AO Foundation

Davos

1992 2012

The Center of the AO Foundation Network

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1992–2012

Editors

Prof. Dr. med. Peter Matter

1982–1992	President of AO Switzerland
1987–1992	AO Center Building Commission
1993–1999	President of AO International
2000–2002	President of AO Foundation
2001–2002	Chairman of the Board of Directors (AOVA)
–	Founding Member of the AO Foundation

Prof. Dr. med. Stephan Perren

1967–1995	Director of AO Research Institute
1982–1988	Director of M. E. Müller Institute of Biomechanics University of Bern
1987–1995	Chairman of International Standards Organization ISO / TC150 "Surgical Implants"
1982–1998	Chairman of AO Technical Commission and of AO Development steering committee
–	Founding member of the AO Foundation, the International Society for Fracture Repair and of the European Society of Biomechanics
–	Hon. Professor Universities of Bern, Montevideo and Aberysthwyth, Dr.sci. (h.c.) University of Guelph CND, adj. Prof. Queensland University of Technology, Brisbane AUS

Contributors

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Message from the Mayor of Davos

It is already twenty years since the "Toblerone-schoggi", as it is lovingly referred to by the Davos locals, was constructed. This building is symbolic of the AO's commitment to Davos.

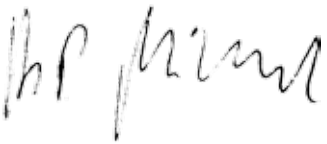
Until the beginning of the nineties the offices of the AO were in Obere Strasse and scattered around several other locations in Davos. At that time an important decision had to be taken about the future headquarters of the AO. Other locations closer to universities and airports were evaluated at the time because of the necessity for an international organization to be close to other scientific institutes and have a good transport connection to the rest of the world.

Fortunately the decision was made in Davos' favor for several reasons; a location in Davos meant the fast-growing AO Foundation could guarantee its independence and also be close to the hospital where Prof. Matter was the head surgeon specialized in bone fracture treatment. Additionally Davos offered many advantages for employees and scientists with stunning natural resources, a huge range of sports and culture, and of course various educational institutes that students could benefit from.

Davos as a location no doubt also benefited from the fact that the founders of the AO Foundation, Prof. Allgöwer, Prof. Matter and Prof. Perren, were–along with their professional reputation and the pioneering spirit–Davos people in their hearts and souls. We owe the presence of the AO in Davos to them.

I would like to express the sincere thanks of the entire Davos population for this solidarity you have shown us. And I am really encouraged that Davos has stood by the world-leading AO Foundation during all these years. We are very proud of our institute, it belongs to us.

I wish all Clavadelerstrasse employees the best for the future. Even if you can't be spared inevitable setbacks and disappointments, the conditions for a successful common future is very bright thanks to the right decisions being taken in the past.



Hans Peter Michel
Mayor of Davos

Letter from the President of the AO Foundation

Dear colleagues and friends,

We are delighted to be celebrating the 20th anniversary of the AO Center building this year. Back in 1992, the growth of the AO necessitated the construction of the AO Center to provide a single, purpose-built, location for all our key functions. The AO has been active in Davos (the heart of the AO Foundation) since 1959, the same year the Laboratory for Experimental Research and Documentation was established here. Over time this lab evolved into two discrete units, AO Research Institute Davos (ARI) and AO Clinical Investigation and Documentation (AOCID). It was also in Davos that the first ever AO Course was held in 1960. Since then our highly-respected AO faculty has been training thousands of medical professionals in state-of-the-art treatment methods and tools for bone healing and better patient care here.

The AO Center functions as the headquarters for course management as well as for AO Education, ARI, important parts of AOCID, the four AO clinical divisions, the AO Technical Commission (AOTK), and the AO Foundation's administration.

The AO has always been at the forefront of research into osteosynthesis as well as many other fields which affect the future of orthopedic and trauma surgery. Advances made in the field of osteoporosis, cell biology, infection, and biomechanics at ARI in Davos illustrate the extent of the research expertise developed over the decades.

The past 20 years in Davos have also seen many ground-breaking developments in the field of education. This is where new teaching and learning methodologies are developed, world-renowned faculty is trained by

experts and modern technology (for instance the online Surgery Reference Modules or the latest iPhone apps) is adapted for medical professionals' needs. Since its inception, innovative treatment options have emerged from the AO Center; principles of periosteal blood supply, biological plate fixation or internal fixators leading to angular stable fixation have been developed through evidence-based medicine in Davos by renowned surgeon members of the AO TK System.

These are just a few examples of the impact that the AO Center has had on the AO Foundation since we moved into the new building at Clavadelerstrasse in Davos in 1992.

With the AO Center closely linked to the Congress Center and the broader world of science in Davos, we intend to remain a world-leading center for the advancement of patient care. From Davos we bring our vision of "excellence in the surgical management of trauma and disorders of the musculoskeletal system" to the world, now and in the future.

Two AO Foundation founders, Peter Matter (President of AO International from 1993 to 1999 and of the AO Foundation from 2000 to 2002) and Stephan Perren (Head of AO Research from 1967 to 1995 and Chairman of the AOTK from 1982 until 1997) share their intimate knowledge of the AO's history with us through this booklet. Both surgeons played an important role in the realization of the new building and the development of the AO. I wish to extend my sincerest thanks to them for these endeavors.

I hope you enjoy learning more about the "Spirit of Davos" through this booklet.

Sincerely,

Norbert Haas
President of the AO Foundation

Davos: the Alpine Science City

Dr. sc. techn. Britta Allgöwer, Head Science City Davos

Visionary ideas are the children of inspiring moments, born maybe on a walk through an enchanted forest freshly carpeted in snow – or over a beer with a fellow scientist. The "rest" is sound education, profound professional skills, an excellent working environment and good living conditions. Davos offers all this, and more.

Science and Culture – the Pillars of Modern Davos

Thanks to the extraordinary observational gifts of two physicians in the mid-19th century, the Davos based general physician Lucius Rüedi (1804 – 1869) and a political refugee from Germany, Dr. Alexander Spengler (1827 – 1901), the farmer village of Davos discovered its healing capacities against tuberculosis – a widespread illness in Europe in those days. Antibiotics were nowhere in sight, experience of hygienic measures was known but to a few. Intrigued by the fact that the farmer population of Davos did not show signs of tuberculosis, they started to investigate the reasons for this phenomenon. Apparently, the absence of germs, the dry and healthy air, sunlight, and a simple but sufficient diet made a difference. Rüedi was the first to prove that the high altitude climate could help to cure tuberculosis. Already in the early 1840's he was able to heal children of tuberculosis. After becoming the general physician of Davos in 1853, Alexander Spengler laid the basis for the high altitude health resort of Davos, together with the Dutch merchant and railway pioneer Willem Jan Holsboer (1834 – 1898). Holsboer came to Davos because his wife suffered from tuberculosis. Even though she died, Holsboer stayed in Davos, remarried, opened the sanatorium Spengler-Holsboer in 1868, and finally initiated the construction of the railway connection between Landquart and Davos (1890). What followed was an unmatched story of success! Davos gave hope to thousands of tuberculosis patients. In the late 19th century Davos had almost as many inhabitants as it does today. Patients from all

over Europe, among them many intellectuals, artists and scientists, were hosted in 26 sanatoriums. In December 1900 the luxury-class Sanatorium Schatzalp opened its doors; it later played a significant part in one of the most famous contributions to world literature, "The Magic Mountain" (Der Zauberberg, 1924). In 1918, Ernst Ludwig Kirchner (1880–1938), by then already a leading expressionist painter, moved to Davos. Nowadays, the widely known Kirchner Museum owns and exhibits a significant part of his work and has become a mecca for art experts and enthusiasts and people interested in modern architecture. In 1992, Annette Gigon and Mike Guyer – the architects of the Zurich Prime Tower – made their international breakthrough in architecture with the design and construction of the Kirchner Museum.

Davos – City of Science and Research in the Heart of the Alps

The health resort history also laid the basis for the place of research in Davos. In 1905, the physician Karl Turban established the Tuberculosis Research Institute Davos. Almost in parallel, the lawyer and chemist Prof. Dr. Carl Dorno, bound to Davos because his daughter suffered from tuberculosis, founded the Physikalisch-Meteorologisches Observatorium Davos (PMOD) in 1907. Dorno is famed as the founder of bioclimatology. While the former institute dealt with the investigation of the illness as such, the latter investigated why tuberculosis would heal better in the high alpine environment than elsewhere. Today, both institutes still exist and prosper in their respective research fields, evolved way beyond their initial foci. The former tuberculosis institute, now called the Swiss Institute of Allergy and Asthma Research (SIAF), has specialized in basic research on immunology and allergology and their practical implications for medicine. In particular, pet owners – especially cat lovers – can now relax as a new vaccine against cat allergies was developed just recently by SIAF. Since 2007 SIAF has established the World Immune Regulation Meeting (WIRM), a highly acknowledged conference on immunology gathering the best of this research community in Davos each spring. The former PMOD – now also called World Radiation Center (PMOD / WRC) – has evolved from studying the effects of ultra violet radiation on the healing process to the investigation of solar radiation as a whole and has changed into one of the world's leading radiation research institutes. In fact, it represents the worldwide calibration center for solar radiation measurements. Every five years, the International Pyroheliometer Comparison (IPC) campaign is held at the PMOD / WRC to ensure worldwide homogeneity and calibration of solar radiation measurements within the six regions of the UN World Meteorological Organization. As a second line of work, PMOD / WRC develops sensor prototypes for

solar remote sensing and is regularly involved in space experiments during missions of the European Space Agency (ESA).

In 1936 the Federal Institute of Snow and Avalanche Research Davos opened its first research station at the top of the Parsenn ski area, on Weissfluhjoch Davos. Now called the WSL Institute of Snow and Avalanche Research SLF Davos (SLF) is renowned among snow and avalanche experts around the world. Both, basic and applied research has an equal focus at this institute. Thus, SLF is not only known throughout all of Switzerland as a national avalanche forecaster but also worldwide for its basic research on snow physics and avalanche dynamics and in particular for its avalanche safety consulting work. SLF avalanche experts are involved in assessing safe winter access in Chilean mining and designing avalanche defense measures for the upcoming Winter Olympic Games in 2014 in Sochi (Russia) and in teaching avalanche courses in various countries to name but a few of the numerous SLF activities.

Finally, in 1958 the AO was founded and work commenced in the laboratories of the former tuberculosis institute. This proved to be one of these rare and magic moments where the right ideas come to the right place at the right time. In the fifties skiing became more and more popular. Yet, the development of safety binding equipment was in its infancy and ski runs were not groomed as they are today; a challenge for many bones. Nowadays, each December, the Davos Congress Center hosts almost two thousand medical professionals who explore the newest developments in trauma and musculoskeletal surgery during the famous AO Courses.

The development of Davos-based research carries on today. In 2008 a fifth, international research institute came into being: The Global Risk Forum Davos (GRF Davos). GRF Davos emphasizes the development of methodologies for risk assessment, education and reduction and provides a worldwide training and communication platform for risk experts in various fields. Every second year, risk experts from all over the World gather in Davos at the International Disaster and Risk Conference (IDRC). Last but not least, in 2009 the Christine Kühne Center for Allergy Research and Education was established in Davos by the Hochgebirgsklinik Davos, SIAF and the Christine Kühne Foundation.

Today, around 400 people are working in research in Davos, thus adding a significant cluster of highly-specialized jobs to the otherwise tourism-lead job market of Davos. Most researchers spend a considerable length of time in Davos and choose to settle down with their families. Hence, good education facilities are crucial. The community

of Davos offers this: it has two high schools (Gymnasiums), a sophisticated system of primary and grade schools as well as a trade school. Moreover, Davos is home to a public library and in particular a documentary library with over 30,000 historical documents on Davos (Dokumentationsbibliothek Davos). In short, urban and Alpine characteristics blend in perfectly, making Davos a unique place to live and work.

Wissensstadt Davos / Science City Davos

Based on this extraordinary science tradition, a group of Davos opinion leaders from science and politics promoted the idea of implementing a common voice to the Davos based research community. Hence, on June 30, 2004, the association Wissensstadt Davos / Science City Davos (www.wissensstadt.ch / www.sciencecity.ch) was founded, gathering the key players of research, education, tourism and politics as its members:

- WSL Institute for Snow and Avalanche Research SLF Davos *www.slf.ch*
- AO Foundation / AO Research Institute Davos *www.aofoundation.ch*
- Swiss Institute of Allergy and Asthma Research SIAF *www.siaf.uzh.ch*
- Physikalisch-Meteorologisches Observatorium / World Radiation Center PMOD / WRC *www.pmodwrc.ch*
- Schweizerische Text Akademie / Swiss Text Academy *www.textakademie.ch*
- Global Risk Forum GRF Davos *www.grforum.org*
- European Asthma and Allergy Research Centre EACD *www.eacd.net*
- Schweizerische Alpine Mittelschule Davos SAMD *www.samd.ch*
- Spital Davos *www.spitaldavos.ch*

Ever since its foundation, the declared goals of Science City Davos are:

- To secure and enlarge the research and education standing of Davos
- To firmly establish research as a major pillar of prosperity in Davos
- To build Campus Davos – the campus for lifelong learning and research

In order to achieve these goals, Science City Davos bases its work on two pillars:

- To initiate and accomplish education projects, courses and conferences, together with the members of a Science City Davos and third parties with a national and / or international background (eg, public Science Coffees, conferences like the ISSW2009 – the first International Snow Science Workshop on European ground, the first conference Young Scientists in Contest (YSC) in 2008, or the implementation of the Open Academy Davos 2008 – 11)

– To initiate and accomplish thematic projects, together with the members of Science City Davos and third parties (eg, a study on the added value of the Davos Research Institutes, study on the push and pull factors of Davos for the research institutes, MountEnergy, etc.)

Detailed information on the various activities of Science City Davos can be gathered under *www.wissensstadt.ch* and in particular from the annual reports *http://www.wissensstadt.ch/en/annual-reports.html).*

Science City Davos – Campus Davos

The fact that a small mountain town like Davos hosts all these internationally recognized research institutes is unique. It is also unique that so much knowledge and scientific expertise is gathered in one location. It usually requires a good-sized, well-equipped university, to do so. However, this also provides unique opportunities to implement teaching and learning environments for young academics. One project is of particular interest: the Open Academy Davos for Students (OAD) which is representative of the Campus Davos model.

Open Academy Davos for Students (OAD)

In 2007 Science City Davos was approached by an international and interdisciplinary group of students, among them Davos-raised Fabienne Fierz, a third year medical student at that time, with the idea to found a summer school, especially adapted to the research environment of Davos. The idea of the OAD for students was borne. In 2008, the first OAD took place, addressing the topic "Tuberculosis – new old disease". During one week, a highly motivated international group of students and lecturers from different academic fields worked very hard on the different aspects of tuberculosis. In 2009 "Malaria and the challenges of foreign aid medicine" were the issue, followed by "climate change and health" in 2010. In 2011, "stem cell research" was addressed together with the AO Research Institute Davos.

The OAD is an interactive education model for students and doctoral students who are willing to engage deeply in an intensive study week. During the OAD participants and lecturers form a partnership of mutual learning. In order to promote interdisciplinary approaches and ways of thinking, the OAD is open to different disciplines and different student age groups. A major challenge, but essential element of the OAD, is the mandatory public presentation of the elaborated results by the participants to a general audience at the end of the academy.

The main organizers of the OAD are Science City Davos and PD Dr. med. Ulrike Schauseil-Zipf from the Medical Faculty of the University of Cologne. Based on the topics, close collaborations take place with the lecturers from the Davos research institutes and other

OAD 2011 – Stem cell research: Prof. Dr. Yann Barrandon (Laboratoire de Dynamique des Cellules Souches (LDCS), EPFL et Université Lausanne) and a participant engaged in a lively discussion during an interactive teaching unit.

experts from Swiss or foreign research institutions. An ideal Campus venue is provided by the Swiss Alpine Boarding School / Schweizerische Alpine Mittelschule Davos (SAMD). Detailed information on the past programs and lecturers may be obtained under *www.openacademy-davos.ch.*

The OAD is a legacy to develop further. Davos as a center for research has all the potential to become a hot spot for training young scientists at the very beginning of their career's not only in their fields but also in trans- and interdisciplinary thinking and last but not least in enhancing their social capital. This has been borne out by the experiences of the students who have attended.

Here in the words of two 2008 participants:

"With its amazing atmosphere and scenery, the interesting subject and the energetic participants, the OAD has created a great motivation to participate and get engaged; again, immediately (after some sleep)."

"The academy was an inspiring and intellectually demanding event which I have never experienced at such quality level in the past. I look forward to the next academies."

The AO and the Academia Raetica

Prof. Dr. med. Thomas Rüedi, Secretary Academia Raetica

The idea to create in the Canton of Grisons an institution with an academic background dates back to about the same time as the opening of the AO Center in Davos, 20 years ago. It was Martin Allgöwer who wanted to offer young scientists at ARI an officially-recognized academy for postgraduate teaching and also to enable them to obtain a postgraduate research degree in the Grisons. In spite of many meetings with Swiss Universities and official bodies, it appears that at that time Allgöwer's vision was too advanced for the Canton of Grisons, despite the fact that several internationally-renowned research institutes are located in Davos. The AO Foundation supported the endeavors of the Academia Raetica from the very beginning and several AO officers from ARI, AO Education and AOCID became founding members in 2006.

It was only when the government of Grisons urgently needed legislation on research and postgraduate teaching, that the Academia Raetica finally got official support. It was agreed that this organization should coordinate all high-level research institutes and clinics in the Grisons and at the same time contribute to the creation of a new law supporting research and education (Gesetz über Hochschulen und Forschungseinrichtungen).

Today the Academia Raetica has an umbrella function covering twelve research institutes and seven larger clinics active in research in the Canton of Grisons and its vicinity. These institutions have a combined total of approximately 3,000 employees and a yearly budget of 300 million CHF. In addition they generate considerable benefits for the local economy and tourism through meetings and larger scale congresses, for instance the AO Foundation Davos Courses.

The significant potential of medical, scientific, technical and life science research and teaching in the Grisons region must be con-

solidated, in order to attract a young, academically-interested group of researchers. The Academia Raetica sees itself as representing the different institutions not only externally but also internally by organizing symposia where young scientists can compete, such as the biannual Young Scientist Contest. This allows Academia Raetica to recognize and support talented and motivated researchers and it functions as a "technology transfer" with regional industries or as preparation for a university career. Through the mutual exchange of knowledge, synergies can be created and interdisciplinary projects established.

Our hope is that with the new legislation on research and education, the Canton of Grisons will be prepared to financially support the Academia Raetica and the various research institutes and clinics. It is only by providing substantial financial support that these institutions will continue to receive any research funding from federal resources, which is absolutely essential for their survival and for them to remain in our canton.

Our newest vision is that of a graduate school – a new structural element of the Bologna Reform which seeks to create a competitive and dynamic area for higher education and research – with an integrated research and teaching unit, offering master's and doctorate degrees. This would allow the Academia Raetica to be acknowledged on a national basis as teaching institution. With about 70 post-graduate students currently working in the canton, the need for such a graduate school has been established and university-level teachers are available locally. Private sponsors are still missing and without them such an ambitious and promising project is unlikely to become a reality.

The origins of AO Research and the AO Center

Prof. Dr. med. Stephan Perren and Prof. Dr. med. Peter Matter

The history of a success story

Early Davos

History of Davos tuberculosis research: During the last century Davos was the mecca for tuberculosis treatment. The classic treatment protocol was bed rest in the crisp mountain air on the balcony of one of the two dozen sanatoriums.

Two centers for lung surgery, where mainly thoracoplasty, plombage or lobectomy and pneumothorax helped improve the healing of tuberculosis cavities, were operating at that time.

As early as 1905, tuberculosis research was established in Davos. This research targeted different aspects of tuberculosis such as the impact of climate, pathology, bacteriology and immunology on the disease. In the early 1950s, pharmaceutical treatment with isoniazid, rifampicin and streptomycin, started to replace the bed rest and some of the surgeries. Over time the sanatoriums closed down or changed their focus to asthma and other unspecific lung diseases. Following this trend tuberculosis research was abolished.

The old Tuberculosis Research Institute located in a private villa.

At that time the AO group, a handful of Swiss surgeons – loosely organized as an association (Association for Osteosynthesis, AO) – intended to realize one of its pillars: re-

Overview of the early AO Research Instiute in the building of the Tuberculosis Research Institute.

The early AO Research Institute located in the vacant tuberculosis research building.

search. Research was, alongside technology development, teaching and documentation, an essential activity of the AO group. The AO took over the empty rooms from tuberculosis research at the Swiss Research Institute, originally a private villa transformed into a research institution. When the Swiss Research Institute restarted its activities additional space was created by first extending the building and then later by constructing a separate animal house close to where the AO Center is located today.

Extension of the old AO Research Institute provided more room for better animal care.

Overview of the "Davos Research Zone." Near the forest to the right is the animal house, on the left is the location of the soon-to-be AO Center.

History of early AO Research Davos:

The surgical research activity, started in 1959 under the guidance of Martin Allgöwer, focused on systemic effects of trauma, hemorrhagic shock, burn toxins, micro vascular thrombosis. Furthermore, the contribution of blood cells to wound healing were top of the task list. In 1962, Herbert Fleisch created a biochemistry working group on what is called today bisphosphonates which target the biochemical control of bone formation and removal. Bisphosphonates are today widely propagated for the treatment of osteoporosis and fight against bone metastasis of cancer. From 1967 onwards the AO Research Institute addressed, under the directorship of Stephan Perren, the mechanobiological issues of bone fracture, treatment and healing.

The focus was on creating and applying basic scientific knowledge in bone physiology to improve the clinical treatment of fractures and trauma in general. Some topics were: pressure necrosis and compression osteosynthesis prevention of unwanted and deleterious implant loosening, and the Dynamic Compression Plate (DCP) (Perren, Russenberger) with its spherical gliding principle. The unusual approach of questioning "generally-accepted" theories led to a different view on the "generally-accepted" misnomer "stress protection". The work of Emanuel Gautier resulted in an understanding of the biological mechanisms of bone sequestration and new implant designs and application. A new concept of plate fixation: the "internal fixator" was created.

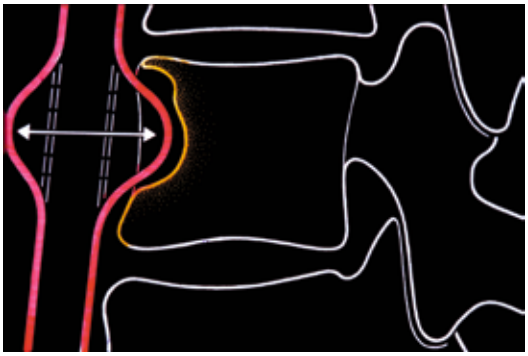
Locked plates, with their proof-of-concept, the "PC-Fix" (Tepic), improving blood supply to the fractured bone, analysis of infection resistance versus implant design, application and material were the focus of studies. The use of titanium as a biologically-superior implant material was initiated based on the study of tissue reaction to corrosion of implant materials. The development of the DCP, the biology of the un-reamed nail (Klein), the radial preloading for improved biology of the fixateur pins (Hyldahl, Pearson), the LISS (Frigg) are only few of the topics where Davos AO research and concept development contributed to better treatment of trauma especially in the field of

Example of research in trauma: Study of microvascular thrombosis using screen filtration method. The filter is clogged by a heavy deposit of platelets, leucocytes and fibrin. Such deposits deteriorate in vivo the function of the lung.

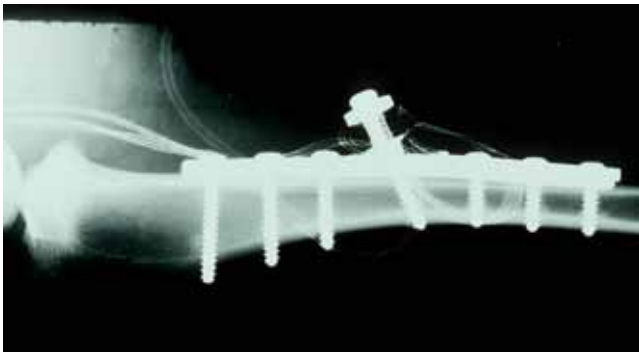
bone fractures. Today's blockbuster, the Locking Compression Plate (LCP), is actually a combination of the two principles developed at the ARI, the DCP and the Locked Screws.

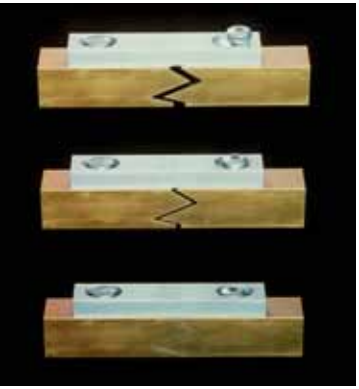
Alongside research activity, the Davos group also contributed to education, developing for instance the artificial bones, producing video teaching clips and enabling live transmission of surgery from the Davos hospital to the participants of the AO Courses. These transmissions enabled the course participants to move from theory and bench work to live surgery and its specific aspects. The AO Technical Commission (AOTK) provided the interface between the AO group and the affiliated producers – it controls the quality of the implants and instruments and monitors the correct application of the AO principles (see chapter on AOTK). Similarly, for an extended period of time, during the collaboration and chairmanship of Perren within the bodies of International Standardization of Surgical Implants (ISO TK 150 "surgical implants") was a function of the AO Research Institute group.

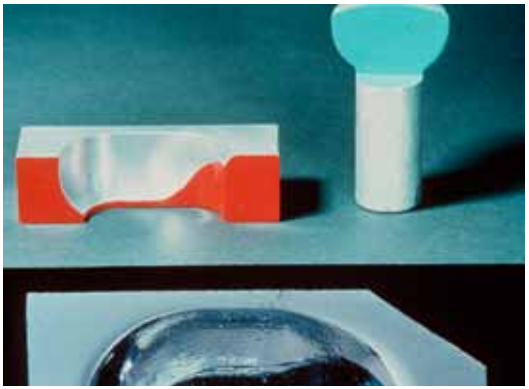
The observation of what was earlier called "pressure necrosis". The understanding was that the pressure exerted by the aortic aneurysm would produce bone necrosis and bone reabsorption.



Typical case of compression fixation. The inclined lag screw and the plate are provided with strain gauges which allow measurement of the axial force exerted by the screw and traction within the plate, which equal the compression exerted on bone.





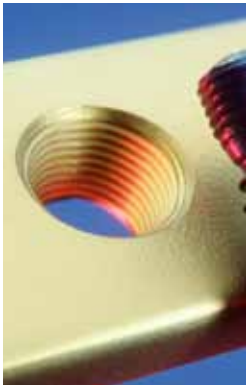


Model of the function of the Dynamic Compression Plate (DCP). When the screw is inserted it hits the oblique surface and pushes the fracture fragments together.

DCP screw and plate hole cut open to visualize the spherical gliding principle.

The principle of locked screws developed in the ARI/ADI. The plate can be kept at a distance from the bone. An important improvement of infection resistance and bone healing was initiated. The new design of the AO bone screw thread was also a contribution of the ARI/ADI.

The PC Fix internal fixator. This was the pioneer of internal fixator and proof of concept of locked screws. The material used was titanium.

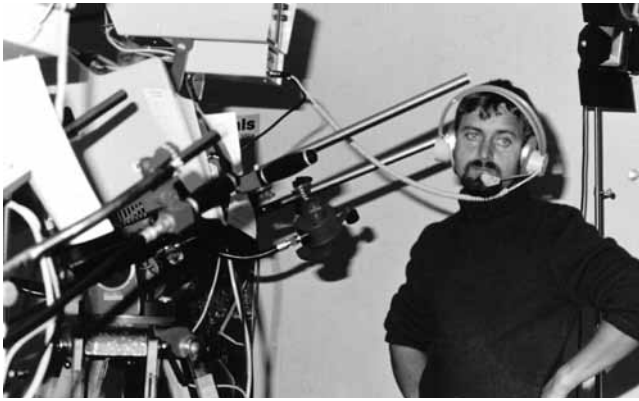


DCP (ARI), one element of today's Locked Compression Plate (LCP).

The conical locked screw of the LISS, another element of the LCP developed in the ARI/ADI.

LCP, a combination of the two principles developed at the ARI/ADI: DCP and locked screws.

Artificial bones as developed by ARI enabled workshops teaching the proper use of instruments and implants.



Live video transmissions from the Davos hospital to the congress house (Robert Moor, cameraman).

Early AO teaching:

The young AO developed a new approach to treating bone fractures. The goal was to recover the function of the bone, limb and patient quickly to avoid disorders due to excessive immobilization of the limb like reflex dystrophy – that is stiff joints and pain and swelling of soft tissues and patchy bone loss. New principles were defined and a set of special implants and instruments was developed accordingly. The new technology was heavily criticized especially in the new world where earlier over-enthusiastic surgical treatment of fractures resulted in unacceptably high complication rates. This was due to, among other reasons, a combination of lack of asepsis, inappropriate metallurgy, lack of understanding of the biology of bone reaction and proper basic handling of tissues. The worldwide accepted assumption that application of compression to bone would produce bone necrosis similar to pressure sores in soft tissues could be countered by the AO research group demonstrating that compression of fractures would not even result in a cell size resorption at the compressed interfaces. The new technology was very demanding in respect to its proper technical and also biological handling. The originator and visionary of the AO group, Maurice E. Müller, soon realized that the transformation of new understanding and technology to successful clinical application could only be realized through extensive teaching of the scientific basics, of clinical application and of monitoring sessions. The approach included frequent workshop sessions with hands-on exercises. This resulted in an enormous challenge concerning the technical support of the AO courses which was the task of the young researchers group in Davos. Knowing that the technology could only be successfully applied when done with highest biological understanding

The participants at the first AO Course in front of the old AO Research Institute, 1961.

An early AO Course with Maurice E. Müller demonstrating.

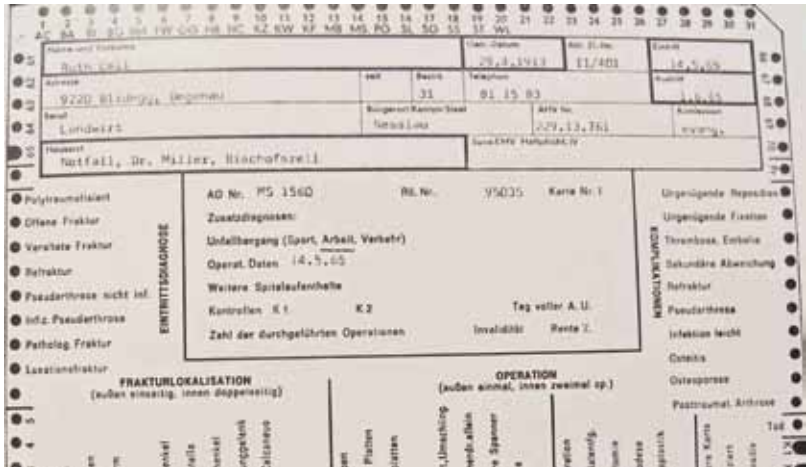
The main goal of AO osteosynthesis was from the beginning on to recover mobility of articulations and soft tissues. Here the day after internal fixation of a tibia fracture Monique Langhans assists the patient for "pain free" mobilization of articulations and soft tissues to avoid the so called fracture disease.

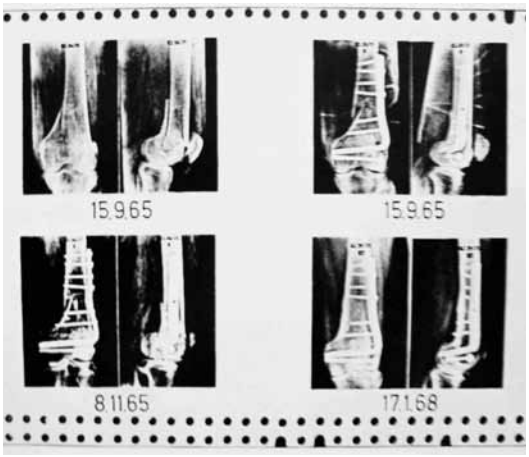
and technical skills, the implants were first made available only to those surgeons who had participated at an AO course. Later with steeply-increasing demand on AO osteosynthesis the courses were given worldwide but the restriction mentioned could not be enforced.

Based on the available rooms and personnel resources the courses were first held in the research institute, then in local movie theaters, hotels and finally in the newly-built congress hall.

Why a new building?

Room conditions: Starting with six collaborators, the interdisciplinary group of medical doctors and biologists on the one hand and physicists and engineers on the other hand grew quickly. Activity and personnel expanded within the rooms of the originally private villa at the Guggerbach. Monitoring the outcome of AO technology of fracture treatment was an important pillar of the AO system. In the early days the AO expansion of documentation, with its handling of the x-rays through image improvement (Logetronic) and establishing a database on Hollerith keypunching cards with glued-on thumbnail x-rays, was also located at the Davos research institute.

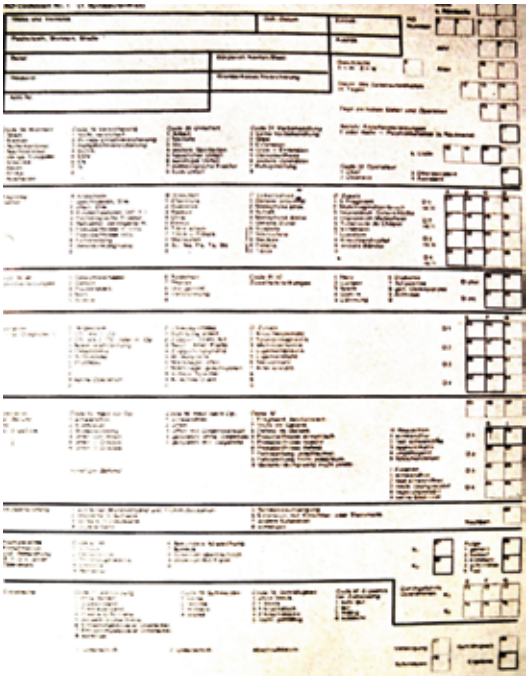




Thus the situation soon resulted in very cramped working conditions. On the upside the interdisciplinary communication was excellent; the researchers were literally standing on each other's feet. Before the situation got out of control, an additional facility for housing the animals and renting space at different locations around Davos helped to resolve this condition but it did so unfortunately at a cost and resulted in the loss of communication and collaboration. In addition to the outlined conditions mentioned the immunological department of the Swiss Research Institute had restarted its activity and the AO Research Institute was forced to share the existing rooms.

The early database of AO documentation: Hollerith punch card.

The reverse side of the punch card with thumbnail x-rays.



Early AO documentation of clinical outcome – a questionnaire.

Typical room condition in the old ARI: Helga Klebl and Rene Küng share 1.80 m width of the common desk.

Decentralized AO functions:

At the outset the AO group was, as mentioned earlier, an association of a few highly-motivated surgeons together with a skilled manufacturer who produced the high quality instruments and implants. With its worldwide expansion the structure was changed into a foundation.

There was no room in Davos to house the headquarters of the AO. The research group needed space and all the documentation was in Bern. The administrative support was also housed in Bern. The medical community, research and production and the AO technical commission also lacked a shared roof. A new building was urgently needed to house all these activities and in order to provide the necessary room conditions for research, education and clinical documentation and contribute to better communication and collaboration.

Why Davos?

The fact that AO research and courses were in Davos and that Davos was synonymous worldwide with the AO led to the consideration of Davos as a potential location for housing a new AO center. The eccentric location far from university centers had its own pros and cons. AO research was meant to serve by priority the surgeons fracture and trauma treatment. Thus the goal and the function of AO research were distinctly different from the research at universities. A good contact to basic research at universities would not require geographic proximity. In turn the high density of local scientific institutions in Davos like the Immunological Research, World Radiation Center, Avalanche Research, World Economic Forum, Global Risk Forum etc. made Davos an attractive location for research.

Another activity also increased the AO focus on Davos, the workshops at the Davos AO courses were using cadaver bones at the outset. The increasing number of participants led to a strict requirement to replace cadaver bones with artificial bones. These were developed in the ARI by Urs Schneider in collaboration with Contraves where Mr. Heller was an ingenious talent producing plastic that mimicked cortical and can-

cellous bone. It is worth mentioning that Contraves was a company which otherwise produced rockets for military applications. The production was later transferred to nearby Filisur but the handling remained in Davos where the local shelter for the disabled took care of this activity in a superb manner.

Where in Davos? Possible locations of the AO center:

1. The picture shows the Basler Sanatorium that was empty at that time. The discussion with the intermediate owners did not succeed, the conditions were simply unacceptable.
2. The possible location "Sand" was special, as the project included a combination of the AO center and a military surgical operation setup.
3. An interesting solution was proposed for a location near the World Radiation Centre This area was tricky because it was on an avalanche trail.
4. At the location where the center is today two projects were of interest. The first project considered looked like a mushroom farm with combined octagonal elements connected in a way that would result in optimal communication between the groups and their collaborators. For reasons of technical and financial uncertainty the project was dropped.
5. The proposition to shape the center like the well-known Toblerone chocolate made it. The team of the architect Jakob Zweifel realized the center housing the different functions.

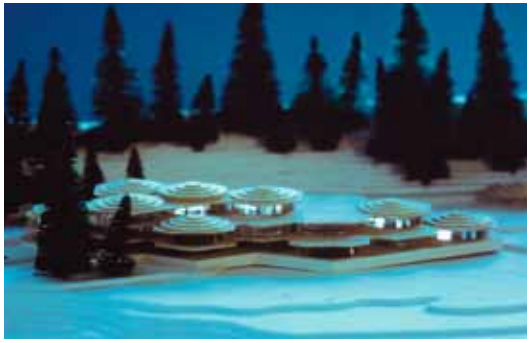
The political situation in Davos was difficult to begin with, given that the plan was to build in an area that was reserved for farming. A public vote was required. The Davos people, with an impressive majority, supported the change of farm land into a zone reserved for research.

Financing of the new building was assured by essential private contributions from the pioneers and by the AO Foundation.

1. The first choice location, an empty sanatorium, superb possibility but at a fantastic price.

2. A construction planned together with the Swiss Army, the lower floors would have housed a military surgical hospital.

3. An interesting but dangerous location in an avalanche area near the POMD.



4. A far advanced project at today's location with octagonal elements had to be dropped, it demanded too much courage.

5. The final project that was executed is reminiscent a special Swiss chocolate "Toblerone".

History of the building

Prof. Dr. med. Peter Matter and Prof. Dr. med. Stephan Perren

The sequence of decisions and construction

June 1987	Boston Trustee meeting	Accepted
June 1988	Baden-Baden Trustee meeting	Information on project
December 1988	Voting in Davos "Research zone"	75 % of Davos population in favor
January 1989	Re-dimensioning	To cut cost
May 1989	Submission	
April 1990	Start of construction	
July 1990	Underground work, pillars	
June 1991	Construction under roof	
Winter 1991 / 92	Indoor construction	
1992	Inauguration	

Construction begins


1


2


3


4

The building process from ground-breaking in April 1990 to inauguration in June 1992

Due to the soft nature of the clay on which the AO Center was built it was necessary to drive numerous piles into the soil to provide a secure foundation for the building.

Close cooperation and frequent meetings between the AO and the construction team made it possible to keep to the construction schedule. Key AO representatives Berton Rahn and Manfred Klebl showed an outstanding commitment to the building process and followed the progress daily. They helped to optimize the plans based on their significant experience and innovative ideas.

Heavy snow during the Davos winters in the first two years meant a five month break in on-site building activities although the detailed planning process went ahead despite the conditions. Once the roof was in place construction was no longer weather dependent.

1. The ground-breaking ceremony.
2. Martin Allgöwer on April 30, 1990.
3. Pile-driving on the construction site.
4. Site progress seen on July 18, 1990.


Berton Rahn


Manfred Klebl

History of the building


1


2


3


4


5


6

1. Seven months into the project on November 1, 1990.
2. The main three floors of the AO Center are visible on May 9, 1991.
3. Footprint of fame made by project leader Stephan Perren.
4. Skeleton construction work visible from a helicopter.
5. The window frames seen from inside.
6. Scaffolding on the building front.

7. The roof was installed on the building on June 24, 1991.
8. The topping-out ceremony.
9. The building close to completion on September 7, 1991.
10. Team AO International.
11. The AO Center's first winter in 1992.
12. AO Center with its unique sculpture.
13. Inauguration of the AO Center on June 28, 1992 with a circus tent.

Inauguration

Prof. Dr. med. Peter Matter and Prof. Dr. med. Stephan Perren

The inauguration was planned in conjunction with the annual Trustee Meeting in June 1992, which at the time was planned to take place in Davos every third year. This was no doubt an historical event for the AO Foundation when the Trustees together with special guests witnessed the "Handover of the Key". The official opening ceremony took place in the new auditorium dedicated to Martin Allgöwer. It ended with the "Handover of the Key" by the architect Jakob Zweifel to the AO Foundation President Martin Allgöwer.

AO Center Davos
Inauguration

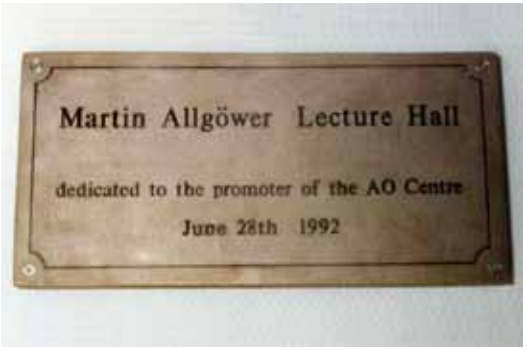
Program

A Vision becomes Reality
Prof. M. Allgöwer, President of AO/ASIF Foundation

AO Research Institute
Prof. S.M. Perren, Director

Greetings of the Swiss Government
Prof. Th. Zeltner, Chief of Federal Office of Public Health

Handover of the Key
J. Zweifel, dipl. Arch. BSA/SIA



After an aperitif in front of the new AO Center, the Inauguration Party took place in the Family Gasser's circus tent. The evening program followed a very detailed plan with a sequence of speeches, meals and impressive circus presentations from artists as well as an impressive performance of lions and tigers. Claude Wenger, the chairman of the Board of Directors, had to give his speech inside the cage with the wild animals and was therefore very keen to finish on time, because otherwise the lions and tigers would have terminated his performance for him!

1. Eugen Kuner, August Guggenbühl, Hardy Weber.
2. Rigmor Texhammer, Ruedi Maag, Anne Murphy.
3. G On Tong, Siegfried Weller, Suthorn Bavonratanavech.
4. Röbi Frigg, Röbi Mathys, Paul Gysin, Werner Christinat.
5. Jörg Auer, Röbi Schenk.

Inauguration


6


7


8


9


10


11


12


13


14

6. Martin Allgöwer.
7. Peter Matter.
8. Stephan Perren.
9. Maurice E. Müller.
10. Jakob Zweifel.
11. Urs Jann, Howard Rosen.
12. Hans Willenegger.
13. Hansjörg Wyss.
14. Maurice E. Müller, Jean-Claude Wenger

Circus performance

This memorable and exciting inauguration of the AO Center was marked the next day by two significant events:

Peter von Rechenberg, Chairman of the Board of Directors until 1991, passed away suddenly while still in Davos.

AO North America was established on the Rinerhorn as the first regional AO Chapter with Peter Trafton as its first President.

The AO Foundation under one roof

Urs Jann, former Director of Finance and Administration (1985–2005), Lukas Kreienbühl, COO

Back in the 1980s and the early 1990s the various AO institutions, and the key AO personalities running them, were scattered across a number of different locations in Switzerland. Understanding how the AO operated twenty or thirty years ago is key to understanding the impact that the creation of a new home, the AO Center in Clavadelerstrasse, had on the evolution of the AO Foundation.

The AO Foundation was established in December 1984 in Davos, with its legal domicile in Chur. The newly-created function of AO Foundation General Manager was filled by Urs Jann in December 1985, with an office and a secretary in Balderstrasse, Bern. AO International had already moved to this location from Murtenstrasse in 1982, with Hans Willenegger, President of AO International, and Walter Bandi who dealt with liability cases and material failures. Once a week Martin Allgöwer, President of AO Foundation from 1984–1992, would visit from Basel or Jann would travel to meet Allgöwer in his office. AO International had two secretaries Astrid Mauerhofer and Doris Bucher while Rigmor Texhammar was responsible for OR personnel education. From 1982 Margrit Jaques was on another floor of the same building. Jaques was responsible for the Minutes of the Board of Directors, Technical Commission, Research Commission and administration of worldwide patents and trademarks on behalf of Synthes AG Chur. Furthermore, as a Member of the Board of Synthes USA and Canada, she was a link to North America.

The Chairman of the Board of Directors of the AO Foundation, Peter von Rechenberg was located in Chur. The patent and trademark exploitation company Synthes AG Chur–of which Jann was General Manager and von Rechenberg its President–also had its domicile at the same location. Curia Treuhand, von Rechenberg's audit company, would do the accounting, financial reports, tax advising, supervise the income of royal-

ties, financial flows, etc. for the AO Foundation and its institutions.

The AO Documentation Center was located in Murtenstrasse in Bern, where Maurice E. Müller had his offices. In the late 1980s the Trauma Documentation and the Documention of Prosthesis were split, and the Trauma Documentation moved to a historical building in Schwarztorstrasse (see page 59). The Maurice E. Müller Institute for Biomechanics at the University of Bern, was also based in Murtenstrasse. Furthermore an office for the AO Technical Commission, with Fridolin Séquin as key collaborator, was located there. Finally a modern auditorium which allowed live surgery transmissions from the University Insel Hospital had been built and financed by Müller. A large number of hip courses and trauma symposia took place at this center.

In Davos, the Research Institute was housed in a rented location in Villa Fontana. The available space was far too small for the growing number of collaborators. It would have been necessary to spend several million Swiss Francs on this rented property in order to make it suitable for their needs; this was not considered opportune at that moment. In addition Stephan Perren, who was then the Director of the Davos Research Institute as well as the Head of the MEM Institute in Bern was using a flat in Balderstrasse as his "pied-à-terre".

Peter Matter, head of AO Switzerland and the surgical department of the Davos Hospital, was responsible for the AO Course Secretariat in Davos. Mary and Claudio Gubser were helping him to organize the yearly Davos Courses with the support of the Research Institute including Perren and his team. Matter covered the medical and logistical side of the AO courses while Perren focused on research and development.

To summarize, while every December since 1960 Davos became the AO mecca, during the rest of the year a significant part of the AO's activities and orthopedic networking was taking place in Bern.

At that time Synthes AG Chur had three licensees: Mathys Bettlach, Straumann Waldenburg and Synthes USA; all three key owners, Robert Mathys, Fritz Straumann and Hansjörg Wyss respectively were members of the Board of Directors of the AO Foundation. The brands Synthes and Protek were considered "the Swiss implant companies" and had joint distribution agencies (with the exception of Switzerland and North America) in over 30 countries

At the beginning, numerous visits by fellows, former fellows, even former and current foreign Ministers of Health, who were participants at courses in Bern, took place in Balderstrasse. Willenegger usually received them for a two-hour audience in which the

The AO Foundation offices at Balderstrasse in Bern.

medical and political situation of a country in general and the situation of the particular hospital were discussed. Guests would usually leave with a big smile on their face and a set of basic slides in their bag. After that Willenegger used to dictate a memorandum in which the surgeon in charge, the potential successors, and other key persons were described in great detail.

With the gradual retirement of the Founding members – Robert Schneider, former head of AO Switzerland (1990) Bandi (1997), Willenegger (1998) – the attraction of Balderstrasse waned.

Due to the widely-dispersed nature of the organization, Allgöwer had the vision to establish an AO Center, whether it was in Bern or Davos. Müller first had the idea to build an AO Center where the Paul Klee Center is today but the local government blocked his projects. Other project locations were reviewed, but did not move forward for the same reason or were not realistic in terms of infrastructure or available funds.

There were long basic discussions about whether a new AO Center should be located close to a University or have an independent location in Davos. Finally the idea of independence won over the close links to a University and the AO Center was inaugurated in 1992. This meant that all AO institutions at that time located in Bern (AO Foundation, AO International, AO Alumni Association, AO Documentation Center) had to be transferred to Davos along with their collaborators. The largest issue of course were the collaborators: about one third decided to leave the AO, one third to move to Davos on a temporary basis and one third were ready to move to Davos permanently. The only exception was Jaques and her office who opted to stay in Berne.

The idea to have all institutions and collaborators in the same building was revolutionary. It meant that the AO could finally show national and international visitors what the organization did and had under a single roof: research; development; documentation; education; an auditorium, an audiovi-

sual studio with the link to the hospital Davos and the Davos Convention Center; Willeneggers old library; various bone models with implants to illustrate the AO techniques in general trauma, spine, maxillofacial and veterinary; an operating room for animals, and more. All heads of the institutions and the key collaborators had their offices there and could be easily contacted. Through close working contact the collaborators from the various institutions started to understand what the other collaborators were doing and why. An AO Center Management team with regular monthly meetings was established to solve the strategic, technological, financial and human resources issues. During the AO Courses in December regular visits to the AO Center could be organized. During the meetings of the Board of Trustees of the AO Foundation, meetings of AO Switzerland and gatherings of the Alumni Association, the work performed and the progress made could be easily shown. The AO Center helped substantially to foster the presence of AO in Davos and within the AO Foundation.

The fears that it would be difficult to find good quality collaborators in a decentralized location did not materialize. Furthermore the increased availability of knowledge via the internet and the interactive platforms of the AO Foundation such as AO surgery and e-learning have partially compensated for the direct link to universities. All international research fellows that spent time in Davos became steeped in the AO philosophy and usually continued to be closely linked to the AO organization of their country.

Over the past 20 years, the number of activities at the AO Center have grown significantly which is evident in the increase in the number of employees. In 1992, the AO Foundation and its institutions employed 107 staff, by the end of 2011 this number had increased to 244 permanent staff (216 based in Switzerland and 28 in Asia, North and Latin America). In 2011, a further 33 temporary staff, including fellows and apprentices, worked for the AO.

The continuous expansion and globalization of the AO Foundation is reflected in the evolution of the operating expenses of the AO around the world. In 1992, the annual operating expenses amounted to 21 million CHF compared to 105 million CHF in 2011. A historic milestone occurred in 2006, when the AO sold its intellectual property rights to Synthes to become financially more independent. As a consequence, the financing model of the AO changed and royalty-based income was replaced by income from the Collaboration and Support Agreement with Synthes and the financial income from the underlying endowment.

Since the level of specialization of the surgeons in the AO network has become more

pronounced over the last two decades, the organizational structure of the AO has had to alter to accommodate this. In 2006, AOSpine was created as a dedicated clinical division in order to focus on the specific needs of those surgeons. Thanks to a positive experience with this concept, the same approach was taken two years later, by establishing AOTrauma under the umbrella of the AO Foundation. As a consequence, a three pillar system defines the organizational structure of the AO employees. In the first instance there are four clinical divisions: AOTrauma, AOSpine, AOCMF and AOVET. Secondly, service units have been created to represent the four core competences of research and development (ARI), clinical investigation and documentation (AOCID), education (AO Education) and innovation (AOTK). And thirdly there are support units dedicated to the areas of finance, information technology, human resources, communications and events and intellectual property. Exploratory research is administratively assigned to the support units, but reports directly to the AO Exploratory Research Board (AOERB).

The globalization of the AO has been strongly supported by the increasing level of activity in the regions and by its regional offices based in the US, Colombia, Brazil and Hong Kong. The number of educational events worldwide grew in 2011 to 694 courses with almost 40,000 surgeon and operating room personnel participants, giving a total, since 1960, of 560,000 participants. Similarly, the AO Foundation Davos Courses flagship event, grew from 69 participants in 1960 to over 1,800 participants and over 400 faculty members in 2011.

In retrospect, the founder's decision to build the AO Center 20 years ago in Davos has proven to be a wise one. Based in the highest city in the Alps, with an open mind and fostering collaborations and exchange on a global scale, the AO Center has been an important and reliable anchor for the continuous and sustainable growth of the AO Foundation. At the same time, its significance for the city of Davos as an employer, and its attraction of congresses and educational events, has made it a cornerstone of the local economy.

History of research

Prof. Dr. Sci. Geoff Richards, Director AO Research Institute Davos

Having been a member of ARI for nearly 21 years, from a young student to my curernt position as Director, I am honored to shed some light on the history of the AO Research Institute Davos (ARI) and what it means to the AO Foundation.

Prior to 1992, the majority of AO employees were members of the Laboratory for Experimental Surgery Davos (LECD) under the directorship of Stephan Perren. This included research, development (ADI and the TK System), finance, video, computer services (under the leadership of Werni Wind), journal supplement publishing, translational services and house maintenance and cleaning. AO International consisted of Mary and Claudio Gubser working at the hospital and reporting to Peter Matter (who was also the Swiss AO President at that time). After an all-encompassing discussion, the Board of AO Trustees decided to build an AO-owned center and decided that the Research Institute should not "belong" to any particular university but should be autonomous, engaging in relationships with numerous universities. Davos was seen as an ideal place for undisturbed thinking and research. In June 1992, the AO employees moved from the former Tuberculosis Research Institute (Villa Fontana, LECD headquarters), Meisserhaus Davos, Davos hospital and Bern to the newly completed headquarters, AO / ASIF Centre to gain space and have all groups under one roof for better collaboration. The LECD was renamed the AO Research Institute Davos (ARI). The 1992 AO Foundation report from Perren stated "the size of the building demands that each member of staff makes active efforts to make contact with the others." These words are even more important now in 2012, with AO branches in Zurich, Bogota, Hong Kong and the AONA in Paoli, Philadelphia.

Period 1: 1992–1996 under the directorship of Stephan Perren

In 1992, the ARI was overseen by a board of six directors, five MD's including our outgoing president Norbert Haas and one with industrial experience, Hansjörg Wyss. This board was responsible for ensuring that ARI was given clinical guidance and, with Wyss on board, strong contact to the industrial partners. The purpose of the ARI employee group was to be available mainly to the AO Trustees as a central pool of human and research resources. The interdisciplinary staff and research of ARI was oriented towards solving clinical problems by improving the knowledge of bone physiology and related principles and techniques. The ADI was devoted to technical improvements of trauma treatment working closely with ARI and TK. Work at the AO Center was performed in an open and friendly atmosphere, with effectiveness stemming from friendship and mutual trust. The yearly Davos courses were technically organized by members of ARI (Manfred Klebl, Robert Moor, Elena Rampoldi, Vreni Geret, Benno Dicht and Helga Klebl) and ADI including all video production and live transmission, design (Urs Schneider) and administration of artificial bones (produced since 1988 by Synbone) together with the course secretariat (Claudio and Mary Gubser) of AO International and the three industrial partners (Mathys, Stratec and Synthes USA), using about one month of the Research Institute's capacity.

In the 1990s creativity was key in ARI, based on sensible questioning of established techniques and facts from experts with ideas which could be worked on immediately within days with lean administration. Often the ARI went against accepted scientific and clinical hypothesis's that were accepted around the world as fact and ARI was often proved right through diligent science. The goal of the ARI and ADI's work was to improve the treatment of trauma by researching relevant clinical questions, developing simplified models including computer simulations (eg., finite element), investigating biomechanical techniques, undertaking cell and bacterial biology along with in vivo testing (ARI had a full time veterinary surgeon employed along with an animal care team under Urban Lanker attending to animal welfare), histology and imaging (including computed tomography) and development of biodegradable polymers. Several research systems were developed within ARI (the systems were not commercially available) to keep it at the cutting edge, these included the ultrasonic microscope (separating local bone density and modulus), six degree of freedom loading machine (for spine biomechanics research and other areas), stereolithography machine (producing physical models based on CT imaging for pre-surgical planning) and the polymer fibre extruder. In all cases these developments offered sufficient technical challenges to support thesis's and were used as state-of-the-art multi-

purpose research tools afterwards. Scientific publications, lectures and books were improved through the outstanding artwork of ARI's Jan-Piet Imken, whose work outlived him.

ARI was innovative in diseminating information, with Stephen Bresina and Perren having set up the first AO web site in 1991, for internal purposes, and going public in 1992, to get information out on AO courses to possible participants. This was one of the first web sites in Switzerland, which I also had the pleasure to be webmaster for ARI for a short time before initiating the move of the AO Foundation web site from ao-asif.ch to aofoundation.org to show its not-for-profit status on a worldwide level. Student courses on fractures and treatment were already offered by ARI at that time to medical students from Bern and Basel and engineering students from ETH Zurich (each with around 50 attendees per course). In 1992, the ARI also hosted 20 medical guests and eight scientific guests along with several medical fellowships for various durations to collaborate with the ARI projects, ensuring clinical collaboration and input. This continued throughout the 1990's.

1992 – Opening of the AO Centre: Hansjörg Wyss, Steve Bresina, Geoff Richards.

Soon after entering the new AO Center, ARI started to shift from bone biomechanics looking at stability and rigidity to biology, preservation of vital soft tissues, tissue tolerance, circulatory disturbance, tissue necrosis and infection resistance, supporting the development of the new locking plate technology from the ARI. In 1992, ARI had one of the most creative engineers in the field, Slobodan Tepic who, together with Perren, designed the point contact plates with locking screws, the locking plate technology that is the basis of all locking plates used throughout the world today. This technology was combined together with the previously developed technology of the Dynamic Compression Plate (DCP) (Perren) by Röbi Frigg to produce today's successful Locked Compression Plate (LCP), the mainstay of Synthes, based upon two concepts from the ARI. In 2008, Frigg was awarded an Honorary Doctor title at the Medicine Faculty of the University of Zurich in recognition of his structured cooperation in the exploration and testing of new osteosynthesis).

Slobodan Tepic in typical lecture style (the only faculty requiring projector).

Tepic and his team including Keita Ito (who received his PhD at MIT in 1994 and became Professor in 2004 at Eindhoven, where after leaving ARI, he joined as a full employee in 2007) and Stephen Bresina and numerous medical fellows worked in the early 1990's on a variety of topics. These included: engineering projects designing new research tools; locking plate technology and monocortical screws; theories on fluid flow in bone; a human prosthesis for Protek (for Maurice E. Müller); a dog prosthesis (which is successful today through Kyon); bone cement delivery systems; Flexafix (a wrist fixator with three rotational degrees of freedom); a telescopic motorized nail; fracture distractors; four bar linkage mechanisms for bone cement caulking guns (Design Prize Switzerland, 1999, which is also very successful with Schering-Plough Corporation); and Swissors® (Design Prize Switzerland 1993, now sold by Wenger, the best imported product prize 1997 for Japan). Another close collaboration was with Stephen Bresina and Jim Green of Synthes on reamers to minimize pressure build up which is now taken shape in the RIA device. Unfortunately in 1996 Tepic left ARI.

The broad scope of resorbable polymers had just started in the early 1990's for possible use in fracture fixation and the basic scientific work of Prof. Sylwester Gogolewski at ARI on designing polymers (from bulk material to membranes to porous scaffolds) to adjunct use to metals is still highly referenced today. Unfortunately the translation to the clinics was much slower than expected. Some translation was in miniplates and degradable pins for non-loaded areas and anchoring systems for ligaments to bone. Several of these polymers were tested for cytocompatibility in the tissue culture group of Hans Gerber.

Along with duties as vice director, histology, microscopy and general bone healing, Berton Rahn worked in the 1990s on several projects in the maxillofacial (MF) field together with several MF medical departments

from reconstruction of defects in orbital walls to cranial defects to screw loosening in the mandible, developing numerous preclinical models for these studies and also using the polymer technology developed in the ARI. Berton's interest in surface topography at that time sparked off my own research into surface roughness to control tissue integration or prevention of integration on metals for the MF and hand areas, which only now in 2012 has caused change to all Synthes implant surfaces with polishing to prevent tissue irritation. It was rather naive that I did not patent the polishing idea for the benefit of the AO endowment.

Infection research under the guidance of Urs Schlegel and Perren was also highlighted in this period. Numerous medical fellows looked at the infection resistance of different materials, plate and nail designs with and without reaming and at the newly developed locking technology from ARI, thus showing by implant design which could protect the blood supply minimized infection risk and that the locking technology far outclassed the previous compression technology in infection resistance.

The late Berton Rahn at eCM IV honored to his research in the year of his retirement in 2003.

In this time period ARI / ADI and the TK System worked very closely together (with Perren as the Director of all three). The TK under the management of Frank Baumgart (at that time with eight specialty groups – long bone, spine, small fragments, pelvic surgery, maxillofacial surgery and veterinary surgery) which defined the AO technique for fracture treatment and reconstructive surgery along with approving AO products. In 1992, TK started a mechanical testing workgroup (later to become an expert group) to define and harmonize testing methods of devices with members from ARI / ADI and the industrial partners. This was soon followed by a materials TK group to control material issues from bulk to surface to reaction to biology, which sparked many of my own project ideas. Already in 1992 modified implants were considered in the Asian working group and TK began to monitor clinical studies in cooperation with AO documentation. ARI and ADI specialists were members of these groups for technical advice and support for research, which worked efficiently and good working relationships

and friendships were made within these teams. The Development Institute, which started in 1989 and was managed by Röbi Frigg with a team of eight (in 1992), looked at prototype development to solve particular clinical problems from surgeons produced and brought prototypes to the TK, with devices in the early 1990s such as pinless external fixators, X-ray transparent aiming devices and the LISS plate. The actual physical building of the AO Centre attracted much attention in Davos, for example Roni Schwyn first saw the AO Centerunder construction while walking along the river, found out what it was for, was motivated by this and joined ADI in 1992. He remained and currently is a member of our biomedical services group.

Röbi Frigg in lecture mode.

In 1995 Perren (one of the signees of the AO Foundation in 1984*) resigned as Director of ARI, TK and ADI though remained as the chair of the Board of Trustees of the ARI which existed at that time (since the ARI is a not-for-profit Foundation in its own right, since 1959). The goals of this team were to support the ARI, supervise activity, communicate its importance and take responsibility for its scientific and economic future. I quote from Perren's leaving comments, "Research does not mean treading familiar ground, making measurements to confirm preconceived assumptions or to prove the obvious. Research consists to a great extent of a risky process of following new hypotheses into the unknown." This statement should also be considered now with the current excessive administrative burden and need to appease the current "experts" on which way ARI projects go and whether they can start or not.

[*Note: The purpose of the early AO association and the new Foundation in 1984 was defined as the support and promotion of the Laboratory for Experimental Surgery, "as well as the advancement of the AO concept, and the research, education, and documentation in the field of medicine in Switzerland and abroad connected therewith."]

1996 / 1997 acting director

Wilson C. Hayes became acting director of ARI (not TK or ADI), until April 1997. From

1996 onwards, the annual report of the ARI was separated from ADI and TK. The 1997 ARI annual report showed the new relationship of the ARI to the Board of Trustees of the ARI under the chairmanship of Perren (until 1998, where he took on a senior advisor role for ARI). Under the interim directorship of Hayes a review of the functions of the institute was undertaken once more, and a new restructuring process was initiated.

Period 2: 1997–2007 under the directorship of Erich Schneider

In April 1997, Erich Schneider was appointed Director of ARI. Extramural funding became a goal of the ARI. Work continued with research in the biomechanics team into disc dimensions and shape recovery at rest with the hypothesis on disc valves at the end plate and disc interface. Biology looked at the cell biology of large bone defects and the influence of cytokines. Work continued on the locked plates. Concerns on bisphosphonates (discovered by Herbert Fleisch, the second Director of the LECD for inhibition of bone resorption) initiated research into their effect on bone strength (which clinically now is known with problems such as bisphosphonate related osteonecrosis of the jaw). The Polymer team looked at the production of polylactide resorbable membranes and sterilization methods with clinical studies in Australia along with inserts for anchorage. The potential of these implants was also assessed by Berton Rahn and Jochen Prein in orbital defects. Another area investigated was the use of polymer foams for cartilage defect repair and I was happy to help with studies on the morphology of cartilage together with our ARI team member Max Kääb. Biocompatibility studies of the clinical metals, tissue tolerance of wear particles and tissue adhesion were also studied. Low cost external fixation clamps were also designed and tested and together with the AO Social Economic Committee (AO SEC) who carried out a small clinical trial.

ARI initiated a joint replacement group with Markus Wimmer, mainly working on joint implant wear. Schneider split the former biomechanics team of Tepic into three groups under Bresina looking at spinal testing, treatment and implants, Ito looking at cartilage biomechanics and Melissa Tate

Erich Schneider describing the LECD and ARI history.

looking at bone biomechanics. Schneider initiated and ran a group on fracture treatment in osteoporotic bone looking at animal models together with the experimental surgery group under Ronald Wieling. In 1998 it was evident that the freedom in research was starting to change as noted by Schneider. "Detailed plans and deadlines are thought to lead more quickly to the desired advances, but researchers work better in a climate of stimulation, excitement and acceptance… the institution capable of providing such environment will be successful in the future." Yet again administration and the need to control and report started to have effects upon the institute within one year of Schneider's period in office.

The ARI members who worked in the area of photographs, graphic art and video in 1998 formed a new group called AO Media Services in AO International, while Röbi Moor continued to run the remaining infrastructure group for the ARI including assisting in preparation for the AO Courses in Davos. In 1999, Schneider increased the focus of ARI in the biology domain (which was cell biology under Hans Gerber looking at cell culture, organ culture of bone and cell differentiation and interface biology looking at cell and bacterial implant reactions under myself) by also bringing in Mauro Alini to lead the new area of tissue engineering looking at areas such as delivery of growth factors and other bone healing stimulants.

In 1999 I ran the first European Cells and Materials (eCM) conference in Davos. In order to maintain and increase networking within Switzerland (and further afield) other meetings such as the Swiss Society for Biomaterials, workshop on bone substitutes and Biomechanica were also held in Davos. In 2000, Stephen Fergusson completed his PhD on the labrum at ARI and like many other students who have worked at ARI through dedicated work have excelled and remain ambassadors for AO (Fergusson is now a Professor at the new ETH Zurich Department of Health, Engineering and Science Technology).

In the last millennium research funding from the AO Foundation was mainly in Davos and as a community development through start-up grants. In the new millennium research funding increased to the community and the Board of Trustees of the Research Institute took on a new role assuming responsibility for all AO Foundation research-related activities (ARI, AO Research Fund and collaborative research institutes that started in Charité Berlin, Müller Institute Bern, University of Nottingham, Harvard Medical School, Boston and Orthopaedic Research McGill in Montreal) and was renamed the AO Research Board.

In 2001, ARI also became one of the first Swiss academic research organizations to achieve certification of its quality manage-

ment system, where quality is defined and then measured, the workflows and standard operations based on 40 years' experience were analyzed and defined and the whole process allowed for self evaluation and reassessment. In 2002, the animal housing facility was renovated and extended which was the first part of having the whole set up for preclinical research under one roof for better animal welfare and streamlined studies; this was completed with a move of the surgical suites to the facility at the beginning of 2011.

Work continued with biological degradation of cements in Rahn's team, several studies on the growth factor TGFß with tricalcalcium phosphate and polymer carriers on the promotion of bone healing. In Interface Biology novel *S.aureus* surface antigens expressed during infection were discovered, numerous coatings evaluated for their anti bacterial adhesion properties and cytompatibilty with eukaryotic cells and a control hypothesis based on surface roughness of tissue integration at the cellular level proven. Models on disc degeneration and intervertebral strain were brought forward along with reinforcement of vertebral bodies with cements and developed porous cements evaluated. Injectable polymers were developed and effects of loading on cartilage and disc cells evaluated. Work on the difficult osteoporotic preclinical models continued, though eventually due to concerns about animal welfare this work was stopped, so that fixation in osteoporotic bone was looked at more in cadaveric models. Numerous in vitro and ex vivo tissue and organ culture bioreactors for bone, disc and cartilage were designed, developed and tested and are still in leading experimental research studies to this date. Ideas on angular stable locking of nails were devised, tested and proven and the technology passed on to the TK and industrial partners.

In 2005, ten years after the last major look at the concept of research in the AO, the process started again and a global research report was produced describing all the new modes of basic and translational research the AO Foundation was initiating and supporting on top of the central ARI (and ADI): the AO research fund, clinical priority programs, collaborative research centres, spine research network and the newly-formed biotechnology advisory board. The details of the science and individual strategies of these new concepts are beyond the scope of this mini history of the first 20 years of research at the AO Centre. The numerous processes and structures together did not form a cohesive strategy for the AO Foundation's research, each going in their own direction, without an overall guiding board for attainment of common goals.

At the end of 2007 Schneider left ARI and took on a new role with Academia Raetica.

Stephan Perren wishing Erich Schneider well at his leaving event.

2008/2009 acting directors

In 2008, Gregor Strasser CEO was Acting Interim Director of the ARI working closely with Alini and Richards until August 31, 2008. Marcel Dissel CEO was Acting Interim Director until August 31, 2009 also working closely with Alini and Richards. In January 2009 the AO Development Institute (ADI) was integrated into the AO Research Institute Davos (ARI). Within these two years, the budget from the AO Foundation for ARI and ADI combined was reduced from 13 million to 8 million CHF and the number of full time employees reduced from approximately 120 to 70.

Period 3: 2009–under the directorship of R. Geoff Richards

It is rather bizarre to write a history of one's directorship while one is still within the third year of the position, but since this is a 20 year history of the center, the task can be accepted, though I will be interested to see how my successor(s) rate my time in office. It certainly is different to the times since 1992 of Perren and Schneider, where there was one board to report to and one flow of funds from the AO with minor external funds overall. The AO has become extremely complex since the 1990s and administrative work to receive the ARI funds has increased exponentially. However the current Price Waterhouse Coopers review (and ISO certification) both note the cumbersome process ARI has to endure to get hold of its own funding from the AO.

After assuming the Director position, the first decision I took was to produce an overall ARI mission (within the AO Foundation mission) and goals. The ARI mission is now "Excellence in Research and Concept Development within trauma and disorders of the musculoskeletal system and translation of this knowledge to achieve more effective patient care worldwide." The ARI, with the integrated ADI, no longer develop physical products to sell to trauma and orthopedic companies to help the AO Foundation endowment, but develop concepts that can be proven and sold and then co-developed with an industrial partner. Four goals were also defined within the ARI mission: contribute high quality research and develop-

Geoff Richards in difficult ARI resources discussions.

Geoff Richards at the Trustees in Lisbon honoring the ARI's past giants.

ment; investigate and improve the performance of surgical procedures, devices and substances; foster a close relationship with the AO medical community, academic societies, universities and industry; provide research environment / support for AO clinicians. Every project we perform at ARI fits into our goals for our mission which is a part of the AO Foundation mission.

Since September 2009, I have been director of the ARI. My first task was completion of the integration of ADI into ARI; it was not easy to combine two totally different cultures. I restarted Medical Research Fellowships with a six to twelve months stay at ARI; the basics of running a scientific project are taught through active participation within an ongoing project to fellows from all over the world. This immediately took off and has become as successful again as it was in the early 1990s when I arrived here under Perren's directorship. This is a clear pillar of the center. I initiated that ARI will teach trauma within the upcoming masters courses from 2013 at the new Health Sciences and Technology of the Swiss Federal Institute of Technology (ETH) Zurich to build a good connection to ETH without losing any control of the ARI to them. Together with Alini, I have met and helped build strong connections to the Orthopaedic Research Society (ORS), where we have held workshops and stand on committees. We have also initiated better contact with the Orthopaedic Trauma Association (OTA) where we have been involved in 2010, 2011 and 2012 in organizing the basic science focus forum and improving overall AO Foundation and OTA relations. Both of these connections have involved help from ARI eCM journal editors (two of whom are past presidents of ORS and advise

the AO Exploratory Research Board–Chris Evans from Harvard and Brian Johnstone from Portland) and also for OTA, Ted Miclau (San Francisco) who was a fellow at ARI in the early 1990s. From January 2012, Miclau became President of ORS. Building and maintaining such collaborations takes time and trust, which only works in friendly atmospheres such as we maintain at ARI and the benefits of such relationships gained (based on merit alone) is not measurable as a key performance indicator. This has helped put ARI back on the academic scientific map along with the continual improvement in quality of our publications (steadily increasing in impact factor), acquiring national and international grants by ARI team members, bringing the ARI team to the forefront of high quality international conferences, editorial boards and societies in committees, chairing positions, keynote lectures as well as organizing important conferences such as the yearly eCM conference, European Orthopaedic Research Society (2010), European Society for Biomaterials (2009).

We at ARI are particularly proud of the fact that we initiated and still lead the way in academic research publishing worldwide. During the first eCM conference in Davos in June 1999, long before open access was a term in the scientific publishing world, the idea of an online "free-to-all" scientific journal was born by Iolo ap Gwynn, University of Aberystwyth, Wales, Godfried Roomans, Uppsala University, Sweden and myself. High production costs precluded a print option so online free-to-all literature was decided upon as the only logical way forward for scientific publishing. A team of internationally established scientists was created to conduct the reviews. An editorial process was set up to deal with manuscripts for papers and supplements. All the work was done voluntarily. After a year and half's hard work by the three founders, we launched our first volume in January 2001. Our goal was to accept only high level publications putting them through a rigorous review procedure. We also had the unique pattern, "Discussion with reviewers" section at the end of each paper, keeping the review procedure more open and transparent than traditional journals to minimize possible favouritism or prejudice. The eCM journal was now live, with a group of dedicated scientists working as volunteers to promote it. In June 2009, the first impact factor (based upon the citations of 2007/8) was given–4.289, we were straight in at number three in the biomaterials field. The eCM journal was fed with excellent papers from the annual single-session focused topic eCM conferences in Davos, which started in 1999 and continues today with subject areas repeating on four year cycles to allow major changes to occur within the respective fields. The 2009 eCM conference, focused on Stem Cells for Musculoskeletal Regeneration, started with a notable first for the eCM se-

ries of conferences (and AO conferences and courses in general) when the opening presentation was given by the winner of the 2007 Nobel Prize for Medicine, Sir Prof Martin Evans. In June 2010, the 2009 Impact Factor of 5.378 was given putting us at number one in trauma research where we remain with our 2011/2012 with the IF of 9.65 and over 12400 registered readers world-wide. eCM was the also the first scientific journal with a transparent review processes and governance, including a transparent route to becoming a member of the International Editorial Review Board (IERB). From ARI team Alini and Martin Stoddart are on the scientific editorial board and several other members of the ARI team are on the IERB making this an ARI success.

Overall the ARI has shifted research from replacement to restoration and regeneration with the expert young team under the leadership of Alini who has a wide knowledge base in the field of tissue engineering. His four areas under guidance of young expert motivated researchers in polymers, disc, stem cells and bone repair are all on the rise for the substances (with or without cells) to be used in treatments of patients in the upcoming future. Fintan Moriarty has started a young group in Infection work improving models to bridge the gap between research and the clinics. Boyko Gueorguiev's team has emerged as an excellent research team in the area of augmentation in osteoporosis in addition to the concept development team which has developed the very exciting X-in-One implant positioning assistance system which has major advantages over current systems on the market. The team also hosts a large amount of collective knowledge in biomechanical testing methods and prototype production for research. Our new program leader Markus Wilke is helping maintain and set new standards with his experienced team, in addition to a young team for the surgery, CT, histology and imaging and modeling of patient scans. His animal care remains in the expert hands of Lanker who also has been with the ARI throughout the 20 years of the new center. The ARI can be proud that the team of Romano Matthys created a spin off at the beginning of 2012, the company RISystem AG was founded by the AO Technology AG (49 %) and Romano Matthys (51 %) and we wish him luck with this venture. The other very successful focus area from the group "Skill training technology" with two core projects the "PlayGround for trauma surgeons" and the "Oskit" (a reusable fracture fixation learning box based on the Müller Classification) were handed over in the value chain to AO Education to be brought into the courses.

Finally, the ongoing review of research throughout the AO Foundation, looks at the overall strategy (or in reality a compilation of individual strategies) including processes and structures. Since 2005, there has been an explosion of different research strategies from

differnt AO clinical divisions, regions and funding bodies. I look forward to a time when a common strategy prevails, removing noise and administrative overload for an efficient and effective future of research for the ultimate benefit of the AO Foundation's mission. AO research is highly-respected in the academic world, unfortunately more so than within the AO Foundation. We at the ARI are motivated, passionate and well-respected experts within our fields internationally and are proud to be part of the AO.

Slobodan Tepic, Stephan Perran and Geoff Ricahrds meet at the 2011 Davos Courses.

From AO Documentation to AOCID

Interview with Prof. Dr. med. Beate Hanson, Director of AO Clinical Investigation and Documentation

History of documentation

From 1959 onward, AO members sent their case documentation to the AO Research Institute (ARI) in Davos. In 1967, AO Documentation was relocated to Bern. With the opening of the AO Center in 1992, AO Documentation returned to its original and spiritual home. Beate Hanson, Director of AO Clinical Investigation and Documentation (AOCID), answers questions on what has happened since then.

> "If you've never been to the AO Center you cannot really understand what the AO is about."

Where is all the documentation collected by the AO in the years prior to moving to the AO Center?

The bulk of the documentation is still in our office, in our ex-employee Riitta Schmid's favorite closet. They built the archive to our specifications 20 years ago because we needed a specially-constructed area for us to house all the punch cards we had collected. We also had a darkroom installed because in those days the investigators sent us the original x-rays. Riitta then had to go to her darkroom and spend many hours in there taking pictures of the x-rays, digitizing them and sending the original x-rays back to the surgeon. It really was a full-time job.

When digital cameras became popular there was less need to capture x-rays in this way. However, we have retained the darkroom because even today, we still receive original x-rays; only a tiny percentage of course, but we have to be able to process them too.

How important is it for AOCID to be able to archive at the AO Center?

Essential! We live for archiving. We have to follow the ICH Good Clinical Practice guidelines. For all Randomized Controlled Trials we conduct, we have to archive all our documents for at least ten years. If we do a cer-

tain type of FDA trial this period can be 30 plus years. So you can see that we must have access to our source documents even when a study is long finished.

What advantages are there for AOCID to be in the AO Center close to other AO divisions?

Many, because we all work together in the same place and we are all part of the AO value chain. A good example of what this close collaboration can bring about is the Densiprobe. This intraoperative device to identify local bone strength was developed by ARI. Because our AOCID employees have informal contact with ARI employees during coffee breaks and more formal contact through regular meetings etc., we knew that this development was coming. So we could already begin thinking about how to conduct a Densiprobe clinical study – even before the product was finalized. The clinical study is now finished and has moved on to the next stage with the TK Commission; they are the next link in the AO value chain, and colleagues we are also in close contact with.

What have been the biggest changes in clinical research processes during the lifetime of the AO Center?

The big change, which made the worldwide conduct of multicenter international trials possible, was the development of electronic devices. We now have e-mail, we can send digitized x-rays, even electronic data capture is possible. This makes clinical research easier and, more importantly, doable. We can reach out to the world from the AO Center. For most of our studies we have around ten to fifteen different sites in ten

AO Documentation at Schwarztorstrasse in Bern.

different countries perhaps. Even a decade ago the logistics of conducting clinical investigations like this were completely different. Every Case Report Form had to be mailed, corrected, mailed back, corrected and so on. So the arrival of the digital age really was the watershed for us.

What has been achieved by AOCID over the past 20 years in the AO Center?

We changed clinical research in orthopedics and trauma; I am 100 percent convinced of this. We introduced evidence-based medicine to the AO and the structured approach to the conduct of clinical research. In this way we increased the quality of research. This is apparent if you look at our publications even a decade ago. Most of what we had at that time were retrospective case series. The work we now do is almost 20 percent Randomized Controlled Trials, and around 30 percent comparative studies. These types of clinical studies yield a high level of evidence. As one distinguished AO surgeon said to me about five or six years ago, "Beate, when you first arrived and you said something about evidence-based medicine I didn't know what you were talking about. Now I would never give a talk without relating it to evidence-based medicine."

What did you personally think the first time you visited the AO Center?

I first visited the AO Center exactly 20 years ago – but it was the old AO building. I was

impressed by the laboratory, to see that they only conducted research on bones and fractures. I was on my way to becoming a surgeon so I thought this is the place for someone like me to be.

My hiring by the AO in 2002 coincided with the celebration for the first ten years of the AO Center. I was always impressed by the AO Center and still am. And it's not just the building, the AO has always had a huge influence on me; I spent years as a patient with many implants as a result of an accident when I was younger. When you work in the AO Center you really have the feeling of being in a Swiss chalet high up in the mountains, a feeling that you just don't find in other offices. I think if you've never been to the AO Center you cannot really understand what the AO is about. It is a unique place. Sheep running around outside while the best researchers and top surgeons work together inside to develop the newest implants.

Whenever I go abroad to give a talk and show a picture of the AO Center, the audience invariably look at it and say the building looks like Toblerone chocolate. Or when people are visiting the AO in Davos and want directions, it's enough to say, "Just go to the end of Davos and look for the building that looks like a Toblerone." So the AO has also made its mark on the topography of Davos. There is no other place in the entire world I'd like to work more!

The history of the TK System

Claas Albers, Director TK System

Introduction

The AO Center has served as a home for the TK System since its inauguration twenty years ago. Located on the ground level of the building, it was extended and refurbished in the end of 2010. In this office every piece of information pertaining to the TK System is stored in a comprehensive IT database, as well as on paper in large cabinets in the basement of the AO Center. Expert Groups (EGs) have been utilizing both the conference room and the excellent lab facilities for their meetings.

Today, the TK System consists of more than two dozen different groups and bodies with medical members from all over the world. In order to fully understand the distinguished role the TK System plays in the AO Foundation, it is necessary to first take a look into the past.

One of the characteristics of the AO under the guidance of Maurice E. Müller was that it did not limit itself to simply developing new implants and instruments but it also cared profoundly about the rationale behind a specific medical activity based on research. This insight was then translated into principles which defined the parameters for goals and approaches, which in turn gave rise to a better understanding and teaching of said principles. The first basic principle was fixing the fracture fragments in anatomical position to restore long term function. Furthermore, solid stabilization of the fragments allowed immediate recovery of mobility of articulations and soft tissues. This was considered important in order to maintain the soft tissues in healthy condition and to avoid trophic disturbances due to excessive immobilization such as reflex dystrophy (fracture disease). An additional principle was the application of compression to keep the fragments from moving, thus allowing healing in a mechanically-neutral environment. The resulting healing process consisted of final internal remodeling without depending

on callus formation (primary or direct bone healing). A further principle defined the appearance of callus as a sign of inadequate fixation while avoidance of callus was not a goal in itself. Callus, in turn, often helped resolving a difficult situation.

Maurice E. Müller 1961 – 1982

1961 Formation of first "Technische Kommission"
1973 TK split into "small" and "large" TK

From the beginning, AO doctors had an intensive collaboration with their industrial producers (initially Mathys, then Straumann and lastly Synthes). This relationship can best be described as a sort of licensor / licensee one, between the nonprofit AO Foundation and its business partners. Doctors and research scientists defined the demands and basic solutions and the producers then transformed these into implants and instruments for clinical use. The doctors in turn tested the outcome under clinical conditions for reliability, ease of handling and avoidance of ill effects.

The monitoring and control of the collaboration between doctors and producers was the task of the Technische Kommission' (in English the "technical commission", abbreviated as AOTK); an AO approval depended on the decision of the AOTK. This technical commission system, implemented and guided by the visionary Müller, consisted of a slowly increasing number of AO doctors and representatives from the producer side. Eventually with a large group it was difficult to find agreement and a small executive body of Müller, Peter von Rechenberg, Robert Mathys, Fritz Straumann, Stephan Perren and Margrit Jaques restored the efficiency of the AOTK's activities. The small AOTK, under the chairmanship of von Rechenberg and later Perren, was transformed in 1984 into what is today the AOVA (Board of Directors), the central administrative body of the AO Foundation. The protocols of the AOTK were first handled by Marcel Madl and from 1970 on by Jaques.

Stephan Perren 1982 – 1998

1991 AOTK and four subgroups for Vet, CMF, Spine and Small Fragments
1993 Founding of an independent AO Development Institute

In 1982 Perren, at that time Chairman of the International Standards Organization (ISO TK 150 "surgical implants") and Head of AO Research, took over the chairmanship of the AOTK with the assistance of Rene Küng and later Röbi Frigg. Later Frank Baumgart and Yvonne Adank took over the administration. The large body of the AOTK (there were about 50 persons, each one with its own ideas) was reduced to a small efficient group. Subsequent to the one hundredth meeting of the AOTK, Perren overhauled the structure of the AOTK with the help of Hansjörg

Wyss from Synthes. Each group consisted now of a maximum of five doctors and one representative from each producer. The AOTK became the central authority deciding upon the proposals of the newly-formed EGs. These comprised small groups of doctors specialized in fields such as craniomaxillofacial, spine and other anatomical regions like foot, hand and wrist, pelvis and knee and also veterinary surgery. Biomaterials, mainly metals were the focus of an additional EG. To keep the groups from growing too big and to maintain efficiency, each group could establish temporary study groups or task forces to take over a task which were dissolved once the task was completed. Chairmanship of an EG was five years and membership three years, with the possibility of renewal.

The collaboration with research and concept development in the AO institutions in Davos was always intense and fruitful. New ideas were developed in Davos such as locked internal fixator (PC-Fix) with its improved biological behavior and the Dynamic Compression Plate (DCP), two principles that are combined in today's successful Locked Compression Plate (LCP). The prototype and proof-of-concept of locked screws was the PC-Fix initiated which was developed by Slobodan Tepic (ARI) and showed in the experiment a solid fracture healing as early as ten weeks post-operative. Extensive clinical testing with the exceptionally high follow-up of 97 percent by Haas et al. revealed reliable healing with an impressively low infection rate. Today's Less Invasive Stabilization System (LISS) developed by Frigg and Robert Schavan is an application of PC-Fix locked screw.

An example of the type of problems that were encountered can be illustrated by looking at the development of the locked nail. This was based on understanding fracture healing under flexible conditions and in view of the shortcomings of the axial and rotational inefficiency of the conventional nail. As early as 1975 Perren suggested considering the locked nail (as developed by Klemm and Schellmann in 1972 and introduced by Grosse and Kempf in 1974). The reaction of some members of the AOTK to this was astonishing: one predicted the demise of the AO because the strict principle of absolute stability would no longer guide the AO Foundation. The expert "nailer" in the AO felt that he could do away with locked nailing because conventional nailing would deliver all that was required; an interesting position because it didn't take into account the basic change, namely the additional possibilities offered by the locked nail. Finally the AOTK member with least experience of nailing "decided" that this was not required. The AO had missed an important change and hampered its leading position by missing out on nailing, which was equally important as plating.

However, a few lost years later, the locked nail was approved without the same discussion. It is interesting to note that the change to locked nailing required a basic new development of the nail which was in the early days of AO a very thin and flexible nail with radial expansion. The locked nail had to cope with higher loads, became stronger and with that stiffer, and had to be used with more extensive reaming. This then led to the development of the un-reamed nail based on the ARI observation of improved endosteal blood supply. The AO had proven that besides being a heavy forerunner it still was able to undergo changes of principles leading the way into new technologies.

Norbert Haas 1998–2009

2003 AOTK (Spine)–first step towards Specialty TKs

2005 Three-Pillars-Model–separate pillars for Trauma, Spine, CMF

Norbert Haas took over the AOTK Chairmanship in 1998. He expanded its structure in reaction to growing specialization of the surgeons, and leveraged the scope to new technical levels, eg, by appointing a dedicated EG for Computer-Assisted Surgery as early as 2001.

Under his guidance, and administratively supported by Philip Schreiterer and later Christoph Nötzli, the "TK System" (as it was now called) underwent its greatest structural change to date; dedicated AOTKs were formed for the three clinical divisions of trauma, spine and craniomaxillofacial (CMF) surgery. Each AOTK had a number of subordinated EGs, each of which was defined by anatomical area and comprised of highly renowned experts in their respective fields. Additionally specialized Task Forces were addressing certain technical issues such as intramedullary nailing or minimal invasive approaches. The introduction of the TK Executive Board, which was also chaired by Haas, ensured that all activities within the TK System were in accordance with the TK Guidelines.

Due to the increased number of activities in the various areas, a large number of projects achieved TK approval, eg, anatomically precontoured plates, new intramedullary nails concepts with the Expert Nail family and the wide introduction of the locking compression plate technique to mention but a few from trauma alone. In spine, fusion technologies such as, pedicle screw systems and vertebral body replacements were brought forward, whereas in CMF new resorbable implants were introduced and the scope was even widened to new areas such as neuro and thoracic surgery.

In 2001, a new brochure was called "New Products from AO Development" was published. Haas, as the editor-in-chief, used it to introduce products which had been newly-

approved by TK into the network. The magazine which was later renamed "TK Innovations" has since its inception been published two to three times a year and continues to be one of the most popular publications of the organization.

Over time the administrative demands of running the TK Sytem had increased dramatically. One problem that required immediate attention at that time was that medical demands often changed during the development period. This made it difficult for the engineers to achieve a final product within a reasonable timeframe and at a controlled cost. Haas installed a sequence of development activities that was, according to Frigg's input, characterized by periods of activity and interspersed milestones with a freeze of design that avoided countless inefficient repetitions. This "TK Milestone Concept" has been the basis of every project process that has since been approved by an AOTK.

As the whole AO Foundation continued to expand globally this change was reflected in the regional membership of the TK System; in 2009 more than 20 percent of permanent members came from Latin America and Asia Pacific. By that time, the TK System had grown into an organization in its own right with the involvement of more than 120 medical members from various clinical divisions and subspecialties.

Tim Pohlemann 2009–today

2009 Process updates
2012 Addressing new challenges moving forward

Already a member of the AOVA, Tim Pohlemann took over the Chairmanship of the TK Executive board as well as the AOTK (Trauma) in 2009. Building on the strong base established by his predecessors, and supported by Claas Albers, who assumed the administrative position of Director TK System in 2010, Pohlemann set the highest priority on the aspects of evidence based development and cross-pollination to foster innovation mining.

Consequently the existing Milestone Concept was harmonized to benefit all internal and external entities involved, the number of biomechanical and clinical studies proving the benefit of the new techniques and the collaboration with internal partners ARI and AOCID strengthened. TK Expert Symposia – in which clinicians exchange their experiences with techniques and technologies to assess the need for improvements in terms of development and education – are now held in all regions and following the same format, gathering clinical feedback from hundreds of surgeons each year.

Enhanced focus was put on the growing needs and requirements for new materials in orthopedic and trauma surgery going be-

yond the established concepts of metallic fixation, eg., for fracture prophylaxis in osteoporotic patients and anti-infective strategies with nails or plates coated with antibiotics.

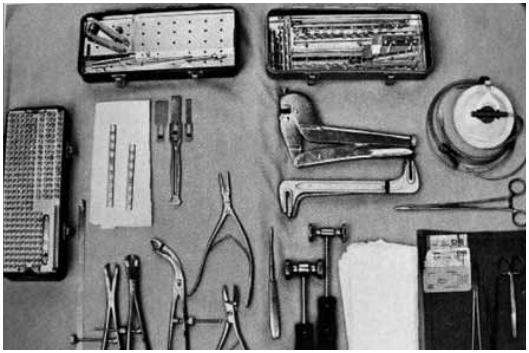
But the world of medical technique development has also changed significantly from former days. Stronger emphasis is put on healthcare financing and cost-effectiveness. Reimbursement agencies and hospital administration expect clear and valid information on the benefits and advantages of new technology over existing treatment options.

The legal requirements for regulatory clearance of new implants have not only increased but are also handled differently in different regions of the world. Consequently it not only takes longer to introduce a new device into the market but different markets also require different solutions.

Having recognized the changing environment in the medical device technology and orthopedic surgery world, the TK System continues to update its structure, processes and workflows to deliver an even stronger focus on evidence-based technique development with peer-reviewed pre-clinical validation and precise clinical data collections in order to evaluate the specific value added to new technologies.

In the future the TK System will maintain its role as an extraordinary source of innovation and excelling quality assurance tool for AO Foundation's industrial partners, offering competitive edge with its unique setup and worldwide renowned experts by collaborative development of surgical techniques and methods to improve patient care.

The Chairmen of the AOTKs and EGs at the AO Trustees Meeting 2011.



First "offical" AO Set.

AO International and AO Education

Urs Rüetschi, Director AO Education

AO International leads rapid international growth

By the late 1960s, AO methods had spread so quickly that spontaneous organizations began springing up in various European countries. In one country, "friends of the AO" began publishing material about surgical techniques that contained errors; in another, surgeons using AO methods attempted to form their own instrument company for personal profit. To prevent such aberrations and ensure that AO standards and techniques were maintained, AO International was formed in 1972, with Hans Willenegger as its first president.

To be admitted, national AO chapters had to include at least six qualified surgeons. Each chapter was expected to foster scientific exchange and to collaborate with AO institutions in conducting research and documenting patient case studies. Instruments and implants could only be approved by the central TK System, and personal gain from hardware sales was prohibited. The original plan was for an International Delegates' Assembly every two years, but it proved impossible to get the necessary number of representatives to attend. Eventually, the idea of forming formal national chapters was shelved in favor of forming closer relationships with more informal groups. This worked in practice due to the willingness of key AO personalities to dedicate time to travelling around the world assessing the ability and character of local surgeons and motivating them to become local teachers and ambassadors of the AO Foundation's philosophy.

Officially founded in 1972, AO International was the key building block for the global spread of AO teaching to surgeons and operating room personnel around the world. AO International was lead by Willenegger for its first twelve years, followed by Martin Allgöwer (1984–1988) and Urs Heim (1988–1993). With the opening of the AO Center, AO International moved its head-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quarters to the new building and Peter Matter took over the presidency (1993–1999), followed by Thomas Rüedi (2000–2005) and Jochen Prein (2005–2006).

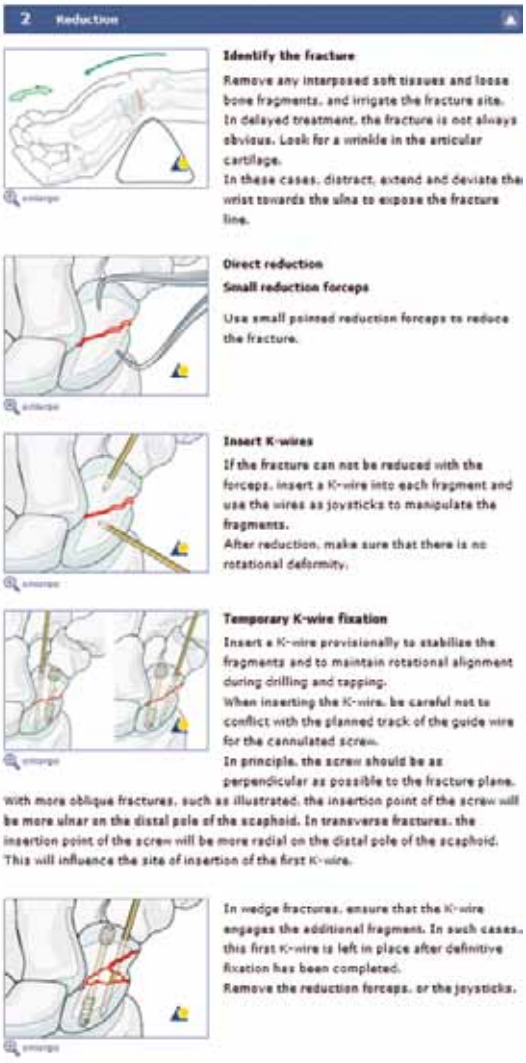
AO International also took a leading role in establishing the AO Alumni Association in 1989. This group of "enlightened" AO-educated surgeons became the driving force behind the global expansion of AO's educational activities around the globe.

Creating a full-service educational hub

In 2007, the AO Foundation radically changed its organizational structure. With the establishment of four clinical divisions–AOTrauma, AOSpine, AOCMF and AOVET–the role of AO International changed; the organization of courses and educational events was transferred to the clinical divisions and more responsibility was delegated to the established AO regions. This also changed the role of AO International; the unit was renamed AO Education and was turned into a full-service provider of educational services to all clinical divisions. Today AO Education comprises a team of 32 professionals providing services in the areas of curriculum development, book and journal publishing, video and multimedia production, skills-training and simulation-building, web and e-learning content development.

Established in 1997 by AO International President Matter, AO created its own book publishing arm in collaboration with the well-known global medical publishing house Thieme Publishers. This investment into content creation was the first building block for today's wide range of educational content offerings.

Over the last eight years a global team of surgeons, project managers, scientific illustrators, and programmers have built the worlds' biggest online reference on operative fracture care. Today over 150,000 visitors per month access this unique repository via the web site or by connecting through mobile apps on iPhones or Android devices.



The changing technology landscape enables new interactive learning on a large global scale. Hundreds of surgeons participate in frequently transmitted webcasts (moderated live surgery on anatomical specimens) and webinars (interactive online lectures) in 2011. With the launch of a new highly interactive web site, AO begins in 2012 to offer social media features to its community in order to foster and enable global interaction. What the founders of AO International envisioned twenty years ago has now – enabled by new technology – become a comprehensive portfolio of educational offerings.