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Rehabilitation after musculoskeletal injuries – an overview about long-term outcome

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Abstract

In this review we focus on long-term outcomes of severely injured patients. Among the topics discussed are general factors affecting the long-term results, as well as the recent literature regarding the role of upper and lower extremity fractures on long-term outcome. Moreover, outcome studies demonstrating the results in patients with pelvic trauma and concomitant injuries (vascular and neurologic injuries) are outlined.

Introduction

Severe musculoskeletal trauma causes a lasting impact on the affected individual, their families and the society. Due to improvements in the delivery of trauma care (implementation of ATLS strategy), initial diagnostics, and surgical strategies (damage control orthopaedics versus early total care) marked decrease of the mortality rates (from 37% to 18%) of multiple trauma patients was described.[1-6] As consequence, long-term outcome parameters, such as patient's satisfaction, quality of life, chronic pain, and return to work gained more attention in trauma care. Long-term investigations revealed high rates of work disability and impaired functional outcomes in trauma patients, underlining the immense economic burden on the society.[7-11] The following review summarizes the risk factors associated with inferior rehabilitation outcome in patients with musculoskeletal trauma.

General outcome

Studies pointed out that not only injury related factors, such as injury severity, injury site and treatment method, but also patient characteristics and socioeconomic factors have a strong impact on long-term outcome.[8,9,12] In addition, post-traumatic depression, anxiety disorders, and chronic pain were common in polytraumatized patients. Recent publications show high rates of Post-Traumatic Distress Syndrome (PTSD) (24-39%), anxiety (32-70%), and depression (3568%).[7,9,13-15] Authors emphasized the importance of psychological support during the post-traumatic rehabilitation.[7-9] In particular, the introduction of self-efficacy and self-management training has been shown to be successful in patients with chronic diseases. Female patients appear to be more prone to develop post-traumatic stress disorder and psychological impairments.[16] These findings are in contrast to the reports demonstrating advantages of premenopausal woman over man in the acute phase after severe injury.[17,18]

Persistent socioeconimic consequences after musculoskeletal injuries were reported by patients even ten or more years after trauma.[19] Patients between 19 and 50 years of age more frequently reported financial losses and net income losses.[19] In contrast, social consequences (number of friends decrease) were found to be common in patients younger than 18 years at time of injury.[19]

The presence of traumatic brain injury also affected the physical and psychological rehabilitation after multiple blunt trauma.[20] Patients with traumatic brain injury reported poorer psychological functioning and more frequently chronic pain.[20]

Upper extremity

Studies focusing the long-term outcome of upper extremity injuries are rare. Follow-up investigations demonstrate superior long-term results in patients with upper limb injuries when compared with patients with lower extremity trauma.[21,22] Concomitant vascular and neurological injuries are known to be a major determinant of worse outcome.[23] Moreover, authors discussed whether associated head, facial and thoracic injuries may potentially interfere with the rehabilitation process.[23] In addition, articular and displaced fractures were associated with chronic pain and functional long-term disabilities.[10] This might be due to the fact that the initial surgical reconstruction of articular fractures is more complex.

Pelvis

Pelvic factures are the result of high energy trauma associated with multiple concomitant injuries of lower extremity, spine and abdomen.[24,25] Studies revealed that not only the pelvic injury severity (stable versus unstable), but also the presence of associated injuries is mainly responsible for worse long-term results.[26] Neurologic sequelae and non-unions were identified as determining factors affecting the outcome of patients with pelvic fractures. Neurologic sequelae, such as peripheral nerve lesion, incontinence and sexual dysfunction are factors that negatively affected patient's satisfaction and quality of life.[27] Chronic pain was also very frequently reported (11-66%) by polytrauma patients with pelvic injuries. Authors hypothesized that non-anatomic reduction or insufficient fixation can provide poor long-term outcome resulting in pain syndromes.[28]

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Lower extremity

The involvement of lower extremity is known to be a determinant factor for inferior long-term rehabilitation.[7-9,29] Two major studies analyzed factors influencing the long-term outcome of lower-extremity injuries.[7-9,29] The Lower Extremity Assessment Project (LEAP) was a prospective multicenter cohort study evaluating the functional and clinical results in patients with high energy lower extremity trauma.[7-9,29] Interestingly, the results demonstrate comparable functional outcomes in patients with amputation and limb reconstruction.[7-9,29] Regardless to the treatment option both groups (amputation group and reconstruction group) showed severe disability as compared with general population.[7-9,29]

The Hannover Rehab Study examined 637 patients with a minimum follow-up of 10 years (mean 17.8 years). In this study, marked percentage of patients (15-34%, Figure 1) with fractures of the lower limb reported persistent

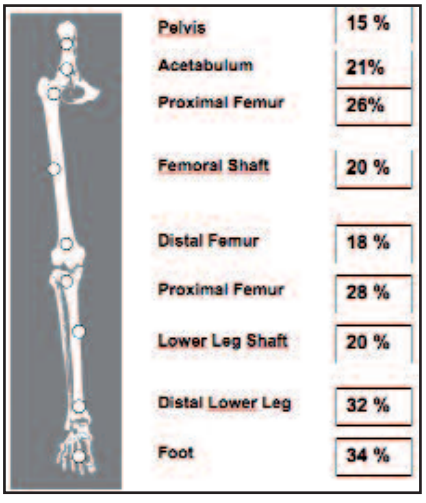

Figure 1. Persistent local pain in patients with lower limb fractures at different localization.

post-traumatic pain and approximately (10-30%) stated to have a limited rage of motion.[12,17,30-33] Moreover, superior long-term outcomes were measured in patients with femur shaft fractures, whereas patients with articular fractures and proximal femur fractures were associated with poor results.[34] The reported rates of arthroplasty were 7.5% for hip joint, 15.1% for knee joint. The ankle fusion rate was reported with 12.3%. Furthermore, fractures below the knee joint demonstrated significantly inferior outcome scores when compared with patients with fractures above the knee, as measured by the HASPOC – Rehabilitation Score, Short Form 12 and Tegner Activity Score.[17] This soft tissue envelope, unfavourable blood supply and complex fracture patterns of foot and ankle injuries are mainly the determinant factors contributing to the above mentioned worse outcome.[30]

Conclusions

Outcome parameters, such as long-term quality of life and patient satisfaction gain more attention in trauma care. Social reintegration of trauma patients and return to work are the main long-term goals. Studies revealed that the articular fractures, especially those of the lower extremity, and the presence of associated neurological impairments were associated with inferior long-term functional outcomes and unfavourable outcome scores. Moreover, psychological factors were found to be crucial. Therefore, polytraumatized patients might benefit from early psychological support after trauma.

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Secret protection and data protection. Legal aspects of the praxis of orthopaedic and general medical approval certificates in public health services

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Introduction

The public health service as a part of the public health sector guarantees a needs-based, economic maintenance of the population, which is in efficiency and quality appropriate to the common level of medical knowledge and especially supports social fringe groups. The general assignment of tasks covers in particular measures of monitoring, controlling and preventative measures, which shall benefit the populations' health protection. On local level, authorities of public health service are districts and cities enjoying district status as lower health authorities. In cities that enjoy district status this leads to data transfer within the authority in many cases and not in between two public bodies. The local health service cares essentially for sanitary prevention; furthermore the assertion of the public health officer function including the health reporting falls to it. Within this assignment of tasks individual-related data processing is required in many cases. Therefore the question arises, if it is possible to allow an exterior third party the inspection of patient-related health data. Furthermore local health service and other bodies are interchanging data in order to satisfy their duties.

The public health service has to attend to the health care of the whole population and serves primarily public welfare and national health. Certain tasks – for example physical examination about the capability of employment – are performed for the local employer, as far as an independent orthopaedic expertise is necessary. Insofar as federal or state law schedule, the public health service provides approval certificates and advisory opinion and it exists a special confidence in the correctness, independence and neutrality in these. For instance it can be appraised, if from a medical point of view for a recipient of social benefit a removal to a flat with a lesser square footage is reasonable or if and which aid for disabled people is medically required. Clients are authorities, law courts, administrative offices, public law institutions and comparable establishments. Exceptionally even individuals can turn directly to the public health department; for instance an examinee can apply for an attestation of inability to be tested, if the examination regulation provides it.

These orthopaedic or general medical approval certificates and advisory opinions for a third party often depend on the concerned person which has to sign a release from the duty to treat medical records confidentially (medical release waiver). This release is often used as a carte blanche to transmit all the existent information. This assay is going to revise that association and is going to demonstrate that from a legal point of view there is no need for a declaration which releases from the duty to treat medical records confidentially if it is allowed to transfer the data in order to fulfil a task because of a legal rule. For this purpose it needs some basic explanation about the relation of the law of secret protection and data protection.

Subject matter of secret protection

Term

The term secret means facts that are not obvious and only known by a very limited group of persons. Furthermore the master of the secret has to have a reasonable interest on the confidentiality. Significant for the classification as a secret are the characteristic elements of un-knowledge of the fact outside of the limited circle of the secret carriers and the intent to keep the secret as well as the interest of the master of the secret to keep the secret.

Master of the secret and secret carrier

Master of the secret is the person who possesses the power of disposal of the information contained in the secret. Usually this is the person whose life and sphere is affected by the facts that have to be kept secret and whose interests should be guarded. The master of secret has to feature the will and a reasonable interest in regard to the confidentiality of the facts. Secret carriers are all the persons who are in full knowledge of the protected facts and who have sworn to secrecy.

Essence and subject of protection

Unlike data protection secret protection includes to a lesser extent the question about the availability of data, but the one about the defence of the confidentiality of the affected persons. Not only is the interest of individuals protected but the common belief in the discretion of the administration or certain professions as a condition that they are able to perform the tasks which are in the interest of the general public.

Function and purpose of protection

An unauthorised interference could happen externally by persons who procure unauthorised knowledge and internally by authorised persons who provide spurious information for others. The function of the directions concerning the protection of secrets is to ensure the respect of the foreign secret through the secret carriers by regularising a disclosure, spreading and use of the affected information. Furthermore aim of the protection of secrets often is a active and preventative acting of the master of secret and the secret carriers in terms of positive action of defence, in order to avoid an unauthorised invasion and spotting by a third party. Moreover the protection of secrets serves the strengthening of existent mutual trusts in generally. The affected person shall be able to trust in the keeping of his secrets in order to assure the efficiency of the state and its organs on one hand, on the other hand the efficiency of certain professions.

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Categories of secret protection

There is a difference between the character of the facts that have to be kept secret and the interests that serve the secret keeping. As a first category private secrets concern the personal area of life of an individual; this contains as well company- and profession-related secrets. Municipal servants can be carriers of these secrets. Protection goal is the mutual trust. The second category includes state secrets which mean secrets referring to the sovereign acting state. This category includes state secrets in terms of state protection as well as official secrets. They serve both the public interests in an untroubled operation of the administration and defence of the general public's trust in the discretion of official bodies.

Legal foundation

There is no structured system of rules that concerns the protection of secrets. In the German constitution as well as in sub-constitutional federal law there is a to some extent complex netting of rules for each special secret.

Important official secrets in the municipal context

Municipal servants have to consider and to preserve a plurality of secrete depending on the manner of the accomplishment of a task. Only a few of them will be listed in the following as a sample:

Privacy of correspondence and sanctity of the mail. The German constitution guarantees privacy of a letter's content and of all the external

circumstances of the correspondence. For example: The municipal employer is not allowed to access correspondence of civil servants for fact-finding and decision-making. The filing department or superiors are only allowed to unclose letters if the address does not show that the letter appeals to the civil servant personally – private or official confidential –; A letter can be opened, if the addressees' area of operation is referred to or if there is an add-on like „attn."

Secrecy of telecommunication. Service providers are obliged to preserve the secrecy of telecommunication. An example: If a municipality grants its civil servants to make private phone calls from the office phone against payment, it is only permitted to examine the correctness of the account.

Fiscal secret. The fiscal secret defends one's financial circumstances from unauthorised disclosure, utilisation or demand in an automated practice. It obtains as well for municipal task fulfilment. Data, including name, address and the tax payer's account number can only be disclosed, if it is permitted by law. An example: data of a dog owner given at the event of paying the dog license fee can only be disclosed in the case of damage but not to pursuit a misdemeanour like contamination of a public street with a dog's excrement.

Secret of statistics. Municipalities have certain bodies according to the federal state law where they process individual-related data for statistical purposes in accordance with the legal regulations for secrets of statistics and destruct them after the analysis. The civil servants of the statistics body are pledged to keep the secret of statistics prior to the commencement of their employment. They are reminded annually of this obligation. Beside their employment in the statistics body they are not allowed to be consigned with other duties and responsibilities of the administrative performance in order to avoid a conflict of interests. It is also demanded by law that the statistic body is organizationally and locally separated from other administration. This can be put into effect by supervising the access and by taking measures of constructional manner.

Business secrets

Business secrets are all business-related facts, circumstances and transaction, which shall be kept secret because of a legitimate economic interest of the businessman. If a municipality has got authorised knowledge of such secrets because of any legal relationships with companies, it has to reject any requests of disclosure by third parties.

Professional secrets

– Obligations of secrecy because of public services and labour law

The official secret which results for the municipal sector from the civil service law, pledges a civil servant to swear to secrecy about all matters he got to know because of his official employment.

– Obligations of secrecy to patients/clients

In municipalities veterinarians and physicians are employed in different functions, for example as a public medical officer or a company medical officer. Social worker and pedagogues perform tasks referring to the social and youth welfare service. School psychologists give pupils advice. All of them are subject to a punishable professional secrecy. A criminal liability is excluded as far as there is an authorisation to disclose because of a legal obligation to notify, a special rule or a justification. The basic principle of legal and administrative cooperation to other authorities neither justifies a disclosure nor a data transaction.

Relation to data privacy law

The scope of secret protection law overlaps to some extent with data privacy law. On one hand the range of secret protection is broader because compared to data privacy law business information without a reference to an individual can be qualified as a secret. On the other hand data privacy contains not only (individual-related) secrets but also every individual-related data which the person concerned may even do not want to or cannot keep secret. The intersection of both extents of protection represents the individual-related secret data. The relation of secret protection to data privacy in this section was controversial for a long time. The *Two-barriers-theory* indicates that conduct ruled settlements and punishable secret protection on one hand and transmission obligations in data privacy law on the other hand coexist. In praxis this would mean that the carrier of a secret has to consider to barriers when disclosing the secret: the special secret protection and the common data privacy. Despite existent transmission rules a release waiver of the concerned person would be required and a data transmission would often be omitted.

For practical reasons it has to be possible to overlap confidentiality interests by data privacy law given authorization of disclosure, for data privacy and secret protection cannot testify different conclusions. The basic principle of the unity of the legal system demands to insinuate common data privacy laws - as far as they include authorities for individual-related data transmission – as authority rules which exclude criminal liability because of a breach of secret, because matters that are allowed by data privacy law or that are even demanded because of transmission obligations, cannot be prohibited and punished with penalties. In this respect Secret protection and data privacy conciliate, hence *harmonise*. In *praxis* it is possible to achieve a legitimate attitude and at the same time a harmonisation by proving the data privacy aspects implicitly in the issue of the information's unauthorised disclosure. In consequence of this, a special release waiver of the concerned person is only necessary, as far as regulations about data transmission do not interfere.

If contrariwise correspondent secret disclosure commandments are able to legitimate a data transfer in a particular case or if they are just a requirement for it, cannot be evaluated uniformly. The legislator does not use consistent terminology in terms of data privacy and secret protection rules. Therefore, a definite and systematic differentiation of both matters is not possible.

Examples

- Facts that are subject to the fiscal secret may only be disclosed if it is explicitly admitted by law. This applies to secret-protected individual-protected data that may be disclosed to the commissioner of data protection and freedom of information in the context of means of control for there must not be spheres without any control. Anyway, this only statutes authority to disclose and does not a legitimate a data transmission. An authority to disclose can only be given by federal state law if there is a legislative competence for it.
- The protection of individual-related data subject to the secrecy of telecommunication is regulated in the statute about secrecy of telecommunication (TKG). This is an area specific telecommunication data protection. The same applies to the social data protection which is subordinated to the social secrecy.

Relation to the information access right

Secret protection is already conceptional in contrary to the information access. Certain secrecy interests are incompatible with the satisfaction of disclosure requests.

In so far the federal state laws about information access regulate that the official secrecy is inapplicable within the framework of the application of the information access laws. In contrary business secrets act as reasons for exclusions for rights to information access.

Conclusion

For the lawful praxis of the public health service which provides orthopaedic or general medical approval certificates and advisory

opinion to a third party this means: approval certificates and advisory opinion made for other bodies which contain individual-related health data do not require a previous medical release waiver, if they serve the accomplishment of a task of the health authorities or the body that receives it or if it is admitted by law. If the purpose allows it to hand the certificate or opinion to the concerned person, so that he is able to perform absolute discretion, a release waiver is unnecessary. Only in particular cases a medical release waiver is reasonable in such a situation: if there is a general agreement between health authority, concerned person and receiving body that certain information should be transmitted and the transmission on its own is not covered by law in default of necessity.

The following appendix is an example for a document which a doctor of the health authority could use for a briefing with the person who has to be examined.

Appendix

Approval certificates, advisory opinions and advices of the health authority to other bodies – Information for the briefing of concerned persons –

The health authority of the city …/ the district … certificates official attestations and reports and provides approval certificates intended for the presentation to other bodies. These certificates contain individual-related health data. For transmission applies the following:

1. Transmission in virtue of a legal assignment of tasks

The transmission of patients' data is always permitted if it is necessary to fulfil a legal duty. If the obtaining of a medical certificate is admissible by law or mandatory, the health authority is entitled or even obligated to transmit the data to the ordering body. Therefore in such cases there is no need to release the doctors of the health authority from their medical confidentiality. This situation applies to an essential part of all certifications by the health authority.

Usually, at the issue of an official health certificate in the public service the requesting body is only allowed to receive the result of the physical examination and the detected risk factors. The exact meaning of the "result" acts in accordance to the enquiry and is in discretion to the examining doctor. The transmission of individual results of the anamnesis, the examination and the transmission of added diagnostic findings to the requesting body is not covered by the term "result". Nevertheless such a transmission is permitted, if the knowledge about it is necessary for the decision of the measurement which was the reason for the medical examination. This is an exception which has to be justified by the requesting body. The ratio of the transmission only of the result applies to all kind of expert opinions.

2. Handing-over to you personally

If the health authority acts initiated by yourself because you need a medical expertise for a certain purpose, the certificate will be handed personally and directly to you. The decision of the further usage is up to you. In this case, the health authority is not going to transmit any information to a third party.

3. Transmission because of your acceptance

In certain individual cases it might be reasonable by way of exception to give some additional information to the requesting authority in order to support the fulfilment of their tasks if the legal basis does not legitimate a transmission or provides your agreement. In both situation the health authority will notify you, ask for your previous agreement (=consent) to the transmission - which is a release from the medical confidentiality at the same time – and will transmit data only after your decision about it.

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Computer navigation in total knee arthroplasty – results of a specialized orthopaedic hospital

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Abstract

In 2006 computer navigation was introduced for total knee arthroplasty surgery in the LVR Klinik für Orthopädie in Viersen. Before introducing this new technique the clinical director and the consultants of this hospital received a training workshop on saw bone. As nearly all patients are now operated with this technique we have collected data of more than 800 CAS (Computer Assisted Surgery) operations up to know. The following studies give an overwiew of the so far collected data and the results found.

Computer-assisted joint replacement surgery. Financial and clinical impact for a specialized orthopaedic hospital

We analysed 200 total knee arthroplasties as well as 60 hip resurfacing procedures regarding radiological alignment and costs produced by using computer assisted surgery. Half of the operations were performed by using the CAS technique, the other half was operated by conventional means. We showed that the number of outliers (outside the target 3° Valgus/Varus) could significantly be reduced. A side effect was the reduced blood loss in the CAS group. Because of the prolonged operation time (15 min) in the CAS group and the costs of the navigation device we calculated extra costs of 442€for every CAS operation.[1]

Effect of computer navigation on blood loss and transfusion rate in total knee arthoplasty. A retrospective analysis of 500 consecutive patients

As the previous study had shown a reduced blood loss in the group of patients operated with the CAS technique we looked at a larger group of patients (n=500) to see if this finding is consistent.

The data of 500 consecutive total knee arthoplasties were analyzed and patient related data, operation related data, blood loss and transfusion rates were recorded. The total blood loss was calculated by use of the OSTHEO formula.

The average blood loss in the drainages (standard procedures: 880 ml, navigated procedures: 761 ml) and the calculated total blood loss (standard procedures: 1375 ml, navigated procedures: 1242 ml) was significantly reduced in the navigation group. The transfusion rate of navigated procedures was almost halved (standard procedures: 0.23 transfusions/patient, navigated procedures: 0.12 transfusions/patient).

In summary our study demonstrated a reduced blood loss if total knee arthroplasties were implanted by use of computer navigation. An explanation can be that if using standard jig instruments an opening of the femoral medullary canal is required. This operative step is not required if computer navigation is used. The diminished blood loss resulted in a 50% reduction of allogenic blood transfusions. Hence computer navigation might be attractive for patients with a high risk of transfusions or uncommon blood groups. Prospective studies are required to verify this potential benefit of computer navigation.[2]

How much tibial resection is required in total knee arthroplasty?

To calculate the optimal tibial resection depth in total knee arthroplasty the data of 464 navigated total knee arthroplasties were analysed. An implant with a minimum insert thickness of 8mm was used. Data regarding leg axis, joint line, insert thickness and tibial resection depth were recorded by the navigation device. An algorithm had been developed to calculate the optimal tibial resection depth. The required tibial resection significantly correlated with the preoperative leg axis ($p<0.001$): In valgus deformities the required resection depth averaged 5.1mm and was significantly reduced comparing knees with a neutral leg axis (6.8mm, $p<0.001$) and varus deformities (8.0, $p<0.001$). Manufacturers recommend undercutting the high side of the tibial plateau with the depth of the thinnest insert available. However, our study demonstrates that in valgus deformities a reduced tibial resection depth is preferable. Taking this into consideration bone loss can be avoided in valgus knee deformities.[3]

Is the effect of a posterior cruciate ligament resection in total knee arthroplasty predictable?

Resection of the posterior cruciate ligament (PCL) in total knee arthroplasty is supposed to increase the flexion/extension gap ratio. However, studies are rare and results are inconsistent. Therefore it had been the question of our study if the PCL release regularly increases the flexion gap. Therefore the data of 50 consecutive posterior stabilized knee prostheses were analyzed retrospectively. The joint gap width was measured over the whole range of motion before and after release of the PCL by use of imageless computer navigation. The analysis of the data showed that the release of the PCL had no effect on the extension gap, but increased the flexion gap significantly. A flexion gap increase >3 mm occurred in 36%, an increase >5 mm in 12% of the patients. No clinical relevant effect (<2 mm) was found in 44% of the patients. We sofar can say that the PCL release increases the flexion/extension gap ratio in mean, but the individual effect cannot be predicted. Therefore we recommend a PCL release before the femoral resections are performed, as this step mainly determines the ratio between extension and flexion gap.

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Is referencing the posterior condyles sufficient to achieve a rectangular flexion gap in total knee arthroplasty?

Femoral malrotation in total knee arthroplasty causes flexion-gap instability. Conventional instruments mostly reference the posterior condyle angle (PCA). Aim of this study was to verify whether the computer-navigated flexion-gap (GAP) method produces a rectangular flexion-gap and if a balanced flexion gap could also be achieved by referencing the PCA. 100 knee prostheses were analyzed using the navigated GAP method, and flexion-gap symmetry along with femoral rotation was recorded. The GAP technique resulted in a rectangular flexion-gap by adequate femoral rotational alignment. If the PCA technique would have been used only 34% of the femoral components had been implanted in correct femoral rotation; the remaining 66% had been implanted with flexion gap instability. Due to the low reliability of the PCA method, modern knee prosthesis instrumentation should not base femoral rotation solely on bony landmarks. [4]

Do residents perform total knee arthroplasty using computer navigation as accurately as consultants?

The implantation of a total knee arthroplasty is a milestone in resident's surgical training. Nevertheless several studies demonstrate

higher loosening rates after total knee arthroplasty for inexperienced surgeons. Alignment outliers should be avoided to achieve a long implant survival. Therefore it has been question of our study if residents implant knee prostheses by use of computer navigation as accurate as experienced consultants. The data of 662 consecutive total knee arthroplasties were analyzed retrospectively. The operations were performed by four consultants (n=555) and five residents under supervision by a consultant (n=107). Cutting errors were recorded from the navigation data. Furthermore the postoperative mechanical axis and the operation time were registered. The operation time was significant prolonged if residents performed the operation (139 vs. 122 minutes). The analysis of cutting errors within each surgeon´s first 20 navigated operations resulted in no significant difference between residents and consultants. During the following operations a trend towards a more accurate placement of the prostheses was detected for consultants. The rate of outliers with a mechanical axis deviation >2° was low and did not significantly differ between residents and consultants (3.7% vs. 2.3%). In conclusion, our study shows that residents implant their first total knee arthroplasties by use of computer navigation as accurately as experienced consultants. However, the residents´ operations take longer and therefore determine additional costs for the teaching clinic.[5]

Conclusions

The use of a navigation device for the implantation of total knee arthroplasties has made the following impact on our technique: i) we have less outliers regarding lex axis; ii)Blood loss is reduced; iii)we resect less tibial bone in valgus knees; iv) we do not rely on referencing the posterior condyles to achieve a rectangular flexion gap; v) if PCL release is necessary we perform this step before the femoral resections are done to prevent a too tight flexion gap; vi) we safely can let residents perform this operation under the supervision of an experienced surgeon; vii) the use of an navigation device prolongs operation time even in experienced hands and therefore costs per operation are increased.

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Monitoring insolvency risks of the self-employed orthopaedist

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Abstract

Increasingly often the insolvency practice has to deal with the insolvency of self-employed physicians even though the profit margin of the average physician is still high compared to regular businesses. This essay gives a short survey on the reasons for financial distress of self-employed physicians as far as orthopedists are concerned. The main focus is on the business reasons for financial difficulties; whereat the article stresses the importance of a thorough and honest analysis of the present business success and the future perspective. Consecutively it outlines the legal reasons for insolvency proceedings and draws perspectives for insolvent physicians. This examination focuses on the legal situation in germany but the subsequent guidelines are applicable to other jurisdictions as well. Disparities can mainly be found in the judical elements of the insolvency provisions and the legal forms the jurisdiction provides for self-employed orthopaedists. Statistical data refer to Germany.

Reasons for financial distress

Financial distress of physicians can be caused by various reasons. It is not only the well quotet dentist´s wife that feels entitled to various credit cards, fur and luxury cars. Unlike some decades ago reasons for financial distress of self-employed physicians have increasingly internal (business) reasons. Nevertheless empirically it is in fact the case that external reasons for financial difficulties – differing significantly from other business insolvencies – still play an important part in the picture of physicians insolvencies.[1] It is not retraceable if orthopaedists in general have a more realistic view of their expenditures than other physicians statistically have.

Internal reasons

As far as business reasons are concerned the financial crisis of a self-employed physician often roots in an insufficient analysis of the current business and probable future developents. This diagnosis is not only valid for physicians but also for most businessmen.[2] Especially in very specialised and highly qualified professionals businesses the manager is very often highly confined to and enthusiastic about his respective performance and neglects the basic economic necessities. Historically there often was no need to occupy themselves with profane things like cost-performance analysis because the output was way higher than buisness costs could be. Physicians insolvency was mainly a problem of consumer spending, failed private investment or divorce. Nowadays no self-employed physician can fully neglect the economic structure of his business. Analysis and planning are the two basic keys to this economic structure; they avert, minimise and migate most financial distress.

Analysis has to begin even before the establishment of a physicians business with the (prospect) location. It is of utmost importance to have a clear idea about the current competitors, their services and the social situation of the prospect patients. These criteria determine the economic starting point and further development of the business.

Analysis and planning is also often neglected with respect to the financial situation. A cash planning has to be set up and updated quarterly to set a frame for the bearable costs.

Every business calculation begins with a prediction of the expected business revenue in the periods ahead.[3] For this purpose the physician has to identify the case numbers of the past periods and – with respect to the current internal business and external social developments – has to predict the case numbers he expects in the short term and in the long run.

At the second step he has to identify the prospect revenue he will be able to draw from the predicted case numbers. He therefore has to take a look at his client structure. In 2003 the average self-employed orthopaedist drew about 70-80 % of his total revenue from public health insurance beefits. Bigger practices with total revenues of more than 500.000,00 €p.a. drew only 50-60% from public health insurance benefits. Only 4-5 % of the total business revenue had been realised by services not being subject to public or private health insurance (IGeL).[4] Since then the importance of these services has been growing significantly. Current data have unfortunately not been available at the german statistic office.

The difficulty the self-employed physician now faces is the prediction of the revenue out of his expected case numbers. The outcome of the public health insurance cases in the long term is almost inpredictable due to the high dependency on political ideas and ideologies. Far better predictable is the outcome of the services for private health insurance patients and services not being covered by health insurance at all. Not only for the sake of productivity and cost-effectiveness but also for the sake of predictability it is of advice to enhance the numbers of privately health insured patients and services *out of insurance*.

Due to the incertainty of the outcome of public health insurance services and the high percentage of those services it has to be stated that for the long term a proper business calculation faces serious difficulties.[5] Long-term business calculation is of great importance for all major investments – be they self financed or financed by credit. With respect to the snowballing medical and technological progress the self-employed physician must not confine his major investments to the acquisition and initial modernisation of an existing practice. The ever increasing competition for privately insured patients can very often only be won with ongoing modernisation and continuous investment.

The way of financing itself is another major reason for the financial crisis of a self-employed physician. Most physicians do not favour financing topics being far away from their day-to-day passion. Consequently they are attracted by straightforward financing and therefore tend to finance their routine business on current account or accept their house banks credit offer. A costly financing structure is easy to change in good times but often very hard to change in times of financial distress when costs have to be brought down.[6]

Needless to say that financial distress can also be caused by internal expenditures. Following the proverb *a penny saved is a penny earned* an orthopedist in financial distress has to set up a straightforward cost-performance analysis consisting of a look at the current costs and the respective performances as well as the structure and productivity of the medical services. Moreover costs very often hide in inefficient workflows and unwilling staff. A well approved strategy of cost saving and performance enhancement is the association with other physicians.

However any partnership of physicians can cause further insolvency risks. If there is no proper treaty of association the insolvency of one member leads inevitably to the liquidation of the complete association regardless of the nummber of physicians being associated and the current business situation (see para 728 s. 1 ss 1 BGB). In addition a physician entering the association is fully responsible for all debts burdened by the association so far.[7] Therefore an association has to be well thought of and thoroughly prepared.

External reasons

Not business related (external) reasons for financial distress endanger not only ortho-

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paedists but people of all qualities. External reasons for financial distress are improper consumer behaviour, failed private investments or divorce.

Insolvency

Financial distress does not inevitably lead to insolvency proceedings even though orthopaedists frequently have a comparably high cost structure due to expensive imaging devices. Still the profit margin of the average orthopaedist is relatively high compared to a *regular* business. In 2003 the average orthopaedist had an profit margin of 40% whereas the profit margin rose to 50% in major orthopaedic practises with revenues of more than 500.000,00 € p.a.[8] Self employed physicians often have the advantage that the cost structure is quite flexible in the medium term. The average orthopaedist spent in 2003 about 20% of his total revenue in salaries and wages.[9] Restructuring is frequently linked with cost reduction and reducing of expenditures for salaries and wages as well as for room costs and machinery.

Generally speaking insolvency is the inability to pay one's debts. Law is the art of differentiation therefore in the legal sense we differentiate between two legal forms of insolvency; cash flow insolvency and balance sheet insolvency.[10] Cash flow insolvency occurs if the debtor is unable to meet all his debts at the time they fall due (e.g. para 17 s 2 InsO). Balance sheet insolvency defines the situation in which the debtor has negative net assets; his liabilities exceed his assets on the balance sheet (e.g. para 19 s. 2 InsO). In the early stages this backlog of liablities consists of debts that are not yet due or debts that are not called for. Therefore balance sheet insolvency oftentimes occurs long before cash flow insolvency when the debts being due cannot be met out of the liquid assets any more.

Balance sheet insolvency is not in all jurisdictions a clear legal reason for insolvency proceedings.[11] In Germany balance sheet insolvency is higly contended as it legally trigers the necessity of filing for bankruptcy of companies with (directly or indirectly) limited liability. [12] Balance sheet insolvency does not necessarily affect the daily business because there is no need to consider debts that are not due or not called for.

In a judical sense balance sheet insolvency is relevant only for companies with in some way limited liability as it legally triggers the necessity and the obligation of filing for insolvency proceedings at this early stage (e.g. para 19 s. 1 InsO). For this examination we can neglect the mandatory petition for insolvency proceedings because having historical and legal reasons almost no self-employed physician is organised in the legal form of limited liability.[13]

Nevertheless as an early warning sign balance sheet insolvency is of major importance for companies and individuals with unlimited liability as well. Frequently if a business has a backlog of liabilities it is not far to go before the cash flow insolvency occurs as well and the pressure of the creditors rises considerably leaving no room for negotiations and restructuring efforts any more.[14] Otherwise if the crisis can be identified in an early stage much can be done to change the course by adapting the costs or enhancing the income.

Even the opening of insolvency proceedings does not necessarily lead to the cessation of the medical activities though conducts with relation to financial distress can lead to the loss of the medical approval (e.g. paras 3 s. 1 ss 1 Nr. 2; 5 s. 2 ss 1 BÄO). The modern german insolvency law holds ready various forms of reorganisation and financial restructuring without having to cease the orthopedic profession. The best known remedy is the so called insolvency plan with which obstructing creditors can be maneuvered to a legally framed settlement.[15] After the settlement the physician can continue his profession without loosing his medical approval.

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The ethos of the medical healing arts throughout history

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Abstract

Is the doctor only responsible for the undisturbed flow of bodily functions? If the doctor is nothing more than a highly specialized repair specialist, who have to balance the bodily functions back into balance, or a technician who is to make regular checks in accordance with a service agreement, keep the engine running to its customers in daily life? The advanced mechanization of modern medicine has its own laws and to consider the tendency of everything in terms of ordered functional processes.

Time and again since the Middle Ages the question was asked: What are the duties of a good doctor? What qualifications, which guarantees the successful University of therapies? This duality of profound technical and scientific training and compliance with fundamental ethical issues of professional identity and appeal to make today, for the good doctor.

The orthopedic surgeon works within the meaning of *Orthos paideuein* as an educator to the upright. This education on the attitude adresses, ideally, as well the inner attitude of the patients because the orthopaedist like every physician has in addition to his medical a social and ethical mandate.

Nevertheless, the medical profession is in its very essence a practical profession.(1) It is about enabling reasonable action on the patient. The concept of the art of medical healing dates back to the teachings on science of *Aristotle*, the art in the sense of *techné* as a range of practical use of concrete objects and persons that is relevant, responsible, principles-based and refers to competent expertise.(2)

Therefore the basic question to modern medicine is directed to the goals that are targeted by medical activities. But does this limited approach fully deplete the ethos of medicine? Is the physician responsible only for the undisturbed activity of body functions? In this sense the physician is nothing more than a highly specialized mechanic, who has to bring the body functions back into balance, or a maintenance technician that does regular checks according to a service agreement. He would then be responsible to keep his customers engine running in their daily life. The advanced mechanization of modern medicine obeys its own laws and therefore tends to subordinate the medical treatment to functionality and effectiveness.

According to the underlying purpose of medicine, certain forms of current medical practice as well as certain aspects of the education of prospect physicians are to be criticised. Beyond the mechanical approach to medicine that is even aggravated by the technical progress finally medicine has to take into account not only the disordered part but the whole body and the whole person.(3) Because if a person is sick he/she is not only disturbed in his body functions but deranged in the wholeness of the *Humanitas*.

Beyond *case-by allowance* and *classification in DRGs* the physician has a specific duty: he draws the absolute confidence of the sick person, of the patient, the sufferer. Nobody else is closer to the patient in the time of suffering. According to current surveys the medical profession is among the most popular professions in all of Europe. The special dependency of the patient results in a strong guarantor position of the physician towards the patient. This guarantor position is legally fixed and has been fully undisputed throughout European cultural history. To minister the health of people has always been the prerogative of the experienced persons that thereby *advance towards the gods* as the philosopher *Empedokles* depicts it.(4)

Where health is absent wisdom cannot be revealed, art can find no expression, strength cannot fight, wealth becomes useless and intelligence has no consequences had already been noted by the Alexandrian doctor *Herophilus* as early as 300 BC; (5) 22 Centuries later to the physician and writer *Arthur Schnitzler*, next to life, health and love are the *absolute properties* of mans entity.(6) In ancient times the range of medical specialists was still wide and the medical profession had been widely respected even though *Herakles* at about 500 BC inveighted against the *worthless physicians*, her painful treatment and their greed.

Even in ancient times people discussed issues of human dignity, freedom of research, medical autonomy, scientific ambition, the marketisation of medicine and the issue of human and animal studies. Those topics are timeless; these issues are still contentious today. They still require a close dialogue of Philosophy, religion and medicine and since ancient days of hippocratic enlightement influence the ethos and mission of physicians.(7) Many a physician benefits from his *metaphysical* status and demonstrates a corresponding self-confidence. In ancient times a successful physician was initially not successful due to his art, but successful only as a result of divine decree to which he was an agent. The medical ethic required to worship deities like *Hygieia*; *Panakeia* as well as *Apollo* and his son *Askleipios*. In case of medical success it was essential to praise their grace and effectively to be grateful.(8) In ancient Greece the physicians influenced the current idea of man, that was ruled by the ideal of *kalokagathia*. According to this ideal health, beauty, soul and moral superiority were the main objectives. Those objectives manifested themselves in and therefore required physical perfection only physicians were able to provide and maintain.

This ideal of beauty however, contrasts to simultaneously existing ethical perceptions that were characterized by compassion to the patient. In the Hippocratic Corpus - one of the most influential collections of ancient medical writings (5th-3rd century BC), the physician is displayed as a servant to his art concentrating on three topics: the illness, the patient and the physician himself. The physician in those days confronts physical and mental suffering simultaneously according to his scientific knowledge and his empathy. After about 500 BC, the high reputation of the physicians was based on their scientific knowledge and the primarily scientific approach of medical treatment.(9)

In early Christianity the ancient scientific and therefore heathenish approach of medicine was regarded as invalid. An anonymous writer of the 4th century displayed his astonishment that heathenism had created something as miracleous as medical remedies.

The then developed idea of *christus medicus* and his healing miracles being described in the new testament elevated the activities of physicians to an *imitatio Christi*. The ethos of physicians had been particularly influenced by the image being transported by Jesus

works of mercy as they are described by the new testament. In those writings Christ does not appear as *christus medicus* but as *christus patiens* (Mt 25, 31-40). Consecutively the image of the physician was determined by one of Christ´s main declarations: *What you have done to the least of my brethren, ye have done it unto me*. Christ is recognized in the suffering person and the battle against illness had been enhanced to the virtue of charity; to the compassion and love of fellow human beings as to Christ himself. The physician that helps someone to sanity is acting in the spirit of the gospel. In medieval Europe the self-understanding of physicians had been primarily based on the compassion to Christ himself by the compassion to his creatures. Scientific

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interest had always been a complement motivation.

In 526 at Montecassino *Benedict of Nursia* laid the roots of the occidental monasteric tradition. The occidental monasteries had established an intermediary approach between the ethical and scientific foundation of the medical profession. Shortly after the foundation of the first monasteries primary health care for the European population had been gradually taken over by the monasteries that were able to provide huge libraries containing comprehensive ancient scientific knowledge.

Monasteries set up great hospitals and cultivated *hospitals of christian character* (*Xenodocheia*).

The establishment of monastic hospitals had prevented affliction and hardship of countless sufferers, poors, lonelies, orphans, and pilgrims, that until then had no help whatsoever. Thereby the monasteries had concluded a dark and hardly perceived Chapter of medieval culture history.

The monasteries provided rooms and specialised staff for health care whilst the physicians treated their patients in separate ambulatories. In the course of the medical practice at the monasteries the moncs developed profound medical-scientifical research and knowledge as well as a proper *health care management*. In the middle age the physicians regarded body and soul as closely connected; therefore *Isidor of Sevilla* postulated a comprehensive wholistic education of a *true* physician. The establishment of universities at Salerno, Montpellier, Bologna, Oxford or Paris elevated the education of prospect physicians on an academic level. Thereby the monasteries lost a great part of their former souvereignty of interpretation whilst the education at the university re-focussed on the antique knowledge and especially the arabic authorities as *Averroes* or *Avicenna*. The *art of healing* was studied after a specific curriculum set up by the university. The universities compelled adherence to ethical principles like gratuitous treatment of the poor, strongly advise the seriously ill to give their confession, not to favour certain pharmacists or dealer and most of all not to dispatch the patients for compassion. The profound ethical education of the prospect physicians in those days was as important as an scientifically elaborated treatment. A science *nerd* seemed unthinkable. Time and again since the Middle Ages the question was asked: What are the duties of the physician? What qualifications and which university guarantees the success of a medical treatment? Until now this duality of profound technical and scientific training as well as compliance with fundamental ethical issues determine the *good* physician. Still today it is the mission and not the profession that constitutes a good physician. This idea was probably best expressed by the contemporary of *Goethe*, the physician *Christoph Wilhelm Hufeland* (1762-1836). In 1806 he stated that "the good physician must not deplete in healing but preserve life even in futile situations, he has to attend the patient even while dying and at least alleviate the process when death is inevitable.

The physician shall and must preserve life no matter if life seems worthy or unworthy, fortune or calamity; the decision is not his. Once he arrogates the decision the consequences are fatal and the physician becomes the most dangerous person in the state.(10)

Since the 19th century the physician's conscience is shaped by two momentums. In the first place it is the discussion of whether if what is scientifically possible is ethically permissible. What is being compelled in the second place are the economic necessities of modern medicine. Nowadays in countries like the U.S.A. healthy appearing persons with a problematic genomic situation have difficulties in finding a life insurance. In our days imponderable things like quality of life are thought to be measurable. Subjective views seem objective despite reverse historical experience. For all centuries until today the unalterable core of medical ethics is still valid: The physician serves life. (11)

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The supply of orthopaedic surgeons and general practitioners in rural regions with respect to demographic change

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Abstract

According to recent prognoses, there will be a lack of orthopaedic specialists in rural regions in Germany, threatening the population's medical attendance. In Germany public sector entities are obligated to assure the services for the public. This is why it is more important to try a prediction of the future of medical supply with general practitioners with respect to demographic change than of medical supply of specialists.

Introduction

Area-wide and adequate health care for the people belongs to the services of general interest of our social state and should, if possible, be available in the area close to where people live. However, people feel attracted again by towns these days, rural regions are losing more and more their attraction – particularly for young people.

They think life in the countryside is more inconvenient than urban life, the infrastructure is not very much developed, and all in all living in the country is by far simply not as practical as in the urban centres of our country.These opinions, of course, also affect the supply of doctors in the region. So there are not enough female and male doctors in every region of Germany already today – despite an increasing number of doctors.

This situation is going to worsen due to the demographic change in the following years. Many of the family doctors who are practising medicine in the countryside now, will stop working by reason of age. But at the same time the number of working female doctors will increase considerably. That means that there will be a higher demand for doctors as a consequence of part-time models and maternity leaves.

Both the supply of general practitioners and of medical specialists will be affected by this.

The services of general interest comprising basic medical care are first of all important at the general practitioner level.

While the number of doctors is decreasing, people are getting older and older.

So the percentage of 60-year-olds and older people increased considerably in the period from 1991 (20.4%) to 2007 (25.3%). This trend is going to continue thanks to medical progress. It is important to note that fewer doctors are going to attend to more patients in the future.[1]

The situation in North Rhine-Westphalia/District of Euskirchen

At the moment there still are not any problems with the supply of general practitioners in the countryside. The age distribution in the district of Euskirchen does not look alarming at first glance either.

About the 7.6% of the general practitioners in the district of Euskirchen are 39 years old or younger, 30.3% of them are between 40 and 49 years old, most of them are in the 50-59 age group (42.4%). Only 19 % are older than 60 years old.

All planning areas are more than sufficiently provided with doctors. The supply of general practitioners accounts for 110% and definitely meets the target.

But the problem is that the distribution within the fifth biggest district of North Rhine-Westphalia is uneven.

The medium-sized and big towns and municipalities belonging to the district (e.g. Euskirchen and Mechernich) are better provided with medical facilities (both towns even with hospitals) than the small municipalities with fewer than 25,000 inhabitants.

However, one has to bear in mind that even in the small municipalities about one third of the general practitioners will give up their medical practice in the following ten years.

In 2009 the government of the state of North Rhine-Westphalia then worked together with the association of statutory health insurance physicians and compiled a list of those municipalities that are threatened by an undersupply so that, as a consequence, primary care will not be ensured furthermore.[2]

The criteria for this list were the number of inhabitants (only municipalities with fewer than 25,000 people) and the percentage of female and male doctors not older than 60 years.

It is assumed that older practitioners are going to give up their medical practice anyway soon and that these practices are not going to be taken up by new doctors.

If the percentage of general practitioners who are older now than 55 years is around at least 50%, the municipality will be threatened by undersupply (category 1).

If the percentage of general practitioners who are older than 55 years is less than 50%, the supply of family doctors in this municipality will be threatened in a medium-term perspective (category 2).

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In both cases the degree of supply threatens to be lower than 75%.

The municipalities of Dahlem and Hellenthal in the district of Euskirchen belong to category 1. The municipalities of Weilerswist and Blankenheim belong to category 2.

Thus, as far as the prognosis of health services is concerned, the district of Euskirchen is comparable to other districts of the region like the city region of Aachen or the districts of Düren and Heinsberg.

The situation is similar in the Westphalian districts that belong to the *Münsterland* or to the *Sauerland* – in other words to the rural areas of North Rhine-Westphalia.

The bigger towns of the district of Euskirchen like the towns of Mechernich and Euskirchen will not be undersupplied in the future from a medical point of view as well.

But the problem cannot be solved by moving people from the southern part of the district to set off to the towns. The distances are partly too long (Weilerswist is barely 50 km away from Dahlem).

Countermeasures

The demographic change of the population cannot be stopped. Politicians, however, attempt in many different ways to keep the effects on the social systems as low as possible.

Politicians and members of the association of statutory health insurance physicians planned a bundle of measures in order to minimize as far as possible the effects that a decreasing number of doctors might have in rural areas and to guarantee the supply of family doctors in this area in future.

Polit measures

At a special conference of health ministers federal and state governments agreed on basic guidelines ensuring primary care. A law regulating medical care is planned. It is still open to which extent the following suggestions will be taken into consideration.

The members of the special conference of health ministers discussed numerous other issues along with the following measures aiming at resolving the problem.

At present the federal state of North Rhine-Westphalia is supporting the taking up of a general practitioner's medical practice in a municipality of category 1 with €50,000, in a municipality of category 2 with €25,000. This

support is given in the form of a loan which only has to be repaid if the candidate runs the medical practice in a municipality of category 1 for less than 10 years. If a general practitioner works less than 5 years in his medical practice located in a municipality of category 2, he has to repay the money.

The Federal Ministry of Health and the members of the conference of health ministers support the idea of raising the number of university places to study human medicine at individual universities. The fact that the students' final marks in the school-leaving exam are the decisive factor for the allocation of university places should be reconsidered as well.

In this connection binding criteria like suitability and motivation should be recorded and formulated definitely. It is also planned that student-doctors commit themselves at the beginning of their studies to work as a general practitioner in the countryside after completing their studies. Thus, they will be able to circumvent the strict requirements for admission to studies.

The federal states support the setting up of professorships for general medicine.

Furthermore, students are to have the opportunity to spend the practical part of their studies outside the university hospitals. Ambulatory health care is to play a more important role during training.

Regional financial incentives regarding doctors' fees are to help prevent an undersupply. In this connection the federal and states governments want to encourage the health insurances and the association of statutory health insurance physicians to provide more money for the supply of family doctors.

Many doctors are overburdened with the organization of their medical practices and the administrative work required. In this connection this effect could be avoided by having the staff provided carry out non-medical tasks. Thus, the doctors will have more time to turn to their primary tasks.

In the rural areas in particular the advancement of mobile provision of health services plays an important role. That means that the planned laws are to lift the rules and regulations of professional law for these have restricted the establishment of branch practices.

Female doctors in particular often have trouble coordinating family planning and job. But the number of female doctors will increase considerably in the future. That is why attempts are made to regulate duty rotas which are not compatible with family life and to extend the section of emergency services.

Measures of the association of statutory health insurance physicians of North Rhine

Above all, the association of statutory health insurance physicians of North Rhine focuses on advisory service and further education. Thus, the association offers advice in seminars regarding the cooperation between the medical practices. They also want to draw the attention to the potentials and opportunities of general medicine, with these concepts being presented during the *Praxisbörsentage Nordrhein** in Cologne and Dusseldorf as well as during the *Weiterbildungsbörse***. In seminars doctors are to be offered advice regarding the establishment of a medical practice and information in order to help them realize their plans.[3]

Assessment and outlook

One would have to be a fortune-teller to be able to predict if the targeted measures will guarantee health care in the district of Euskirchen in future. Above all, these measures are projects if need be, so far they have not become law yet. But numerous measures are to be welcomed, e.g. the change of the conditions for studying medicine or the circumvention of these conditions by offering student-doctors the opportunity to commit themselves voluntarily to work in the countryside.

Indeed, there are a great number of young people who wish to work as country doctors but who cannot realize their wish because the requirements are too strict. In absolute terms the targeted measures will lead to the situation that more general practitioners will settle in the countryside. In the light of the geographic situation of the district of Euskirchen (Cologne, Bonn and Aachen as well as Belgium are in immediate neighbourhood as well as good motorway links) one has also to proceed on the assumption that this will have positive effects on the district of Euskirchen.[4]

However, it would be desirable if, due to the expected law regulating health care, the municipalities concerned could have more power in decision-making. As the spatial conditions within the districts are partly very different, the district governments should also be able to flexibly decide clearly-defined measures. Unfortunately the plans of the special conference of health ministers have not yet shown such an approach so far.

But finally, despite all the laws and measures, it is a matter of taste if somebody wants to live and practise medicine in remote areas in the countryside. Administration and politicians in general are challenged to improve the basic conditions that could make life in the country more attractive for young people.

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**Information meetings in the North Rhine area.*
***Information event about further education.*

Magnetic resonance imaging of hip joint cartilage and labrum

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Abstract

Hip joint instability and impingement are the most common biomechanical risk factors that put the hip joint at risk to develop premature osteoarthritis. Several surgical procedures like periacetabular osteotomy for hip dysplasia or hip arthroscopy or safe surgical hip dislocation for femoroacetabular impingement aim at restoring the hip anatomy. However, the success of joint preserving surgical procedures is limited by the amount of preexisting cartilage damage. Biochemically sensitive MRI techniques like delayed Gadolinium Enhanced MRI of Cartilage (dGEMRIC) might help to monitor the effect of surgical or nonsurgical procedures in the effort to halt or even reverse joint damage.

Introduction

Osteoarthritis (OA) of the hip joint is a major cause for disability and pain in the adult population of developed countries.[1] Instability and impingement or combinations of instability and impingement are the most important mechanical factors that put the hip joint at risk of developing early OA.[2] Childhood diseases like hip dysplasia (instability), Legg-Calve-Perthes disease (static impingement) or slipped capital femoral epiphysis (dynamic impingement) are major etiologic contributors to the development of early hip OA.[3] While 50 years ago it was assumed that 50% of hip OA was not attributable to anatomic deformities (idiopathic OA),[4] nowhere days some authors suspect that more than 90% of hip OA is due to instability or impingement.[2]

In order to diagnose and treat patients with FAI or hip dysplasia according to the disease severity, adequate knowledge of magnetic resonance imaging of the hip joint pathology is mandatory.

Hip joint anatomy

The hip joint is large, has to bear a lot of weight and its stability is provided by its rigid ball-and-socket or nut-configuration as well as the surrounding strong ligaments and muscles. The acetabular cartilage is horse-shoe-shaped with a central part without cartilage coverage that does not articulate with the femoral head (fossa acetabuli). Within the fossa, fatty tissue and the ligamentum teres are imaged on MRI. The femoral head is completely covered with hyaline cartilage except for the insertion of the ligamentum teres. The hip joint cartilage is thin in comparison to other joints with the maximum thickness ventrocranially at the acetabulum and ventrolaterally on the femoral head.

The joint capsule is strengthened by 3 ligaments: the iliofemoral ligament is the strongest ligament of the 3 and originates from between the anterior inferior iliac spine and the acetabular rim and inserts along the anterior portion of the intertrochanteric line and greater trochanter. It assists in the maintainance of an erect posture without much muscular activity. The pubofemoral ligament originates from the ramus superior ossis pubis and inserts anterolaterally in the joint capsule while the ischiofemoral ligament is dorsally, originating from the ischium and going horizontally inserting on the upper limit of the intertrochanteric line.[5]

With increasing interest in hip arthroscopy, the role of the ligamentum teres as a secondary contributor to hip stability[5] is under reinvestigation: lesions of the ligamentum teres have gained attentiveness through hip arthroscopy and have been described in up to 15% of hip arthroscopy patients and as a common cause of hip pain in athletes.[6-9] The ligamentum teres (Figure 11H) arises from the transverse acetabular ligament and is attached to the periosteum by to fascicles along the ischial and pubic marcins of the acetabular notch.[6] The acetabular labrum is a sealing rim around the hip joint that consists of fibrocartilaginous collagen fibers attached to the acetabulum and contiguous with the transverse aectabular ligament. The functions of the labrum comprise an increase of the acetabular volume, dissipation of force across the hip, facilitation of synovial lubrication, compensation for minor joint incongruities and dissipation of contact forces encountered by the hip joint.[10-15] The capsular side of the labrum consists of dense connective tissue, whereas the articular side is composed of fibrocartilage.[16] Without intrinsic vasculature the blood supply is provided by the capsule and synovium.[16-19] Its nociceptive and proprioceptive function are still under investigation. Different types of corpuscles represent pressure receptors, receptors of deep sensation and temperature sensation while free nerve endings are pain receptors.[10,17,20] Other than the nociceptive and proprioceptive impairment, a torn labrum will cause a reduction in the described mechanical sealing support thus not anymore maintaining the synovial fluid for force distribution, smooth gliding surface, and nutrition and thus resulting in more cartilage damage.[21]

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Figure 1. Common locations of tendinosis and sprain in the athlete.

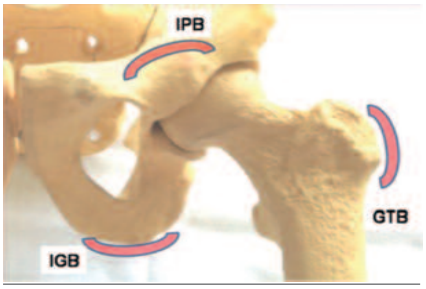


Figure 2. Bursae of clinical relevance.

Rule out other factors of hip pain

In contrast to other joints and due to its anatomic position the hip joint is not always easy to examine and pain around the hip joint might be due to other factors than labral or cartilage damage due to FAI or dysplasia.

Avulsion fractures, insufficiency fractures, osteoporotic or pathologic fractures and tumors around the hip joint have to be ruled out as cause for hip pain. Chronic inflammatory arthritis including rheumatoid arthritis might be accompanied with morning stiffness and other systemic manifestations of the disease. Lumbar radiculopathy and lumbar spinal stenosis might mimic hip pain. Intrapment of the lateral femoral cutaneous nerve might cause meralgia paresthetica with pain or numbness on the lateral aspect of the hip and thigh. Lose intraarticular bodies, gout or pseudogout, synovitis or acute bacterial arthritis have to be ruled out as reason for hip pain. Piriformis syndrome is referred to an iritation of the sciatic nerve by the piriformis muscle.

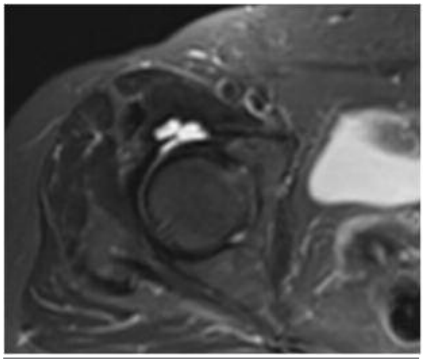


Figure 3. Bursitis and distension of a bursa iliopectinea.

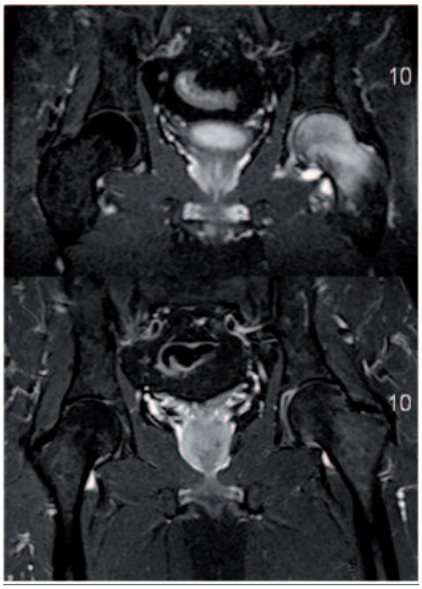


Figure 4. AVN ARCO I.

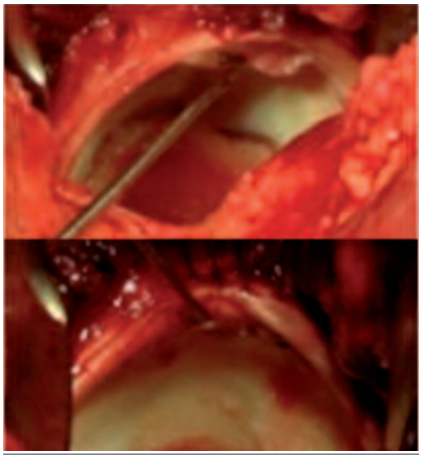


Figure 5. Torn Labrum, suture during surgical hip dislocation.

Iliotibial band syndrome might radiate along the lateral thigh and cause an external snapping hip, in contrast to the internal snapping hip that is caused by the iliopsoas muscle. Sports hernia or athletic pubalgia are occult hernias caused by weakness or tear of the posterior inguinal wall without recognizable hernia, Gilmore's groin with tear in the external oblique aponeurosis, conjoined tendon and dehiscence between the conjoined tendon and the inguinal ligament as well as injury at the insertion of the rectus abdominis muscle, avulsion of the internal oblique muscle or tearing within the internal or external oblique aponeurosis or muscle (Figure 1).[22-24]

Hip abductors have been compared to the rotator cuff of the shoulder[25,26] and gluteus medius tendinous or muscular pathologies including fatty degeneration may be graded and treated according to rotator cuff pathologies.[27]

Other reasons for referred hip pain might be synovitis or mechanical blockade or the sacroiliac joint, osteitis pubis, muscle injuries and enthesiopathies of the adductors, iliopsoas or hamstrings. Chronic microtrauma and injury to the adductors might be caused by an externally rotating *cam-avoidance* gait pattern in cam-FAI-patients.[28,29] A *sports hip triad* has been described recently decribed, consisting of a labral tear, adductor strain and rectus strain.[30]

Bursae might be inflamed and swollen and might be mistaken for tumors or cysts. Bursae commonly affected by acute or chronic bursitis are the greater trochanteric bursa, the iliopectineal bursa (= ilioposas bursa) and the ischiogluteal bursa (Figure 2).

The iliopectineal bursa is the biggest bursa around the hip joint and might communicate with the hip joint in 15% of the people. That is why in MR-arthrograms contrast agent might extend into the iliopsoas (Figure 3).

Therapy of avascular necrosis (AVN) of the femoral head depends on the stage of the disease. MRI has reported sensitivities and specifities as high as 100% for the detection of ON (Figure 4).[31] Treatment strategies for AVN depend on the stage of the disease that might be classified by the Association Research Circulation Osseous (ARCO).[32-34] Since joint preserving procedures for advanced stages of AVN are limited, early diagnosis and effective treatment are necessary.[35,36] The vasoactive, stable prostacyclin analogue iloprost is approved for therapy of critical limb ischemia due to peripheral arteriosclerotic obliterative disease and diabetic angiopathy as well as an inhalative for patients with pulmonary arterial hypertension.[37] Our group and others use iloprost for the treatment of early stages of AVN.[38-41]

Labrum

The healthy labrum has a triangular shape with sharp margins and continous attachement to the acetabular rim and cartilage (chondrolabral junction).[42] The labrum is contiguous with the transverse aectabular ligament, which appears cuboid and marks the medial-inferior part of fossa acetabuli. A labral tear shows increased intra-substance signal with in labral detachment from the acetabular rim, synovial-fluid-intensity signal will undermine the labrum. Labral tears are typically located antero-superiorly. A degenerated labrum appears clumsy with intralabral signal alteration due to mucoid degeneration (Figure 5).

Figure 6. Intra articular contrast administration.

In order to achieve useful images, high MR resolution and contrast to noise ratio are required. Non-contrast MRI is used for the evaluation of bone, necroses, tumors, muscles and marrow space. It seems to be unreliable for detecting more subtle lesions. Mintz et al. found a sensitivity of 96%, a specificity of 33% and an overall accuracy of 94% for the detection of labral tears at 1.5T.[43] Sundberg *et al.* found comparable results for the detection of labral tears comparing 3-T non-arthrographic with 1.5-T arthrographic techniques.[44] With the studies available today, non-contrast MRI is not optimal in the evaluation of cartilage and labrum. In the future and with more sophisticated hardware and software as well as the availability of higher field strength machines, this may change. Direct Magnetic resonance arthrography (d-MRA) after the intra-articular injection of gadolinium-based contrast agent has emerged as the standard method for the evaluation of labrum and cartilage.[45-48] Approximately 10-20 mL of contrast agent is injected into the hip joint under fluoroscopic guidance, followed by MRI within approximately 30 minutes (Figure 6).[49] The intraarticular contrast agent increases the spatial resolution and causes a capsular distension with separation of capsule, labrum and osteochondral structures. The contrast agent can fill into labral and cartilage clefts. Compared to hip arthroscopy as gold standard, d-MRA is reported to have sensitivities of 63-100%, specificities of 44-100% and accuracy values of 65-96%.[50-55] For the detection of labral tears, the inter-observer reliability has been reported to

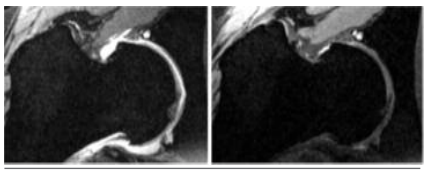


Figure 7. Comparison of i-MRA and d-MRA in one Patient with FAI, cartilage damage and torn labrum.

be moderate.[50,56] With 2 dimensional in contrast to 3 dimensional MRI techniques, the assessment of thickness and orientation of the acetabular lesion was not optimal.[45,50] For indirect MRA (i-MRA) of the hip joint, gadolinium-containing contrast agent is administered intravenously, followed by a delay with or without physical activity. The contrast agent will distribute into the joint, enhancing synovial fluid and providing greater contrast as well as distension of the capsule, allowing for the interpretation of labrum and cartilage.[49,57-61] In one study comparing i-MRA and d-MRA, i-MRA showed a sensitivity of 88% and an accuracy of 90%.[62] Byrd *et al.* demonstrated that D-MRA was much more sensitive in the detection of various lesions, however, arthroscopy demonstrated that d-MRA was interpreted falsely positive twice as much compared to i-MRA (Figure 7).[63] One major advantage for the d-MRA is the possibility to perform a diagnostic infiltration of the hip joint at the same time as contrast agent administration: it has been shown that the reduction of pain after intra-articular administration of a local anesthetic is a 90% reliable indicator of intraarticular pathology.[63] However, the informational value of this probe-infiltration of the hip joint is diminished by the fact that with administration of 20 mL of contrast agent the joint capsule is distended, causing pain itself. Advantages of i-MRA versus d-MRA comprise: the lesser risk of vascular or nerve injury by the injection; the absence of radiation through fluoroscopy; the reduced resource and time intensity as well as reduced logistical effort.

Cartilage

Hip joint cartilage is thin and bony hip anatomy is complex with the shape of the head being more or less spherical. Cartilage lesion assessment is not as well established as labrum lesion assessment. Non-contrast techniques to describe cartilage changes revealed low diagnostic efficiency with sensitivities of less than 50%.[64] Mintz *et al.*[43] described a low reliability in classifying cartilage according to cartilage thickness and signal intensity changes according to the Outerbridge Score.[65] In a study of Schmid *et al.*, the sensitivity of cartilage grading was only 47%.[56] Overall the cartilage diagnosis in the hip joint is limited so far and no reliable staging and grading system has been established.[50,56,66,67] The articular cartilage can be graded with a modification of the classification system of Outerbridge (Table 1).[43]

Femoroacetabular Impingement

The concept of femoroacetabular impingement (FAI) as a major contributor to the development of premature hip OA has been recognized and accepted all over the world. Table 2 demonstrates the remarkable number of publications in PUBMED concerning *femoroacetabular impingement* within the past decade. The cam-lesion is the reduced head-neck offset and bashes against labrum and acetabular cartilage during flexion and internal rotation. This mechanism may cause cartilage delamination from the subchondral bone and labrum. This carpet phenomenon is located mostly in the anterosuperior region of the acetabulum.[68-70] as well as causing intraarticular cartilage damage. In pincer FAI, the acetabulum might be too deep globally or locally, causing an abutment of the femoral neck against the acetabulum so that the labrum might be damaged prior to cartilage damage.[71-75] Further causes for FAI are rotational anomalies with reduced femoral neck antetorsion and/or reduced acetabular retroversion[72,76] or a focal overcoverage after periacetabular osteotomy (PAO) (*Bernese Disease*).[77] In many cases patients show pincer and cam deformities (Figure 8). Untreated FAI can lead to premature osteoarthritis (OA)[69,83] and surgical intervention by open surgical dislocation of the hip, arthroscopy or combined approaches may be warranted. Surgical treatment is associated with positive medium- and long-term outcome. A comparison of the three therapy methods is difficult due to the different outcome measures employed. Studies directly comparing the approaches are warranted to distinguish more clearly between the different treatment options.[78] As in surgery for hip dysplasia, the outcome of surgery depends on the quantity of pre-existing OA with poor results in patients with advanced degenerative changes. Beck et al. described after favourable results after open or arthroscopic FAI-surgery in particular in the subgroup of patients without advanced OA.[69,83] Therefore in FAI-as well as in hip dysplasia patients it is of great importance to identify early stages of cartilage degeneration to be able to identify patients that will profit from osteo- and/or chondroplastic types of surgery.

Diagnosis of FAI

Diagnosis of FAI is based on clinical findings, standard x-rays (anteroposterior and lateral) and MRI. Plain radiographs are often inadequate in underrepresenting the extent of head-neck pathology.[79] Due to the importance of detecting the extent of the deformity as well as early cartilage and labral lesions, MRI is the standard tool for diagnosis of FAI.[46] Furthermore, it is becoming clear that standard coronal, axial and sagittal MR views are less reliable than radially reconstructed planes perpendicular to the acetabular labrum in detecting early degenerative pathologies of the hip.[46,80] For the assessment of the femoral head-neck morphology, radial reconstructions along the femoral neck axis are described[54,81,82] that improve the understanding of the FAI pathomechanism and correlate well with the prediction of an FAI and intra-operative findings.[83] These imaging techniques are increasingly recognized as an important tool for morphologic assessment of FAI as well as improved techniques to detect early labral and chondral damage in the hip (Figure 9).[84]

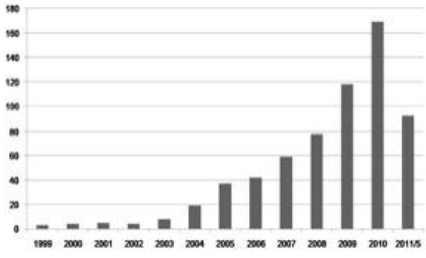
Table 1. Modified Outerbridge classification for cartilage damage.

	Grade	Macroscopy	MRI
	0	Normal cartilage	Normal cartilage
	1	Rough surface; chondral softening	Inhomogenous, high signal; surface intact
	2	Irregular surface defects; <50% of cartilage thickness	Superficial ulceration, fissuring, fibrillation; <50% of cartilage thickness
	3	Loss of >50% of cartilage thickness	Ulceration, fissuring, fibrillation; > 50% of the depth of cartilage
	4	Cartilage loss	Full thickness chondral wear with exposure of subchondral bone

Measurements in FAI

On MRI, different parameters defining FAI can be measured: alpha-angle, head-neck-offset, acetabular depth and acetabular version (Figure 10). Easiest to measure and most important is the alpha-angle of Nötzli[86] that can be measured as described by Pfirrman:[67] the angle is measured between an axis parallel to the femoral neck and passing through the nar-

Table 2. Publications concerning FAI.



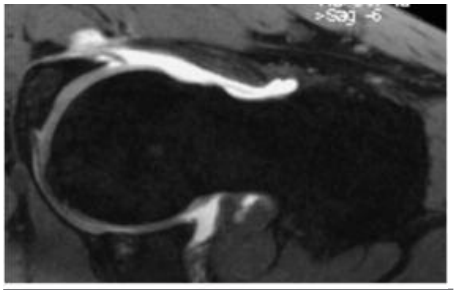


Figure 8. Radial image of a patient with mixed FAI demonstrating a deep socket and a bump deformity. Corresponding labral tear and paralabral cyst.

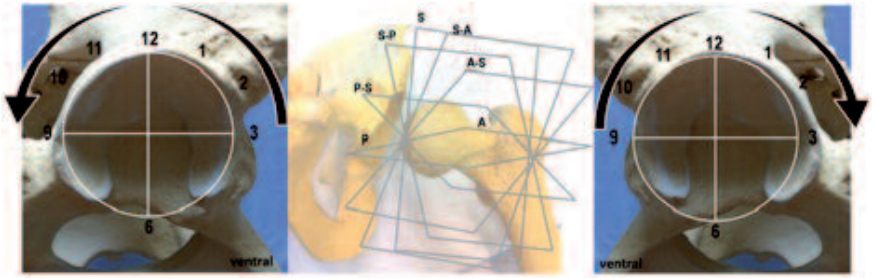


Figure 9. Radial sequences.

rowest portion of the femoral neck, and an axis passing through the point were the head contour passes into the metaphysis as shown in Figure 11K. An angle of more than 55 degrees is indicative of cam deformity. An interval of 30° among the radial reformats should be used to assess alpha angle. The acetabular coverage might be measured by assessing the acetabular depth within in axial reformation. The depth is expressed as distance between a line drawn among anterior and posterior acetabular horn and the center of the femoral head. The acetabular version can be measured on axial 2D T1 weighted images through the acetabular roof, when on the image superiorly where anterior- and posterior rim become apparent. However, acetabular version is better estimated on plain ap radiographs.

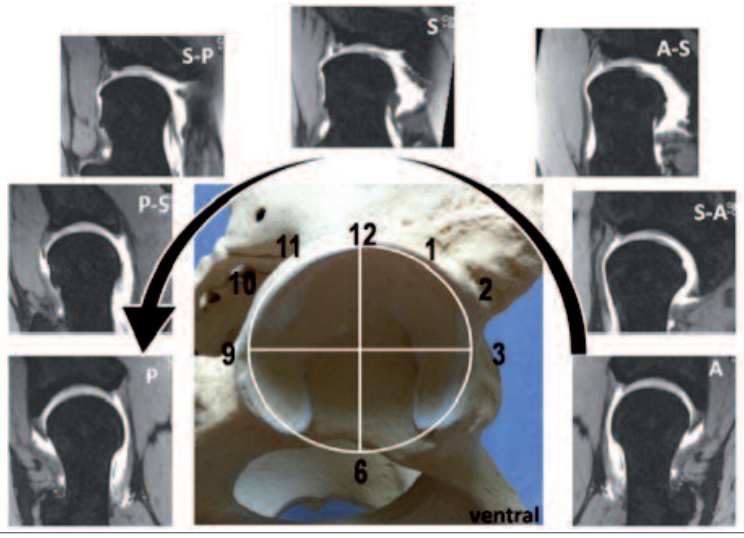


Figure 10. Radial images in a hip dysplasia patient.

Hip dysplasia

In contrast to the FAI, the labrum is typically thick and tears or dissociations are often further dorsolaterally. Chronic overloading of the labrum causes mukoid degeneration and cysts. In hip dysplasia, cartilage damage is more globally than in FAI,[87] although intraoperative findings show, that cartilage damage occurs predominantly in the antero-superior quadrant both in DDH and in FAI.[69,71,88] Figure 12 shows the hip joint of a 17 year old patient with symptomatic labral tear and hip dysplasia.

MRI appearance of normal and pathologic features

Labral shape can differ from small and sharp to thick and round or even absent. Increased signal within the labrum is found in symptomatic as well as asymptomatic patients. A poor histologic correlation is reported for these MRI-findings.[89] Figure 11A shows an intralabral cyst in a 24 years old asymptomatic women. Figure 11B shows a torn labrum in a symptomatic patient that profited from intraarticular lidocain-injection. Obvious perilabral cysts are shown in Figure 11E in a 28 years old woman with extensive hip dysplasia. Sublabral sulcus or recessus (Figure 11F) are reported to be present in about 25% of patients without pathological meaning[90,91] while other investigators found no evidence of a normal sublabral sulcus.[48,92] Perilabral recesses (Figure 11G) can mimic cysts or be mistaken for a labral tear. D-MRA helps appreciating the recess in contrast to i-MRA (Figure 7).[48,93] Figure 11D shows an os ad acetabuli in a symtpomatic FAI-patient. The os ad acetabuli is frequently assicoated with FAI and might be due to a nonunion of secondary acetabular ossification centers, ossifications of the labrum or incomplete healing of rim fractures.[94] Supra-acetabular fossae (Figure 11C) appear as additional cavity anterosuperiorly and can be mistaken for osteochondral defects or osteochondrosis dissecans.[95] Lesions of the ligamentum teres (Figure 11H) have gained attentiveness through hip arthroscopy and have been described in up to 15% of hip arthroscopy patients and as a common cause of hip pain in athletes. Plicae are embryologic remnants in synovial joints that are often symptomatic in the knee joint, whereas in the hip joint, reports are anecdotic. Fu *et al.*[96] describe 3 locations for plicae: labral, ligamentous and neck plicae. The pectinofoveal fold is a band that runs parallel to the inferior neck (Figure 11I) with an incidence of 95% in MRI and 99% in hip arthroscopy,[97] this structure should be regarded as normal and distinguished from pathologic and symptomatic plicae. Slipped capital femoral epiphysis (SCFE)[98,99] might cause cam impingement and early OA. Figure 11J shows the MRI of a 39-year old women with advanced OA with osteophytes and capital drop in the long term follow up after SCFE. The alpha angle is added to Figure 11K as mentioned above. Herniation pits (Figure 11L) are fibrocystic changes along the anterior head-neck-junction that are speculated to be second to FAI.[100,101]

Biochemical Imaging

Even high field MRI machines image fairly late events while minor changes in cartilage degeneration or regeneration cannot be monitored. Biochemical or molecular imaging of cartilage offers the perspective of closely watching into the cartilage structure. Thus, the real amount of cartilage damage can be visualized and the effect of surgical or non-surgical intervention may be observed. Different biochemical imaging methods are able to visualize cartilage quality in measuring collagen or glycosaminoglycan (GAG) content

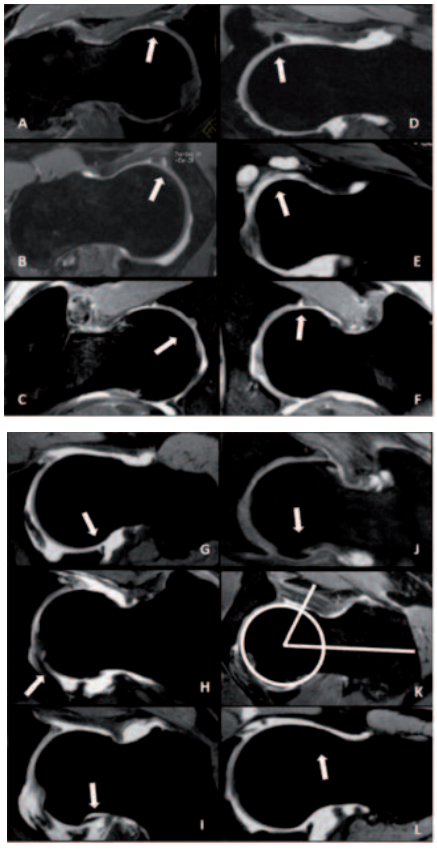


Figure 11. MRI appearance of normal and pathologic features.

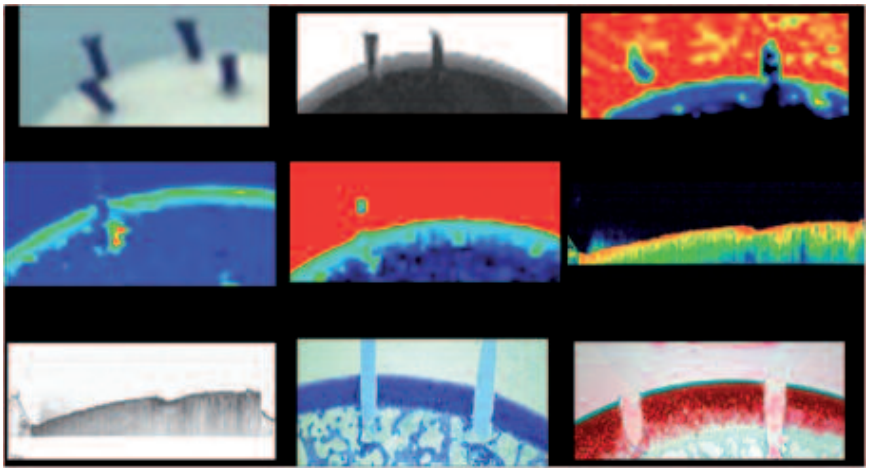


Figure 12. Pre-OP x-ray.

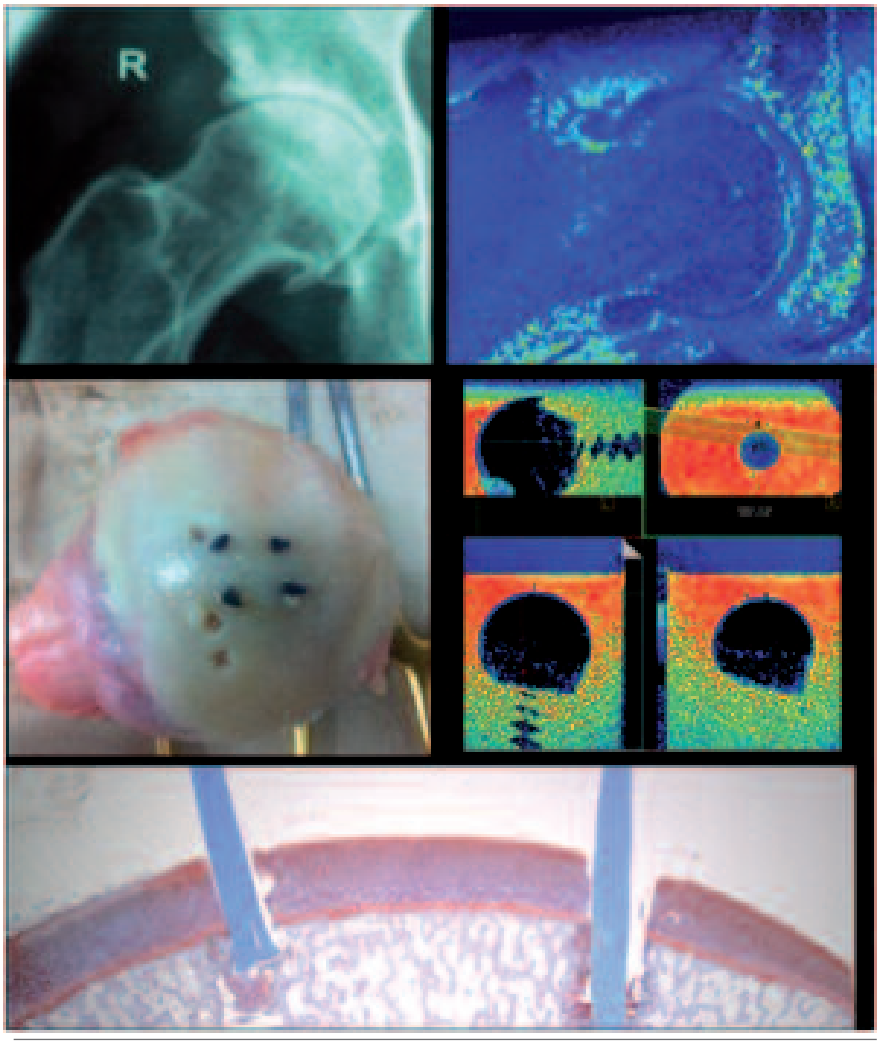


Figure 13. Histo and OCT.

of cartilage. The imaging modalities can be conducted at regular MRI machines, using the contrast agent, that is also employed on a routine basis. Acquisition time is not much higher than standard morphological sequences. However, the post-processing of the images is still fairly sophisticated and time-consuming, preventing these new and promising techniques to become incorporated into clinical routine. GAGs are proteins of the extracellular cartilage matrix that make out more than 90% of the negative cartilage charge. GAG are lost early in the development of OA[102] and might be repleated in cartilage regeneration. Delayed Gadolinium Enhanced MRI of Cartilage (dGEMRIC) takes advantage of this fact: after intra-articular or intra-venous injection, the negatively charged contrast agent gadolinium-diethylene triamine pentaacetic acid ($Gd\text{-}DTPA^{2-}$) penetrates into the cartilage in a reciproce proportional manner to the content of GAG within the cartilage. The contrast agent within the cartilage causes a reduction of T1-time that can be measured in MRI. The dGEMRIC index or $T1_{Gd}$ represents the GAG content within cartilage and high $T1_{Gd}$ values are supposed to be found in healthy cartilage whereas low $T1_{Gd}$ values are found in degenerated cartilage, due to the higher amount of $Gd\text{-}DTPA^{2-}$ within the cartilage. After i.a. or i.v. administration of contrast agent, a delay of 30 to 60 Minutes is warranted before the MRI is performed.[103] T1 relaxation times that are investigated are: T10 (i.e. T1 prior to contrast administration), $T1_{Gd}$ (post-contrast T1) and $\Delta R1$ that defines the difference in relaxation

rate (R1 = 1/T1) between $T1_0$ and $T1_{Gd}$ measurements ($1/T1_{Gd}$-$1/T1_0$). Some authors found out that ΔR1 is a more precise parameter to reflect the Gd-DTPA^{2-} concentration within cartilage as.[104-106] Bittersohl *et al.* evaluated $T1_{Gd}$ and ΔR1 in two different radiographic grades of hip osteoarthritis in symptomatic FAI patients.[107] Asymptomatic young-adult volunteers served as control. A high correlation between T1Gd and ΔR1 in all study groups could be observed. Based on these results, we conclude that $T1_{Gd}$ assessment is sufficient and a further pre-contrast imaging is not necessary. However, some circumstances require the calculation of ΔR1 for accurate GAG evaluation including follow-up of cartilage repair therapy where T10 values may differ especially in the early postoperative stages post-surgery.[105,106,108] Several clinical studies have been conducted so far to evaluate hip joint cartilage using dGEMRIC: in his classic report, Kim et al. report the diagnostic potential of dGEMRIC for assessment of early OA in patients with hip dysplasia.[59] Tiderius *et al.* evaluated the time course of T1 values after Gd-DTPA2- injection with hip dysplasia and early signs of OA.[109] The same group investigated 47 patients undergoing a Bernese periacetabular osteotomy (PAO) for the treatment of hip dysplasia.[110] Multivariate analysis identified the dGEMRIC index as the most important predictor of failure of the osteotomy. Still the same group retrospectively analyzed 37 symptomatic hips with FAI[60] and suggested that dGEMRIC may be a useful technique for diagnosis and staging of early osteoarthritis in hips with impingement. Pre-Arthritic deformities after SCFE and Legg-Calve-Perthes disease were evaluated using dGEMRIC.[111-115] GEMRIC may depict the complex damage pattern of hip joint cartilage spatially and qualitatively better than other radiographic methods. The limitation of these studies using 2-D sequences was that only coronal T1 maps could be obtained. However radial evaluation around the hip joint, which is standard in morphologically MRI or MRA, is essential for the detection of cartilage pathologies for.[46] Recently, fast T1 assessment using dual flip angle (FA) gradient echo (GRE) has been validated and was used in-vivo enabling faster imaging times and three-dimensional (3D) dGEMRIC.[108,116] This technique utilizes inline T1 measurement and allows for faster imaging. Bittersohl *et al.* proved this technique to be a reliable instrument in the assessment of asymptomatic hip joint cartilage.[117] In a pilot study Bittersohl et al. proved the feasibility of cartilage assessment in symptomatic FAI patients using intra-articular delayed Gadolinium Enhanced MRI of Cartilage (ia-dGEMRIC).[118] In another study Bittersohl *et al.*[119] found that mapping with both iv-dGEMRIC and ia-dGEMRIC demonstrated obvious differences between various grades of cartilage degeneration. In ongoing studies we evaluate sequences histologically: in patients that are scheduled for a total hip endoprothesis, an in vivo and postoperatively *in vitro* scan of the hip joint cartilage is performed. Both scans can be combined and evaluated histologically. Different sequences are then subject to further immunhistochemical analyses as well as optical coherence tomography. (Figures 12 and 13).

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The orthopedic in legal cases

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During his professional career the celebratee had to grapple with all kinds of judical provisions covering his faculty of orthopedy like the *regulation for orthopedy* (OrthV),[1] the association articles for the Rhenish hospitals (RK)[2] and the Rhenish hospital for orthopedy in Viersen as well as the *regulation for orthopedic shoemakers* (OrthSchMstrV)[3] and the *regulation for the apprenticeship of orthopedic shoemakers* (OrthSchAusbV).[4] The present article does not broach the issue of these special provisions but gives a very brief survey of the orthopedic in renowned judical cases. During his legal education a prospect lawyer in germany comes across various judical cases dealing with the specialities of orthopedics. These cases determine the view lawyers have on orthopedics. Apparently the author holds a different point of view.

In his first year the law student has resolve the following case.[5] A lawyer and an orthopedic went by their cars one after the other. The lawyer wanted to turn therefore he slowed the car down. The subsequently driving orthopedic was in a hurry and annoyed by the slow motion; he blew his horn and tried to overtake the lawyer. The lawyer unwinded his window, called the orthopedic names and used the translation of the middle of the musculus gluteus maximus. The orthopedic disliked verbal arguing and left his car. The lawyer left his car as well whilst both parties changed over to more palpable arguments. In the course of the scramble the orthopedic pulled the tie of the lawyer whereafter both men were floored. The dispute ended when one of them found himself lying in a front garden behind a little wall. At the end of the day the lawyer complains about a neck disease and therefore wants to consult an orthopedic. The orthopedic himself laments about a cut and is about to mandate a lawyer. The task is to adjudge the respective behavior. In the course of the legal education there are reams of cases dealing with orthopedics as authorised experts in civil law cases or so called expert witnesses in penal law accusations. The only duty of the prospect lawyer concerning these testimonies is to assess the coherence of the testimony and detect infirmity and obvious flaws. In this context there is one special case to be dealt with. A decision by the higher regional court in Zweibrücken (Rheinland-Pfalz) ruled that an orthopedic is not qualified to give testimony about the mental health of the accusee when his expertise is neither obvious nor documented.[6] Though this decision is not a great surprise it is astonishing that this testimony had taken place in the first place and it surprises even more that subsequently to the testimony the lower regional court had in fact confined the accusee to a hospital. Cases get more interesting when the orthopedic itself takes part as a party. Later in the judical education in rather remote fields of law, the prospect lawyer comes across more elaborate cases. In the field of competition law the higher regional court of Schleswig (Schleswig-Holstein) ruled that an orthopedic does not commit a breach of the rules of fair competition in the sense of paragraph 1 of the applicable UWG if he conducts magnetic resonance imaging because the regional constitution demands a corresponding interpretation of the relevant regulation for further education.[7]

A different opinion is held by the lower regional court of Saarlouis (Saarland)[8] and the lower regional administrative court of Cologne.[9] The respective judges agree that an orthopedic is not competent to operate an MRI properly. Please form your own opinion on this topic but as far as there is no decision of the highest national court there is no reliable advice to give.

Another orthopedic sued a public health insurance. He runs a public swimming bath next to his orthopedic practice and attempted to certificate the bath for after treatment with bathes of oxygen or carbonic acid.[10] He remained unsuccessful.

A successful claim was made by an orthopedic who had been interdicted to send all his patients to the same orthopedic technician. The highest national court ruled that this procedure cannot be interfered with if the orthopedic is familiar with the methods of the technician and the advice has a medically justified background.[11]

Orthopedics win in other fields of law as well when the regional court of Hamburg (Hamburg) acceded to the matrimonial agreement of an orthopedic with his former wife providing that after a divorce the orthopedic has no obligations whatsoever to his former wife even though the orthopedic did earn a lot more than her.[12] Precondition for this finding was the fact that both parties were 50 years old, had children of full age from again different relationships before their marriage and were economically independent from each other before their marriage. A different judical perspective to orthopedics and lawyers can be seen by our last sample case. Two orthopedics had been interdicted to advertise their services with the addicion Specialists for knee and backbone operations. The constitutional court of Germany ruled that this kind of advertisement is justified if the orthopedics had been conducting these operations for decades and executed thousands of corresponding operations.[13]

Referring to this judgement a lawyer attempted to advertise for his services as specialist for traffic law. The lawyer lost the subsequent lawsuit because the advertisement as a judical œ would be misleading and unfair competition.[14]

A glimpse in the bible would have told the lawyer that the physician has the competence to cure himself.[5] A lawyer is not addressed…

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15. Lukas 4, 23.

Injury pattern due to falls from hunting stands

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Abstract

Hunting is a historically constructed cultural act and continues to be a passion and a popular recreational pastime worldwide. Along with a high population density in Europe and a large volume of hunters hunting injuries such as falls from hunting stands continue to occur regularly and are a significant cause of morbidity among hunters. The purpose of this study was to review typical injury patterns after falls from hunting stands in Germany between 2000-2009 using the German agricultural statutory accident insurance database and to compare these findings to other causes of hunting accidents. The most common injury pattern after falls from hunting stands in Germany in the period of 2000-2009 are closed fractures. However, data collection is incomplete. Thus a more precise data collection would help to be able to better analyze accident mechanisms in order to be able to prevent further accidents.

Introduction

The thrill of hunting consists in the fact that it is always problematical because it is not essentially for the hunt to be successful.[1] With this remark Jose Ortega y Gasset, one of the greatest cultural philosophers of our times tries to describe the ambivalence of the hunters attitude: On the one hand his loving relationship to the natural flora and fauna and on the other hand the will of chasing and killing the game, which can not always be successful. Very often the hunter comes home preyless, he returns bredouille, but nevertheless with another unique personal experience of outdoor life. Additionally to the pursuit aspect the idea of preserving and taking care of the wildlife creatures and their surrounding is an important challenge and task for todays hunters.

Hunting in Germany is a popular outdoor activity and it is mainly seen as a certain attitude of life rather than a sports activity (Table 1). Referring to the German national hunting company (Deutscher Jagdschutzverband, DJV) there were approximately 350.000 licensed hunters in the hunting year 2009/2010,[2] 82% of them (about 286.000) are members of the DJV. Seen the population of the whole country (approximately 82 million) there is a percentage of about 0,42% hunting enthusiasts (relation of 1 hunter:234 inhabitants). Compared to other European countries e.g. like France (62 million inhabitants; about 1,4 million hunters = 2,25% of the population, relation 1:44) it is a quite rare pastime.[3,4]

Hunters usually classify the huntable wildlife animals into small (e.g. pheasant, partridge, rabbit, hare etc.) and big game (wild boar, red deer, bear etc.). The various different hunting techniques used for both of them include elevated platforms, so called hunting tree stands (mainly in North America) or hunting stands/ high seats (Germany, Europe) (Figure 1). Both of them allow the hunter an expanded field of vision, decrease human scent dispersion at ground level, and lessen the chance of being seen by the game.

In Germany and North America there are several types of hunting stands available, some are commercially manufactured, and others are constructed by the hunter. Mainly in North America there is also a variety of *climber* and *locked-on* models constructed of one or two pieces that permit the hunter to ascend to the desired height.[5]

Tree stands are built in or attached to trees with access provided by a self-constructed wooden ladder, rail spikes, or wooden steps nailed onto the tree trunk. The in Germany more often used high seats however are in most cases homemade or industrially preformed wooden bar constructions with a platform on the top and a so called pulpit nailed on it. Through the surrounding windows the hunter can observe the ground around him. Other kinds of high seats are for example wooden ladders with a small seat on it that rest against tree trunks. All of those constructions are typically placed between 15 and 30 feet above ground level, although there is a certain variation of height depending on the hunters needs.[6] Safety harnesses especially for tree stands are straps attaching the hunter to the stand and are intended to reduce the likelihood of falls.[7,8]

Thinking about hunting related accidents there is above all the concern about the number of firearm injuries, which are well known and widely described.[9,10] In general, hunting-related injuries are often thought to be associated with an intoxicated hunting companion who has a *happy trigger finger*, which is a contention often sensationalized by the press. Throughout the last years the dangers of hunting tree stands have already been characterized in the American Medical Literature. In a retrospective study of patients involved in hunting related accidents Crockett *et al.* demonstrated that in the Midwestern USA tree stands and not firearms were the main cause of heavily injured hunters and that alcohol consumption seemed uncommon among hunters who fell.[11] Other authors also describe falls as the most common way for hunters to be injured.[5] It is estimated that about 10% of hunters who use tree stands are injured annually and more than 75% of tree stand injuries occur during use of fixed positions or climbing stands.[12]

Falls from tree stand heights are associated with high morbidity, in the study of Crockett et al. 80% of the fall victims underwent operative intervention and nearly 10% had permanent neurologic deficits. Common fall sequelae were spinal injuries, lower extremity fractures including the hip joint, and traumatic brain injuries. The severity of the injury pattern after falls is explainable seen the height of the stand (mostly 15 to 30 feet) and the fact that the body can reach impact velocities of up to 30mph. Other factors that influence the type and amount of trauma include the time duration and orientation of the body at impact, the landing surface, the time duration of impact, the distribution of force, secondary impacts, and age and physical condition of the patient.[11,13,14] As Lowenstein *et al.* already described the height of the fall directly influ-

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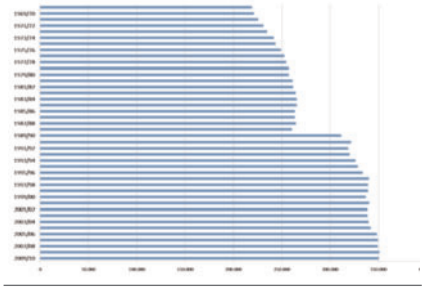

Table 1. Number of Hunters in Germany. Note: German re-union of East and West - Germany in 1989/1990

ences the velocity of impact. The maximum impact velocity or terminal velocity is limited largely by air resistance and for the human body is approximately 120 miles per hour and requires a height of 480 feet at sea level.[13,14] Hunters falling from trees can also sustain secondary impacts with tree limbs. These secondary impacts affecting the body orientation at final impact can cause additional injuries and can also reduce the final impact velocity.[13]

The incidence of tree stand falls is difficult to determine because many falls happen unreported. Deaths occur, but infrequent.[5,6,13-16]

In the current study we retrospectively look at injury patterns after falls from hunting seats in Germany in the years 2000-2009. The used data was presented by the German agricultural statutory accident insurance company (*Landwirtschaftliche Berufsgenossenschaft, LBG*), a federal insurance institution responsible for the prevention, protection and medical treatment of patients involved in accidents while working professionally in jobs on the rural site like farmers, forest rangers, professional hunters etc. Because of the lack of an obligatory registration of hunting accidents in Germany most cases might remain unreported and neither the exact anatomical injury sight nor a follow up of patients reaching a local trauma center can be given. A helpful tool to estimate the number of hunting related accidents and to ensure a follow up of patients concerned may possibly be the recently erected trauma registration of the German Society of Traumatology (DGU, Traumaregister).

Materials and Methods

For the presented retrospective study data was given by the LBG, the German agricultural statutory accident insurance company concerning the total number of hunting-related accidents from 2000-2009 and especially those with hunters involved in falls from hunting stands/high seats. There were in total 8563 reported cases of hunting-related accidents, 684 of them due to falls from the height of a high seat/hunting stand. The LBG confirmed a total amount of 51 deaths, 6 of them due to falls from hunting stands. The data included apart from the pure number of cases a superficial overview of the anatomopathology of the injuries without giving details about the precise body location.

Unfortunately there was no information about age, gender, comorbidities, height of fall, time until presentation to emergency department, medical treatment including emergency room treatment, precipitating causes, exact anatomical level and type of injury, associated injuries, time of hospitalization and patient outcomes.

Results

In the years 2000-2009 there were 8563 cases of hunting related accidents reported to the LBG in Germany. 684 of them were reported as falls from hunting stands. Most injured persons have been counted in the year 2002 (1009), 102 of them after hunting stand falls. Throughout the years there were in total 51 deaths, 6 of them due to falls from hunting stands. The most common injury pattern were superficial soft tissue injuries/ skin injuries (1978) followed by concussions (1466), closed fractures without further anatomical detail (1139), dislocations/luxations (1000) and penetrating of foreign bodies (477). Looking at the injury pattern after falls from the height of a hunting stand closed fractures were the most common injury sequelae (245) followed by concussions (172) and dislocations/luxations (82).

Firearm injuries occurred in 85 cases (0,99% of the total amount of hunting related accidents) and ended deadly in 11 (12,9%). The fatalities due to falls from hunting stands (6 of 684) make up 0.87% of this entity compared to 0,07% seen the total amount of hunting accidents. Most of the hunting related injuries happened in the year 2002, both the total amount (1009) and the amount of hunting stand falls (102). The years to follow are 2003 (971/ 72) and 2001 (912/ 84). In the year 2004 most of the hunting fatalities occurred (11), followed by 2008 (10). 2008 has also been the year with the highest amount of deathly injured persons by falls from hunting stands (3).

Constrictively we have to say that the results are preliminary and that the estimated number of unreported cases is much higher.

Discussion

In the current study we present the available descriptive epidemiology of hunting stand related injuries in Germany in the past decade. To the best of our knowledge there is no other study describing the amount or injury pattern after falls from hunting stands. We compare our findings to American studies, that deal much more often with this subject.

As we could see from the LBG data closed fractures including the lower extremities made up the most common injury pattern due to hunting stand falls. This is consistent with other studies demonstrating a similar injury pattern.[6,8,15] The often injured lower extremity can be explained by hunters trying to land on their feet after they fall. This is also consistent with previous studies that suggest fractures to be the most significant type of injury associated with most body locations[6,7,8,15] and consistent

Figure 1. Typical hunting stand/ high seat in Germany

with falls from a substantial height.[17] Spinal fractures are also a very common injury pattern and play a significant role, often associated with concomitant neurologic injury, extended hospitalization, and permanent disability. Up to 33% of spinal injured hunters are permanently paralyzed as a result of their accident.[5,17] Regarding the age of hunters involved in accidents there is evidence, that younger hunters are more likely to be injured in general.[18] As Terry *et al.* described in 2010 25-34 year old hunters have a higher injury rate although only 17% of hunters in the USA are in this age group and nearly half of hunters are aged between 35 and 54 years.[7] Regarding the German LBG database on hunting accidents we see according to Crockett *et al.*[11] a higher rate of injuries due to falls than to firearm accidents. Falls occur much more often, but they are not as lethal as firearm injuries.

Within the presented data of the LBG we found no evidence on alcohol being cause of hunting injuries, although previous research showed that it is a possible cause of hunting stand-related accidents, because it both decreases the perception, balance and concentration needed to operate a hunting stand correctly and to increase the risk of falls.[6,8,19] However, evidence suggests that only approximately 10% of hunting stand-related injuries might be attributed to alcohol.[6-8,15]

During the thorough 9 month hunters training in Germany which ends with an exam over 3 days the aspirant learns among other things some theoretical and practical aspects of outdoor constructions such as hunting stands, ladders etc. Nevertheless hunting stand safety regulations must be a higher priority for hunters as well as manufacturers of hunting stands, because it is estimated that 30 per cent

to 50 per cent of all hunting stand falls are attributable to failure of the stand, and failure seems to be more common in homemade stands than in commercially available stands. Although mechanical failure of hunting stands may be the most common preventable cause of these falls other factors could contribute to falls from these platforms like small platform size, darkness, fatigue, exposure to environmental extremes, user inexperience, less commonly drug or alcohol abuse.[11] In Germany the legal hunting day for large game from a hunting stand begins 1 hour before sunrise and ends 1 hour after sunset except for wild boars, that can also be hunted during nighttime. Therefore darkness may compound the difficulty of ascending to or descending from a tree stand. After successfully mounting their stands deer hunters often remain perched on these tiny platforms for hours, holding a weapon and enduring variable weather conditions.[11] In many states of the USA hunters education includes a mandatory hunters safety course with a special dedication to tree stand safety. Most commercially available tree stands warn hunters of the risk of falls and recommend the use of safety straps while ascending, sitting, and descending from the stand. At present all manufactured new tree stands in the USA come equipped with safety harnesses, but it is unknown what percentage of hunters are using these arrest systems.[11] Nevertheless hunters should be properly educated on the safe and proper use of these stands including besides the use of safety harnesses a regular maintenance of the stands, and for those hunters who prefer to build their own stands, proper instruction on construction of stands.[17]

Conclusions

Although hunting stand-related injuries are a major cause of morbidity among the hunting population they are preventable.[7] Aggressive hunter education programs should help reduce the incidence of these potentially serious accidents while focusing on safe climbing techniques, use of safety equipment and abstinence of alcohol while hunting. Additionally hunting stands should not be used by persons with medical conditions that may predispose them to an increased risk of falling down.

For the local situation in Germany it is desirable to have a more precise registration of the circumstances of hunting accidents including the above mentioned aspects, exact anatomical injury region of patients, and information about the further medical treatment. These informations given future prevention of severe hunting accident sequelae may be much easier. Further study efforts in this direction are surely helpful. Proposing this we fully acknowledge the limitations of a retrospective epidemiological study, but on the other hand the nature of the mechanism of injury and the individuality of each injury prevent a thorough prospective randomized analysis.

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The idiopathic clubfoot and its treatment options

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Abstract

As congenital clubfoot is one of the most common skeletal deformities, the incidence is known to be 1-2/1000 in newborns. Pathological changes of joints, bones (especially the talus), muscles, tendons and soft tissues result in subtalar malposition: equinus, varus, adductus and cavus. Systemic or neurologic disease developing over time or present at birth may cause secondary clubfoot. Primarily conservative treatment, involving manipulation and serial casting should start early after birth. Today the Ponseti method is the treatment of choice. The rate and extent of surgical treatment is substantially reduced and functional outcome has improved.

Background

Clubfoot is one of the most frequent birth defects involving the musculoskeletal system. It is classified in two groups: postural or structural. It is characterized as a three dimensional complex deformity consisting of equinus at ankle joint, inversion at subtalar joint and adduction at talonavicular joint in different extent. It is diagnosed clinically and may be acquired or congenital. The Ponseti method has changed the management of idiopathic and increasingly also secondary clubfoot in children from a typically surgical to a primarily conservative approach.

Epidemiology

The incidence of congenital clubfoot in the Caucasian genome in central Europe and North America is known to be 1-2/1000 newborns. In Polynesians, idiopathic clubfoot is 6 times more frequent than in central Europe, in the Chinese genome it is rare (0.5 to 1 per 1000). The male to female ratio is 3:1 and 30-50% are bilateral.

Etiology

The reason of idiopathic clubfoot is yet still unknown. Multi factorial origin affecting the development and differentiation of soft tissues, bone and joint surfaces is becoming more clear. Intrinsic[1-3] and extrinsic cause[3-6] can be proposed. Genetic factors clearly play a role. Lochmiller *et al.*[7] showed a 33% concordance of identical twins and 25% familial disposition. The congenital clubfoot has to be distinguished from the secondary clubfoot and is associated with neurological or systemic disease.

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Pathophysiology of the clubfoot

Bone

Malrotation of the subtalar joint . In relation to the talus, navicular, os calcis and cuboid are displaced medioplantar (Figure 1).[8] Cavus is due to pronation of the forefoot in relation to the hindfoot. Additionally the first ray is plantar flexed. The metatarsals and cuneiforms are normally shaped but adducted. The navicular is medially displaced and inverted and as well as the talus wedge shaped. Calcaneus is medially displaced, plantarflexed and inverted. Calcaneus may lie in line with the talus (reduced anteroposterior and lateral talocalcaneal angle in the x-ray).

Muscle and soft tissues. According to Virchow, Scheel and McKay[9] clubfoot is characterized by subtalar malrotation caused by thickening of the joint capsule and ligaments and hyperactive m. tibialis posterior. Atrophy of the peroneal group is always found in congenital clubfoot and persists also after successful correction of the foot. The number of fibers is normal,[10] but smaller of size. Tendon sheaths, joint capsules and ligaments of the medial part are shortened and thickened and on the lateral part of the foot lengthened. Contractures especially of the talonavicular and calcaneaeocuboidal but also of the posterior ankle capsule and subtalar capsule exist. Shortening of the m. tibialis posterior are frequent findings. The shortened deltoid, the long and short plantar, spring and bifurcate ligaments are contract, fibrotic and contribute to the cavus.

Diagnosis

Presentation

Congenital Clubfoot is diagnosed by inspection and palpation immediately after birth . Inspection of the clubfoot with characteristic symptoms (Figure 2): i) inversion at subtalar joint; ii) equinus and varus position of the ankle joint; iii) pronation of the forefoot in relation to the ankle; iv) as sign of a structural clubfoot the skin fold is medioplantar; v) forefoot adduction; vi) talipes cavus with the first metatarsal plantarflexed (Pronation!).

Palpation

i) The heel may be small and *empty* as a result of the equinus. The Achilles tendon can be palpated as it is shortened; ii) the talar neck is easy to palpate; iii) navicular is subluxed medially, the medial malleulos is difficult to palpate; iv) the extent to correct the malposition by manipulation helps to classify the severity of the clubfoot.

Several classifications for clubfeet are published. The classification of Dimeglio[11] and Pirani[12] are common. They enable a standardized documentation and help to assess progress of treatment results.

True clubfoot must be distinguished from postural deformity (soft-soft according to Dimeglio classification) that can be corrected with passive stretching and does not require active treatment.

Medical imaging

Radiographs

Indication for radiographic examination of clubfoot may only be surgical planning or clinical monitoring[13,14] and should only be performed in babies older than 3 month.

The adjustment technique according to Simons[15] has proved to be useful in patients not able of full weight bearing.

Reduction of the talocalcaneal angle is characteristic (norm a-b 30°-50°). Severe forefoot adduction (norm a-d: plus-minus 10°) is demonstrated by an increased tarsometatarsal I angle Reduction of the talocalcaneal angle (a-b norm 30°-50°) and the reduced calcaneal pitch (b-c norm 15°-30°). The tibia seems to be dislocated posterior in relation to the fibula. The talometatarsal I angle (a-d norm plus-minus 10°) is increased.

Ultrasound

Several methods described the assessment of clubfoot,[16-18] but no method has shown wide acceptance yet.

Computertomography (CT)/Magnet resonance imaging (MRI)

CT and MRI are not essential in ordinary clubfoot. MRI and CT have shown to be useful in assessing treatment outcome.[19-22]

Pedobarography

As a dynamic examination pedobarography can be helpful for clinical monitoring.[23,24]

Therapy

Conservative therapy

The treatment of congenital clubfoot should be started as soon as possible after birth.

Ponseti technique for therapy of clubfoot

In several studies, the Ponseti management has proved to be the most effective and economical treatment of clubfeet.

Derotation of the subtalar complex is the basic principle of any clubfoot treatment.

All components of clubfoot deformity, except for ankle equinus, are corrected simultaneously. Manipulation is performed by abduction of the foot beneath the talar head. The talar head - well palpable in severe clubfoot-is the fulcrum for correction. Usually clubfeet are corrected in 5-7 weeks. Weekly manipulations is followed by plaster cast application: long-leg-cast ought to be applied with hip and knee 90° flexed.

Complete correction is obtained when 60°-70° of foot abduction and 20°dorsiflection are achieved. A splint is necessary to maintain the foot in position. In the first 3 month after cast removal, this abduction brace needs to be worn 24 hours a day. Subsequently the brace should be applied at night time and 2-4 hours in the middle of the day until 3-4 years of age. If 20° dorsiflexion can not be obtained after 6 weeks of manipulation and casting, percutaneous achilles tenotomy is indicated.

Before each cast application, the foot is manipulated. Never touch the heel! Allow the calcaneus to rotate with the foot.

According to a study by Zionts *et al.*[25] the rate of extensive surgery to treat idiopathic clubfoot decreased substantially. They analyzed the data from the Center for Disease Control and Prevention and the nationwide Inpatient Sample in the United States. The number of surgical releases in patients less than twelve month old decreased from 1641 in 1996 to 230 in 2006.

This trend is likely due to the increased use of the Ponseti method. A growing body of evidence has shown this method to be a viable treatment option for clubfoot.

Manipulation and cast correction in detail:

The first step of correction is to reduce the cavus deformity by positioning the forefoot in proper alignment with the hindfoot. Cavus is due to the pronation of the forefoot in relation to the hindfoot. In newborns it is usually corrected with supination of the forefoot in 1-2 casts. Sufficient alignment of the forefoot with the hindfoot is important for effective abduction of the foot to correct the adductus and cavus.

Manipulation. Locate the talar head (Figure 5). Stabilizing the talus provides a fulcrum around which the foot is to be abducted. To achieve a normal longitudinal arch elevate the first ray of the forefoot (supination). Never pronate! Never touch calcaneus.

Figure 1. congenital bilateral clubfoot of a newborn.

Figure 2. Secondary clubfoot in the right foot in a newborn with strangulation mark on the right lower leg. Supination and adduction of the forefoot in contrast to the healthy left side can easily be detected.

Casting. Aim of the first one to two casts is to correct the cavus and adductus. The foot is kept in marked equinus. The adductus and varus need to be fully corrected in the next 2-4 casts. Abducting of the foot is to be performed in supination while counterpressure is applied over the lateral aspect of the talar head (Figure 7). Navicular, cuboid and the rest of the midfoot and forefoot derotate underneath the talar head. The anterior part of the calcaneus follows the derotation – *subtalar derotation* – thus varus deformity is corrected. This can only be achieved when the calcaneus is not fixed> do not touch calcaneus!

Tenotomie. When ankle dorsiflection remains less than 10° after cavus, adductus and varus are fully corrected, tenotomy of the achilles tendon is indicated. In 85% a percutaneous tenotomy is necessary. Do not apply forceful dorsiflexion to the foot[26] > rocker bottom-deformity.

According to Ponseti, the achilles tendon has to be dissected completely in local anesthesia in the outpatient clinic. In our hands this procedure is safely performed in the operating room. After tenotomy, the cast is applied in 60°-70° abduction and 15°-20° dorsiflection and left in place for 3 weeks. Recurrent dispute is held over gap healing following achilles tenotomy. In several studies complete healing of the tendon after 6-12 weeks[27,28] are shown. Maranho *et al.*[18] examined 37 tenotomies in 26 patients with a mean follow up of 1 year after section. Ultrasound was performed at 3 weeks, 6 month and 1 year post tenotomy to assess the reparative process. A fast reparative process that reestablishes continuity between stumps was found. Except for mild thickening, sug-

Figure 3. Anteroposterior view of a two year old girl with bilateral idiopathic clubfoot standing.

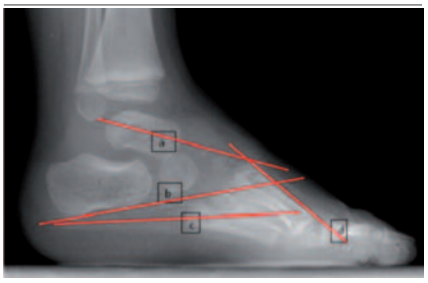

Figure 4. Lateral view of a two year old girl with bilateral clubfoot, standing position.

Figure 5. Location of the talar head.

Figure 6. First cast is applied in equinus mainly correcting the cavus and adductus by elevating and supinating the first metatarsal in relation to the hindfoot.

Figure 7. Cast 2-4: increasing abduction.

gesting a predominantly intrinsic repair mechanism, the reparative tissue evolved to tendon tissue with a normal ultrasonographic appearance. According to Ponseti, tenotomy is peformed under local anaestehsia in the outpatient clinic. Parada *et al.*[29] showed that percutaneous tenotomy under general anesthesia in patients less than 1 year old can be safely performed and may offer potential advantages of better pain control and the ability to perform the procedure in a more controlled manner. To prevent relapse, the Ponseti protocol now calls for a brace to maintain the completely corrected foot in 70° abduction and dorsiflection. The brace (Figure 8) consists of high-top straight-last shoes attached to a bar. In unilateral clubfoot, the brace is set at 60°-70° of external rotation on the clubfoot side and 30°-40° of external rotation on the normal side. The first three month after cast removel the abduction brace should be worn 24 hours a day. Neuromuscular and syndrome-associated clubfeet may also be treated by the Ponseti method.[30] Non-idiopathic clubfeet may require more casts and have a higher rate of failure, recurrence, and additional procedures but correction can be achieved and maintained in most patients. Manipulation and percutaneous tenotomy according to Ponseti achieve excellent results (Figure 11). Relapses occur in more than 80% of the fully corrected clubfeet if the bracing program is not accurately followed.

Treatment of recurrent clubfeet according to the Ponseti protocol. Relaps occurs, according to Ponseti,[31] when the foot shows loss of abduction and/or of dorsiflexion and recurrence of adductus and cavus. Forefoot supination is another sign for loss of correction. At the first sign of relapse, again casting according to the original Ponseti should be applied. When the deformity is corrected, bracing program is restarted. Re-tenotomy may be necessary when equinus reoccurres. Several reports discuss results and clinical experience of the Ponseti method in older age groups.[20,32-35] The ultimate overall results in older children proof to be satisfactory, reducing the need for extensive surgery.

In children older than 2.5 years a dynamic supination deformity may be treated by transfer of the tibialis anterior to the lateral cuneiform.[36] Park *et al.*[37] reviewed 48 recurrent or selective clubfeet initially treated by the Ponseti method. Selective a la carte soft tissue release was performed at average 2.3 years and preoperative Pirani score of 2.8 points. In the mean follow up of 3.6 years (2-5.3) Pirani score improved to 1.1 points but 6 out of 13 patients needed further surgery. Transfer of the anterior tibial tendon may restore balance and provide improvement of forefoot adduction. A review of Farsetti, Ippolito *et al.*[38] revealed that transfer of the anterior tibial tendon to the third cuneiforme corrected 16 relapsed clubfeet treated with the Ponseti method. Outcome was evaluated clinically and by plain radiographs and CT scan. Transfer of the anterior tibial tendon corrects and stabilizes relapsing clubfeet by restoring their normal function of foot dorsiflexion/eversion. But subsequently, the cuneiforms and the cuboid are shifted more laterally, as shown by x-ray and CT scan. However, a study of Lampasi *et al.*[39] discovered, 11 out of 38 relapsed clubfeet in average of 24.8 years follow up after anterior tendon transfer were regarded as failure. He concluded transfer of the anterior tibial tendon has a considerable high complication rate, including failure of transfer, over correction and weakening of dorsiflexion. In his opinion the procedure should be reserved for those limited cases in which muscle imbalance is a causative or contributing factor.

Complication of the Ponseti method. A case of pseudoaneurysm after percutaneous Achilles tenotomy in a 8 weeks old baby was reported by Burghardt R. et al. (40). The large pseudoaneurysm together with incomplete correction made another 4 weeks additional casting necessary. Emphasis on applying pressure over the pseudoaneurysm was made. Nevertheless repeated ultrasound after 4 weeks casting showed entirly resolved pseudoaneurysm. In the study of Boehm and Sinclair.[41] possible effects of foot abduction brace on the femoral anteversion and tibial tor-

Figure 8. Foot-abduction-brace by MD Orthopaedics.

Figure 9. 14 month old child with bilateral clubfoot treated with the Ponseti method: Equinus, cavus and forefoot adduction are diminished, only small scar after tenotomy can be found.

Figure 10. Ten year follow up of a child treated with the Ponseti method.

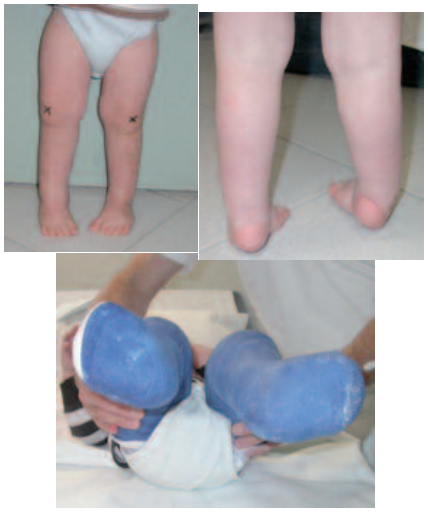

Figure 11. 19 month old child with bilateral neurogenic clubfoot treated with Ponseti method.

Figure 12.Peritalar arthrolysis in a 7 month old child with bilateral clubfoot. Preoperative the medial crease is marked in both feet. Postoperative right foot is temporarily fixed with a K-wire. After Cincinnati approach and peritalar release the medial crease is diminished and a good plantigrad position is achieved.

Figure 13. The Copenhagen night splint keeps the knee joint in 90° flexion, a hinge permits dorsiflexion at the ankle. The foot is fixed in 15° external rotation, the hindfoot is stabilized by a padded strap.

Figure 14. 8 year follow up of a boy treated by classical casting and peritalar artholysis with reposition of the tibio-talar, talocalcaneal, talonavicular and calcaneocuboid joint, lengthening of the ligaments as a 8 month old baby. The scar is asthetically pleasing, the boy able of active dorsiflection and plantarflection with slight overactivity of the supinators.

Figure 15. Bilateral neurogenic clubfoot in a 29 years old woman.

Figure 16.x-ray ap and lateral of the same patient 3 years after triple arthrodesis with full consolidation of the osteotomies.

sion were assessed by ultrasound and clinical examination in 20 children. No pathological changes of femoral anteversion or tibial torsion were found.

French method

Souchet and Dimeglio[11,42] developed a functional method for non-surgical treatment of newborn's clubfoot. This method requires daily manipulation of the newborn´s clubfoot by a physiotherapist and special passive motion machine for the first 2 month. Stimulation of the muscles around the foot (especially peroneal muscle lengthening), and temporary immobilization of the foot with nonelastic adhesive strapping are necessary. The passive motion machine must be adapted to size and type of clubfoot.

Success of this method relies on early start of treatment in the first 3 months of life and strict compliance with the guidelines of the functional method. Dimeglio[11] showed considerable reduction for the need for surgery (75%). Surgery after treatment by the French method is less severe and less extensive especially in grade II and III clubfeet according to the Dimeglio classification. Steinmann *et al.*[43] compared the outcome in the treatment of 267 idiopathic clubfoot treated by the Ponseti method and the french functional (physiotherapy) method. They conducted a prospective study with an average follow up of 43 years. The Ponseti method was superior especially in treatment of the equinus, but the difference was not significant. Furthermore the Ponseti method was the parents first choice twice as often as the French method. Correspondingly Richards and Dempsey[22] evaluated MRI of infants with congenital clubfeet treated with both method. In both treatment methods chondroosseous abnormalities improved, but in the French method equinus persisted more often and in greater degree.

Operative therapy

Operative treatment of clubfoot is necessary, when clinically and radiologically proven residual deformities continue despite conservative treatment.[37,44-47] This might be necessary especially in syndromic and neurogenic clubfeet.

The peritalar arthrolysis. The peritalar arthrolysis is described in detail by Simons und McKay[9] as well as Krauspe and Parsch[48] (Figure 12).

Subtalar derotation *a la carte* applying the Cincinnati approach is performed according to the pathological findings.

The peritalar release allows a complete medial, posterior and lateral exposure of hind- and mid-foot as well as a correction of any deformity of the subtalar, talonavicular, and calcaneocuboid joints. Restoration of the joint axis is obtained by correcting the position of the talar head to the subtalar joints. In older clubfeet bony deformity must be taken into account and best possible position. Fixation with Kirschner wires after soft tissue and bony procedures are recommended.

Fixateur extern. External fixateur can be a useful option because of its ability to correct by gradual distraction in a 3 dimensional manner as described by Franke *et al.*,[49] Wallander *et al.*[50] and others.[51,52]

Postoperative care

Postoperatively a padded long leg plaster cast is applied and subsequently a Copenhagen night splint is being applied (Figure 13).

Conclusions

The Ponseti method has demonstrated good results in idiopathic clubfeet and secondary clubfeet in young patients. The French functional method may be another option of conservative treatment in idiopathic clubfoot, but the effort in time, costs and organizing are more complex. Additionally, equinus often is not fully corrected. Relapse should be retreated by serial casting and splinting. Extensive surgery should only be performed after conservative treatment has failed to correct the deformity because stiffness and poor functional outcome may occur. In relapsed clubfoot or older patients peritalar release or the use of the external fixateur is the method of choice to

achieve a plantigrade foot. As salvage procedure triple arthrodesis may be a reasonable option in adults.

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