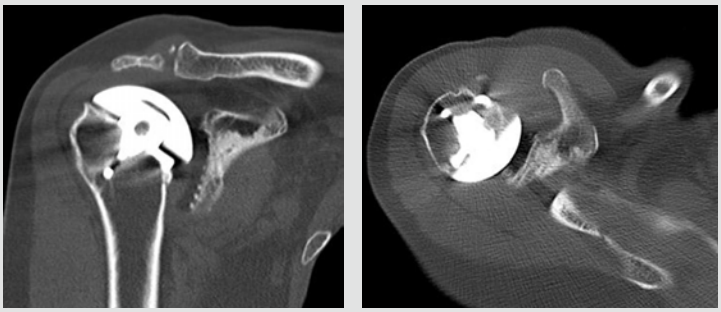
A female patient, age 59, with numerous previous operations due to instability impingement in 2004, rupture of the supraspinatus tendon after a skiing trauma in 2007. For permanent painful limited mobility with an instability omarthrose, a stem-free total endoprosthesis (Affinis short) was implanted in 2017. Due to insufficiency of the subscapular tendon in 2018, an open revision with osteotomy of the tuberculum minus and a reinsertion of the subscapularis took place. Due to remaining painful subluxation of the TEP with rupture of the subscapularis and supraspinatus tensons and unchanged strong suffering, explicit wish of surgery, indication to switch to an inverse total endoprosthesis (Affinis Inverse with Metaglene CP).

Diagnosis

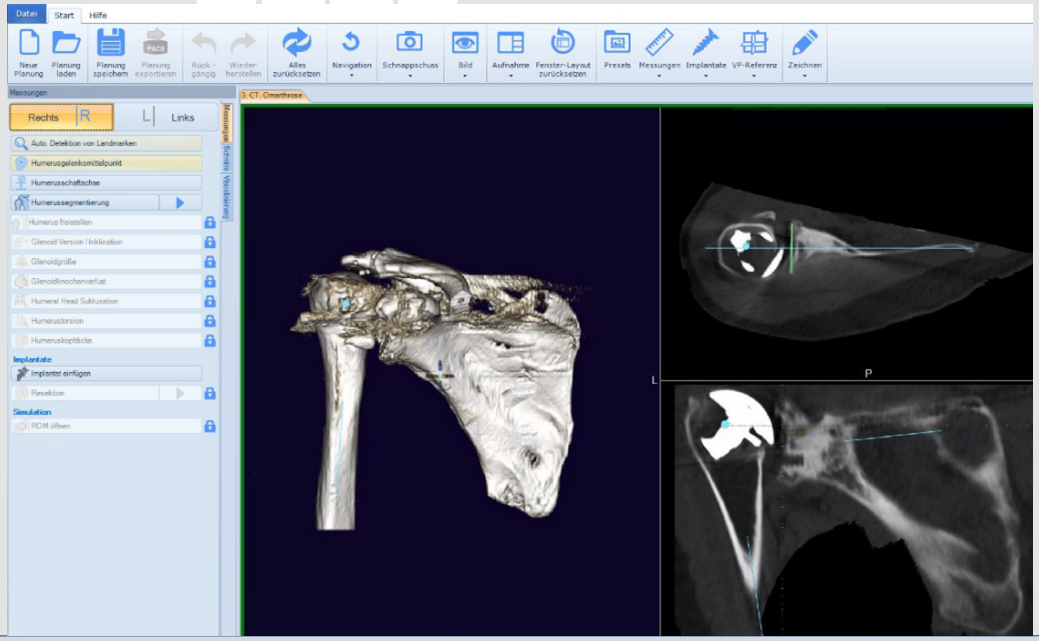
Preoperative x-ray and CT-Scan:



Affinis short with cemented glenoid without easing, minimal bone resorption at the medial calcar, cranially decentered.



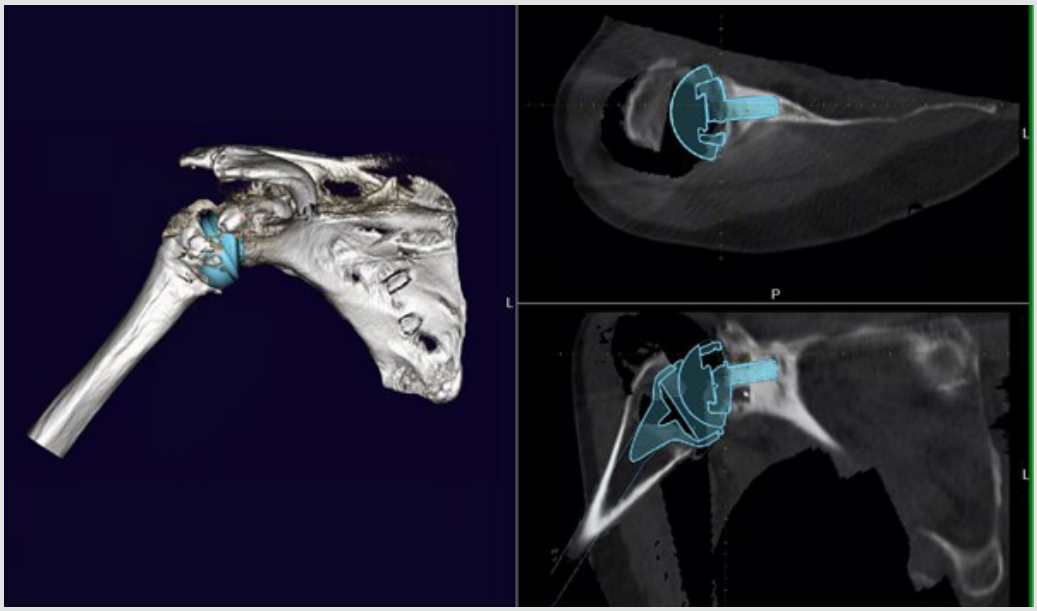
Preoperative CT-Scan before change of prosthesis, decentering of the stem-free TEP to cranial and dorsal (at examination in recumbent position), no easing.



Case 3

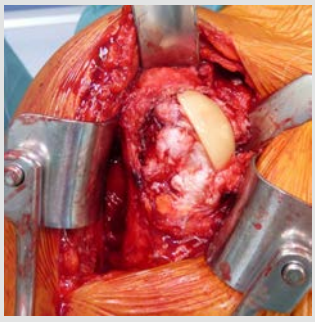
Planning

Having excluded a low grade infect by diagnostic arthroscopy and sample recovery, an unilateral change of prosthesis to an inverse total endoprosthesis with Metaglene CP and vitamys® glensophere with a central post of 20mm at caudal inclination of 10° is planned.

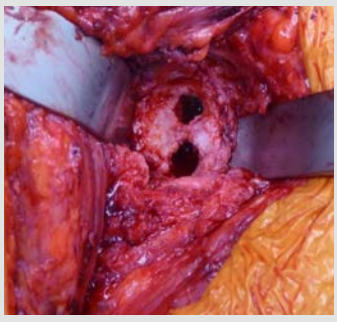


Care

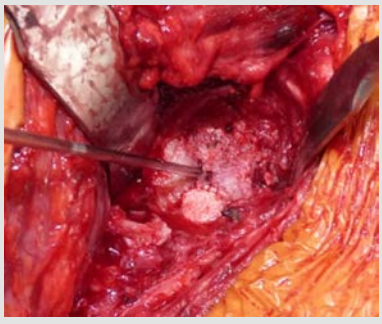
Explantation of the stem-free total endoprosthesis, filling of the glenoid defect with spongiosa of the humerus metaphyse and usage of osteoconductive absorbable bone replacement material. Then intraoperative verification of the inclination of the guide wire for the glenoid drilling jig and implantation of the inverse total endoprosthesis (Affinis Inverse with Metaglene CP and vitamys® glenosphere).



Ceramic head after opening the joint capsule with absent subscapularis and anterior supraspinatus tendon.



Removal of the Peg Glenoid without strong bone loss at the osseous glenoid.



Refilling of the bone defect with autologous spongiosa and a ceramic bone substitute.

Case 3

Follow-up

Postoperative x-ray control.

X-ray follow-up six months after the surgery.

mediCAD®:

Thank you very much for your help and your time Dr Reuther.

Current situation and prospects

The preoperative planning software mediCAD® 3D Shoulder permits a better planning of implantations of shoulder joint prostheses. A big advantage is the scaled imaging for detailed evaluation of the anatomic structures. These are decisive for the definition of optimal component size, position and orientation. mediCAD® has accepted the challenge of producing useful tools for orthopaedic and trauma surgery. Now it is necessary to transfer as accurately as possible the virtually planned model into reality, the operating room. Which procedure will prevail, has to be seen in the future.

The software engineers of mediCAD® design a tool for “Mixed Reality“ (MR) which will help surgeons effectively plan an intervention in 3D and then intraoperatively implement it with aid of the MR-glasses.

mediCAD Hectec GmbH
Opalstr. 54
DE-84032 Altdorf

Tel. +49 871 330 203-0
E-Mail: info@mediCAD.eu

Print no. 1149/ 06-2021