# Osteopathic treatment during immobilization of conservatively treated radial fractures in patients older than 45 years

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# DECLARATION

Hereby I declare that I have written the present master thesis on my own.

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All sources and references I have used in writing this thesis are listed in the list of references. No thesis with the same content was submitted to any other examination board before.

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## II. List of abbreviations

| | |
|---|---|
| AO | Arbeitsgemeinschaft für Osteosynthese |
| | Consortium on Osteosynthesis |
| ap | antero-posterior |
| BLT | balanced ligamentous tension technique |
| CRPS | complex regional pain syndrome |
| CTS | carpal tunnel syndrome |
| DASH | disabilities of arm, shoulder and hand |
| dp | dorso-palmar |
| DRUJ | distal radio ulnar joint |
| NB | follow-up x-ray |
| TFCC | triangular fibrocartilaginous complex |
| VAS | visual analogue scale |

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## ABSTRACT

Problems like pain, restricted movement and loss of power after a distal radius fracture are common.

The question behind this study was to see whether osteopathic treatment during immobilization is able to influence the healing process of distal radius fractures. Is there any change in the perception of pain, function/strength, movement and callus formation after the end of the immobilization?

32 patients with fresh distal radius fractures were included; all of them received normal conservative medical treatment. 16 were attributed to the control group, the other 16 patients received osteopathic treatment on the first day after the trauma and then after one, two, four and six weeks. After the end of the immobilization (6 weeks after the trauma) and again two weeks later power and movement were measured, and the DASH questionnaire was answered. Follow-up measurements of both power and movement were taken and the DASH was answered for a second time.

The osteopathic treatment was able to reduce the pain. After the treatment the VAS score was on average 10 points lower.

Eleven of the osteopathically treated patients had sensations such as warmth, pleasant circulation, stillness and pain reduction.

The osteopathic treatment did not influence the healing of the bones, as the radiological parameters (ulnar variance, palmar inclination, ulnar inclination and callus formation) showed no difference between the two groups. The measurement of strength did not show a change either. After the end of the immobilization and eight weeks after the trauma, the osteopathically treated patients had a significantly better movement in the sagittal and the frontal plane, the DASH score was better and they used fewer analgesics.

At the follow-up evaluation, no differences between the two groups were found.

Therefore it is possible to say that osteopathic treatment has positive effects for a short time after immobilization and also for pain reduction during immobilization, but has no effect in the long term.

# 1 Introduction

With a share of 25% fractures of the distal radius are counted among the most frequent fractures in adults. Most of these fractures result from a fall onto the outstretched wrist. The adults most at risk in this context are older women suffering from osteoporosis.[1]

Conservative medical care consists in immobilization which usually lasts 4-6 weeks. In the case of many patients, in particular elderly persons, who may either have other complaints and restriction of movement or may live alone, this can lead to an enormous additional handicap in everyday life.

Although many radial fractures can be treated with surgical methods, the emphasis is still being attributed to more conservative methods of treatment. For many years the problems which may arise as a result of a distal radial fracture have thus remained unchanged. Even after anatomical re-alignment another dislocation of the fracture may occur. Restrictions of mobility of the hand are possible consequences as well as reflex dystrophies or post-traumatic carpal tunnel syndromes.[2]

During the period of immobilization, alternative therapies or methods of complementary medicine (including osteopathy)[*3] are not and have not been used up until now; at least, the relevant literature on the subject does not mention anything in this respect. This may be due to the fact that additional methods, such as osteopathy, are not so well known. In addition, the knowledge on these kinds of therapy is not yet fully comprehensive. Nevertheless, it is possible that patients may benefit from accompanying treatment with alternative methods.

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[1] Kramer W, Neugebauer W, Schönemann B, Maier G; Langenbecks Arch Chir (1986) 367: 247-258

[2] Schneiders W, Biewener A, Rammelt S, Rein S, Zwipp H, Amlang M; Die distale Radiusfraktur; Der Unfallchirurg 2006; 109: 837-844

[*] Osteopathy is not included in the curriculum of the university degree course in human medicine and thus no speciality of conventional medicine; Newsletter of the Medical University of Vienna; Academic year 2006/2007; Ausgegeben am 29.6.2007 – 28. Stück

[3] Pschyrembel, Klinischer Wörterbuch; de Gruyter; 261. Auflage; 2007

In addition, more and more patients are demanding additional methods of treatment to help their recovery. [4] As regards osteopathy the indications are often quite non-specific: e.g. insomnia, menstrual cramps[5], chronic pain, headaches or backache[6], dyspepsia; even fractures can be included in this category.[36] The reason for these completely general indications, which belong to many (medical) fields may be due to the fact that osteopathy follows a completely individual approach, i.e. it does not treat the illness alone, but rather the individual patient as a whole. A possible problem in this context is that osteopathy could be used indiscriminately to treat anything and anybody.

Therefore it makes sense to ask more precisely, what exactly can be achieved using osteopathy and what not; or more to the point: can the desired result be achieved?

This thesis aims to evaluate whether osteopathy is capable of positively influencing the healing process in the case of fractures, in particular those of the distal radius. It also aims to examine whether osteopathy can reduce subsequent complaints or improve strength and mobility and whether pain occurring during the period of immobilization can be alleviated by the application of osteopathy.

[4] Stocker R; persönliches Gespräch über Erfahrung bei der Behandlung distaler Radiusfrakturen, 2007
[5] Tempelhof S; Osteopathie Schmerzfrei durch sanfte Berührung, GU-Verlag; 7. Auflage; 2006
[6] Gillemot B, Newiger C; Osteopathie für Frauen; TRIAS-Verlag 2002

# 2 Fundamentals

## 2.1 Anatomy and mobility of the wrist

Together with the proximal radioulnar joint the *distal radioulnar joint (DRUJ)* [Latin: Articulatio radioulnaris distalis] facilitates a rotation movement of the radius around the ulna with the axis for the pronation and supination running proximal to the radial head [Caput radii] distally to the ulnar head [Caput ulnae]. Within the DRUJ the articular circumference of the ulna [Circumferentia articularis ulnae] articulates with the ulnar notch of the radius [Incisura ulnaris radii]. The ulnocarpal disc [Discus ulnocarpalis] also plays a role in guiding the movement of the joint. The broad and strong joint capsule is attached all around just next to the joint surface.[7] The flat M. pronator quadratus runs in the immediate vicinity of the intraosseous membrane [Membrana interossea]. It originates at the palmar surface of the distal ulna and is attached to the palmar side of the distal radius. [8]

The *proximal carpal joint* [Articulatio antebracheocarpalis] consists of the radius and the proximal row of the carpal bones. The ulna is linked with the proximal row of the carpal bones only through its extension via the fibrous-cartilagenous articular disc [Discus articularis, Discus ulnocarpalis, Discus triangularis]. At its edges the almost triangular articular disc is about 2mm thick; its middle section is clearly thinner with only 1mm. With its broad base it extends from the distal margin of the ulnar notch of the radius to the tip of the styloid process of the ulna [Processus styloideus ulnae]. The articular disc has contact with the triangular bone [Os triquetrum] and lunate bone [Os lunatum].

The triangular articular surface of the radius [Facies articularis carpea] articulates with the scaphoid bone [Os scaphoideum], the quadrangular articular surface of the ulna articulates with the lunate bone. The actual spacious capsule around the radiocarpal joint [Articulatio radiocarpalis] is reinforced on all sides by ligaments. The capsule is attached next to the joint surfaces of the carpal bones, the radius and the articular disc.[8,9] (cf. Fig. 1 and 2)

[7] Schmidt HM; Die Anatomie des ulnokarpalen Komplexes; Der Orthopäde 2004; 33: 628-637
[8] Lanz T, Wachsmuth W; Praktische Anatomie; Springer 2004
[9] Schmidt HM, Lanz U; Chirurgische Anatomie der Hand; Hippokrates 1992

The joint surface of the radius has a palmar and ulnar inclination. According to varying descriptions the dorsopalmar angle of inclination of the radius ranges around 15°[10] or 10-15°[9], while the radioulnar angle of inclination ranges between 15-20°[10] or 20-25°.[9,10] (cf. Fig. 4 and 5)

The pisiform bone [Os pisiforme] is the fourth bone of the proximal carpal row. It lies on the triangular bone on the palmar and ulnar side. It serves as sesamoid bone for the M. flexor carpi ulnaris and does not participate in the proximal carpal joint.[9]


Fig. 1: left hand, dorsal view

| | |
|---|---|
| C | Os capitatum |
| DU | Discus ulnocarpalis |
| H | Os hamatum |
| L | Os lunatum |
| LCR | Lig. collaterale carpi radiale |
| LCU | Lig. collaterale carpi ulnare |
| LRD | Lig. radiocarpale dorsale |
| MC I–V | Ossa metacarpalia I – V |
| MI | Membrana interossea |
| S | Os scaphoideum |
| Tq | Os triquetrum |
| Tz I | Os trapezium |
| Tz II | Os trapezoideum |

Only the directions of the ligaments are indicated in the picture.

The *triangular fibrocartilaginous complex* (TFCC; ulnocarpal complex) consists of the articular disc, the dorsal and palmar radioulnar ligaments [Ligg. radioulnare dorsale / palmare], the ulnocarpal meniscus [Meniscus ulnocarpalis], the collateral ligament [Lig. collaterale carpi ulnare] and the tendon sheath of the M. extensor carpi ulnaris.[11]

[10] Rauber/Kopsch; Hrsg. Leonhardt H, Tillmann B., Töndury G., Zilles K.; Anatomie des Menschen Band I Bewegungsapparat; Thieme 1987

[11] Palmer AK, Werner FW; The triangular fibrocartilage complex of the wrist – anatomy and function; J Hand Surg 1981; 6A (2): 153-62

According to Schmidt also the ulnolunate, ulnotriquetral and ulnocapitate ligaments [Ligg. ulnolunatum, ulnotriquetrum and ulnocapitatum], as well as the prestyloid recess [Recessus ulnaris] are part of the TFCC. From a functional point of view the distal part of the intraosseous membrane [Membrana interossea antebrachii] and the distal radioulnar joint also belong to the ulnocarpal complex.[7]

The distal carpal joint [*Articulatio mediocarpalis*] is formed by the proximal and distal row of the carpal bones. The dorsal part of the capsule around the joint is flaccid while its palmar part is tight. The proximal row consists of the scaphoid bone, lunate bone and triangular bone and has a certain range of motion, while the distal row of carpal bones allows only for little shearing of the individual bones against each other.
The carpometacarpal joints II – V [*Articulationes carpometacarpales II – V*] are formed by the distal row of carpal bones and the metacarpal bones II – V. They are bridged by tight ligaments and can be seen as a functional unit.
The carpometacarpal joint I [*Articulatio carpometacarpalis I*] is not an amphiarthrosis like the other carpometacarpal joints but a saddle joint. This joint form allows the abduction, adduction and opposition of the thumb.

The dorsal radiocarpal ligament [*Lig. radiocarpale dorsale*] runs from the radius to the triangular bone and sends some weaker fibres also to the scaphoid and lunate bones. During pronation the ligament is stretched. The stronger palmar radiocarpal ligament [*Lig. radiocarpale palmare (volare)*] runs from the radius to the capitate and triangular bones without having contact to the lunate bone. The ligament is activated in supination and dorsalflexion (extension).
The palmar and dorsal radioulnar ligaments [*Ligg. radioulnare palmare and dorsale]* limit the longitudinal movement of radius and ulna against each other and also prevent that the two bones of the forearm move apart.[7]
Together with the palmar radiocarpal ligament the palmar ulnocarpal ligament [*Lig. ulnocarpale palmare (volare)*] which originates at the styloid process [Processus styloideus ulnae] forms the arcuate ligament [Lig. arcuatum palmare (volare)], which acts as a counter bearing for the capitate and lunate bones in dorsalflexion.[8]

The short and strong radial collateral ligament [*Lig. collaterale (carpi) radiale*] connects the styloid process of the radius with the scaphoid bone. It restricts the ulnarduction. The longer but weaker ulnar collateral ligament [*Lig. collaterale (carpi) ulnare*] runs from the styloid process of the ulna, where it is connected with the articular disc, to the triangular and pisiform bones. It restricts radialduction.[8]


| | |
|---|---|
| C | Os capitatum |
| DU | Discus ulnocarpalis |
| H | Os hamatum |
| L | Os lunatum |
| LCU | Lig. collaterale carpi ulnare |
| LCR | Lig. collaterale carpi radiale |
| LRP | Lig. radiocarpale palmare |
| LU | Ligg. ulnolunatum, ulnocapitatum, ulnotriquetrum |
| MC I–V | Ossa metacarpalia I–V |
| MI | Membrana interossea |
| S | Os scaphoideum |
| Tq | Os triquetrum |
| Tz I | Os trapezium |
| Tz II | Os trapezoideum |

Only the directions of the ligaments are indicated in the picture.

**Fig. 2: left hand, palmar view**

The carpal bones are linked with each other by the Ligg. intercarpalia dorsalia, interossea and palmaria. On the palmar surface they fuse and continue to the Os capitatum as radiate carpal ligament [ Lig. carpi radiatum].

The extensor retinaculum [R*etinaculum extensorum* (Lig. carpi dorsale)] can be seen as a reinforcement of the fascia of the forearm. It extends from the triangular and pisiform bones and the ulnar collateral ligament [Lig. collaterale carpi ulnare] to the dorsal surface of the radius [Facies dorsalis radii]. Through vertical septums the extensor retinaculum forms canals for the tendons. The strong flexor retinaculum [*Retinaculum flexorum* (Lig. carpi transversum)] extends between the pisiform bone, the hook of the hamate bone [Hamulus ossis hamati], the scaphoid tubercle

[Tuberculum ossis scaphoidei] and the tubercle of the trapezium [Tuberculum ossis trapezii] and forms the end of the carpal tunnel. The two retinacula surround the carpus like a ring and have a retaining function for the tendons.[8,10,12] (cf. Fig. 1 and 2)

The interosseous membrane [*Membrana interossea*] forms a connection between the two bones of the forearm along almost their entire length. The membrane reaches from the attachment of the tendon of the M. biceps brachii to the distal radioulnar joint. It is responsible for part of the transmission of force. Together with the bones of the forearm the intraosseous membrane represents the origin of the deep extensor as well as the flexor muscles. Most of the fibres of the interosseous membrane run from the proximal radius in an oblique direction to the distal ulna. Some fibres are also sent to the capsule around the DRUJ[8].[10] Due to its net-like structure the intraosseous membrane has an elasticity of about 3%. It is stronger in its medial section than at its distal and proximal ends. [13]


**Fig. 3: ulnar (U), intermedial (I) and radial (R) columns**

The transmission of force can be explained with the *three-column-model* (cf. Fig. 3). Acording to this model the forearm consists of a radial column (Processus styloideus radii and Fossa scaphoidea of the Articulatio radiocarpalis), an intermedial column (lunate fossa [Fossa lunata] and ulnar notch) and an ulnar column (distal ulna and triangular fibrocartilagenous complex/TFCC). Measurements have indicated that the force is transmitted via a radial and an ulnar centre, with the ulnar centre being projected mainly on the TFCC, and is not limited to the lunate fossa as it is often assumed. During extension and flexion these centres remain in a sagittal plane centred in the middle of the radio-ulno-carpal joint, while they shift a little bit in an ulnar or radial direction during ulnar or radial duction. The radial column has more a stabilizing function. The intermedial column serves the transmission of force and absorbs

[12] Moriggl B, Putz RV; Der Carpus im Konflikt zwischen Stabilität und Mobilität; Der Orthopäde 1999; 28:822-832
[13] Kwasny O; Die Unterarmschaftfraktur des Erwachsenen; Facultas 1990

compression forces in the case of fractures. The ulnar column transmits forces but also stabilizes the carpus.[14,59]

Mobility of the wrist

The proximal carpal joint [Articulatio antebrachiocarpalis] and the midcarpal joint [Articulatio mediocarpalis] participate in the movements of extension, flexion radial and ulnar duction. The movements of pronation and supination are mainly guided by the proximal and distal radioulnar joints and their ligaments as well as the intraosseous membrane.[8]

Measurements with the neutral-0-method[15] show that the range of motion of the forearm with a 90° flexed ellbow in rotation is: 80 -90°[15,16] in pronation and supination; for the radial duction of the wrist it is 25-30°[15,16] and for the ulnar duction it is indicated with 35°[15] or 30-40°[16]; dorsal extension 60°[15], palmar flexion 50-60°[15,16] , with the maximum value indicated for dorsal extension being 80° and for palmar flexion 85°[10].

## 2.2 Bone fractures and healing

The most common cause of bone fractures is the impact of direct or indirect external forces. More rarely spontaneous fractures or pathological fractures occur in previously damaged bone tissue or stress or fatigue fractures through repeated microtraumas.[17] Factors like the kind, duration and direction of the impact of force as well as the rigidity and thickness of bone play a role in the degree and extend of the fracture.[18]

Fractures are categorized according to the mechanism that caused the fracture, its form, the direction of the fracture lines and possible shifts of the fractured parts of the

[14] Rikli DA, Honigmann P, Babst R, Cristalli, Morlock MM, Mittlmeier T; Intra-Articular Pressure Measurement in the Radioulnocarpal Joint Using a Novel Sensor: In Vitro and In Vivo Results; J Hand Surg 2007; 32A: 67-75

[15] Bruzek R; Leitfaden Gelenksmessung; Urban & Fischer 2006

[16] Niethard FU, Pfeil J; Orthopädie; Duale Reihe; Thieme 2005

[17] Jerosch J, Bader A, Uhr G: Knochen curasan Taschenatlas spezial; Thieme 2002

[18] Marzi I, Mutschler W; Pathophysiologie des Traumas; in: Praxis der Unfallchirurgie hrsg. von Mutschler W, Haas N; Thieme1999

bone. The assessment also includes whether a joint is affected, and whether it is a simple or multiple fracture.[17]

A fracture is an interruption of the continuity of the corticalis and spongiosa bone structures. In addition, the periosteum is lifted, shifted or ruptured and the small blood vessels running through the Harvers' canals are injured. In the adjoining soft tissues and between the fractured parts of the bone a haematoma develops within which a network of fibrin filaments forms, which is important for the following healing process. In the region of the tissue damage an acute inflammatory abacterial reaction occurs. The thrombocytes and other blood cells contained in the haematoma at the fracture site release growth factors, which control the angiogenesis, chemotaxis, cell differentiation and proliferation.[17,18]
Subsequently fibroblasts start to form collagen, the haematoma turns into granulation tissue and a connective tissue callus is formed. This callus gets more and more mineralized until it turns into woven bone which connects the two ends of the fracture. In the following phase of modelling or remodelling, which can last several months, the primary callus made up of woven bone is increasingly replaced by hard lamellar bone.[17,18]

An important physiological factor for bone healing is a well-functioning local blood supply of the bone fragments. In the region of the fracture the blood supply is increased and remains like that over a longer period of time.[18] Lacking vascularization leads to necrosis and a resorption of the bone fragments.[17]
Bone healing is also influenced by growth factors, cytokines and hormones[18] as well as by the nutrition, age and general state of health of the affected patient. Also the degree of injury and the number of present fractures at the time play a role. Problems in the healing can occur if there is no repositioning, insufficient immobilization and delayed start of therapy.[17]
Mechanical factors like micro-movements support the callus formation. A delayed union or even a non-union (pseudarthrosis) are facilitated by insufficient stability or too much movement. Vascular dysfunctions, diseases affecting bone metabolism and

lacking pressure in the fracture line are additional factors that can play a role in this context.[19]

If a fracture definitively does not heal (bony consolidation) and cannot be expected to heal anymore without further treatment, one can speak of a pseudarthrosis after a period of six month in the case of hollow bones (long bones). Depending on the biological reaction a differentiation can be made between hypertrophic and dystrophic pseudarthrosis. In the case of atrophic pseudarthrosis there is no callus formation at all.[19,20]

### 2.2.1 Radial fractures

With a share of 10-25% of all fractures, radial fractures figure among the most common bone fractures among patients. Among younger patients the most common causes for such fractures are sports injuries, traffic accidents and falls from certain heights. In the case of older adult patients falls on even ground onto the outstretched wrist are the most common mechanism of injury.[1] In particular elderly women suffering from osteoporosis are affected.[21]

Fractures of the distal radius can be divided into the much more common extension or Colles fractures and the rarer flexion or Smith fractures. Most of the Colles fractures are extra-articular fractures that occur at typical sites (Fractur radii loco typico). Whether the forearm was pronated or supinated at the time of injury is not differentiated in the literature.[1,22].

In the case of conservatively treated radial fractures a secondary or indirect fracture healing can be assumed. It continues endostally and periostally and from the fracture haematoma. The callus formation and osteogenesis take several weeks. The final

[19] Stocker R, Vecsei V; Pseudarthrosen in: Komplikationen bei der operativen Knochenbruchbehandlung; Hrsg. Egbers HJ, Roth W, Schroeder L; Wachholtz Verlag 1998
[20] Vécsei V, Nonnemann HC, Klemm K, Kempf I; Knochenbruchbehandlung; Thieme 1995
[21] Handoll HHG, Madhok R, Howe TE: Rehabilitation for distal radial fractures in adults; Cochrane Database of Systematic Reviews. 4, 2006.
[22] Pechlaner S, Gabl M, Lutz M, Krappinger D, Leixnering M, Krulis B, Ulmer H, Rudisch A; Distale Radiusfrakturen - Ätiologie, Behandlungsmethoden und Ergebnisse; Handchir Mikrochir Plast Chir 2007; 39: 19-28

remodelling, where the woven bone is replaced by lamellar bone, takes several months and should lead to an anatomical and functional regeneration of the bone.[17]

Immediately after the end of the conservative treatment of a distal radial fracture by means of immobilization through a forearm cast the patient has to expect a restriction of movement, loss of power and pain during movement and/or strain. However, these complaints usually disappear after a few days to weeks.[31]

Complications in the context of radial fractures can be persisting restrictions of movement, a shortening of the radius despite exact primary reposition[23], adhesion of ligaments, a compression of the N. medianus, carpal tunnel syndrome (CTS) and also reflex dystrophia (complex regional pain syndrome, CRPS) or persisting pain.[17] A bad aesthetic result does not necessarily figure among the complications but for many patients this factor also plays a major role.[24]

[23] Gabl M, Pechlaner S, Sailer R, Frießnig P; Dorsale Stauchungsbrüche der distalen Radiusmetaphyse; Akt Traumatol 1992; 22: 15-18
[24] Prommersberger KJ, Lanz U; Biomechanik der fehlverheilten distalen Radiusfraktur; Handchir Mikrochir Plast Chir 1999; 31: 221-226

## 2.3 Radiology

**Radiological criteria [2,25]**

X-rays of the wrist in two planes, i.e. in the antero-posterior (ap) or dorso-palmar radiation path and lateral plane, are taken to diagnose distal radial fractures. (In this paper the term “antero-posterior” and the abbreviation ap will be used.)

On the basis of these pictures the fractures are classified (cf. page 21) and the following angles and distances are measured:

**Ulnar and palmar inclination**

The ulnar inclination (cf. Fig. 4) is measured between a perpendicular line to the longitudinal axis of the radius and a straight line that goes through the tip of the styloid process of the radius and the point of the radius that is still part of the joint and

**Fig. 4: ulnar inclination**

**Fig. 5: palmar inclination**

[25] Fernandez DL, Jupiter JB; Fractures of the Distal Radius – a practical approach to management; Second Edition; Springer 2002

most distal and palmar (volar) to the ulna. The average value for this angle is indicated with 20-25°[9].

The palmar inclination (cf. Fig. 5) is measured between a perpendicular line to the longitudinal axis of the radius and a straight line than runs through the ventral and dorsal lip of the distal end of the radius. The average of this angle is indicated with 10-15°[9].

It is difficult to define the axis of the radius on the x-rays. Since usually only the distal third of the radius is displayed on the x-rays and the radius can have an s- or c-shaped curvature in the radio-ulnar plane, measuring errors cannot be excluded.

**Ulnar variance**

The ulnar variance (cf. Fig. 6) is the distance between the most distal point of the ulna without the styloid process of the ulna and the most distal point of radius that forms part of the distal radioulnar joint.

The evaluation of the ulnar variance depends on the angle from which the x-ray has been taken and on the resulting picture. Thus it may happen that despite predetermined imaging techniques imprecision in the measurements can occur.

**Fig. 6: Radius-Ulna-Index**

**The ulna variants**

In the so-called ulna zero variant radius and ulna have the same length; the ulna plus variant means that the ulna is longer than the radius, while in the ulna minus variant the ulna is shorter than the radius.[9] The thickness of the ulnocarpal disc [Discus ulnocarpalis] depends on the ratio of the lengths of the two bones, i.e. in the ulna plus variant the disc is thinner than in the ulna minus variant[7] (cf. Fig. 7-9).

**Fig. 7: ulna plus variant**

**Fig. 8: ulna zero variant**

**Fig. 9: ulna minus variant**

## 2.4 Classifications & Scores

Classifications

There are numerous ways of classification to describe distal radial fractures. The different classifications look at the fractures from different points of view.

The classification according to Pechlaner[22] (cf. Tab. 1) focuses on the direction of dislocation of the peripheral fragment. It distinguishes three main groups of fractures (dorsal, central and palmar fractures) which are further differentiated into subgroups.

| | |
|---|---|
| Type I-1 | dorsal metaphyseal fracture |
| Type I-2 | dorsal metyphyseal-articular fracture |
| Type I-3 | dorsal luxation fracture (instability of the carpus in a dorsal direction) |
| Type II-1 | central metaphyseal fracture |
| Type II-2 | central metyphyseal-articular fracture (further differentiated into A-D) |
| Type II-3 | central luxation fracture (instability of the carpus in dorsal and palmar direction) |
| Type III-1 | palmar metaphyseal fracture |
| Type III-2 | palmar metaphyseal-articular fracture |
| Type III-3 | palmar luxation fracture (instability of the carpus in a palmar direction) |

**Tab. 1: Pechlaner classification[22]**

The Mayo classification[22] (cf. Tab. 2) distinguishes between five different forms of fractures. It takes in particular the participation of the radiocarpal joint surface into account.

| | |
|---|---|
| Type 0 | metaphyseal, extraarticular fracture of the radius |
| Type I | intraarticular, undisplaced fracture of the radiocarpal joint |
| Type II | intraarticular, displaced fracture of the radioscaphoid joint |
| Type III | intraarticular, displaced fracture of the radiolunar joint |
| Type IV | intraarticular, displaced fracture of the radioscapholunar joint |

**Tab. 2: Mayo classification[22]**

In the systematic classification of the AO[26] (Arbeitsgemeinschaft für Osteosynthese; consortium on osteosynthesis; cf. Tab. 3; Fig. 10) the fractures are divided into extraarticular (Type A), simple intraarticular (Type B) and complete articular fractures (Type C) and further described with numbers according to a predefined system. The higher the number the more complex the fracture. The classification according to the AO describes mainly the stability and degree of the fracture.[26]

| | |
|---|---|
| A 1 | isolated fracture of the ulna |
| A 2 | simple fracture of the radius |
| | A 2.1 undisplaced<br>A 2.2 dorsal displaced<br>A 2.3 palmar displaced |
| A 3 | fracture of the radius, multifragmented or comminuted |
| | A 3.1 impacted; shortening<br>A 3.2 with metaphyseal comminution<br>A 3.3 with metaphyseal and diaphyseal comminution |
| B 1 | sagittal fracture of the radius |
| B 2 | dorsal margin fracture |
| B 3 | volar margin fracture |
| C 1 | simple articular and metaphyseal fracture of the radius |
| | C 1.1 postero-medial articular fragment<br>C 1.2 sagittal articular fracture line<br>C 1.3 frontal articular fracture line |
| C 2 | simple articular fracture of the radius, metaphyseal multifragmentary or comminuted |
| | C 2.1 sagittal articular fracture line<br>C 2.2 frontal articular fracture line<br>C 2.3 meta- and diaphyseal comminuted |
| C3 | articular and metaphyseal multifragmented and comminuted fracture of the radius |
| | C 3.1 metaphyseal simple<br>C 3.2 metaphyseal multifragmented or comminuted<br>C 3.3 meta- and diaphyseal comminuted |

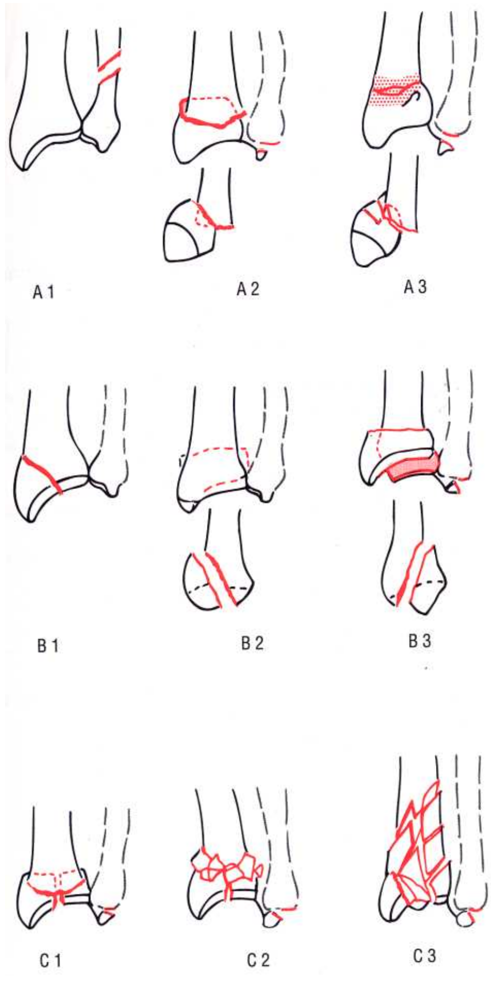



**Fig. 10: AO classification** [26]

Since no fractures of the types A1 and B were found, a more detailed description of those fractures was omitted.

**Tab. 3: Classification of distal radial fractures according to Müller et al.**[26]

[26] Dittrich V, Stedtfeld HW; Manual der Frakturklassifikation S 50; Deutscher Ärzte Verlag 1992

The more functional and more frequently used classification according to Frykman[27] (cf. Tab. 4; Fig. 11) also indicates accompanying fractures of the Processus styloideus ulnae. This classification takes the kind of articular participation into account but does not consider the degree of dislocation.[28]

| | |
|---|---|
| Type I | Extra-articular fractures without fracture of the distal ulna |
| Type II | Extra-articular fractures accompanied by fracture of the distal ulna |
| Type III | Intra-articular fractures involving the radio-carpal joint but without fracture of the distal ulna |
| Type IV | Intra-articular fractures involving the radio-carpal joint and accompanied by fracture of the distal ulna |
| Type V | Intra-articular fractures involving the distal radio-ulnar joint but without fracture of the distal ulna |
| Type VI | Intra-articular fractures involving the distal radio-ulnar joint and accompanied by fracture of the distal ulna |
| Type VII | Intra-articular fractures involving both the radio-carpal and the distal radio-ulnar joint but without fracture of the distal ulna |
| Type VIII | Intra-articular fractures involving both the radio-carpal and the distal radio-ulnar joint and accompanied by fracture of the distal ulna |

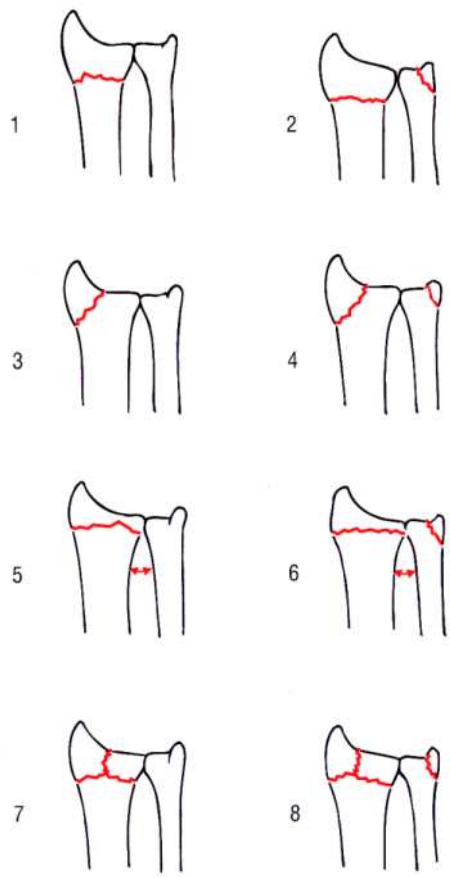



**Fig. 11: Frykman classification[26]**

**Tab. 4: Frykman classification[27]**

[27] Krämer KL, Maichl FP; Scores, Bewertungsschemata und Klassifikationen in Orthopädie und Traumatologie; Thieme 1993

[28] Neumann K, Langer R; Radiologische Skelettdiagnostik: Traumatologie des distalen Unterarmes, der Handgelenke und der Hand; Akt Radiol 6 (1996) 171-175

The Fernandez classification[25] (cf. Tab. 5) is based on the mechanism of the injury that caused the radial fracture and distinguishes five types.

| | |
|---|---|
| Type I | metaphyseal bending fracture (Colles-Pouteau and Smith-Goyrand-fracture) |
| Type II | shearing fracture of the joint surface (Barton's and reverse Barton's fractures) |
| Type III | compression fractures of the joint surface |
| Type IV | avulsion fractures |
| Type V | combined fractures of type I-IV, often high-velocity injuries |

**Tab. 5: Fernandez classification[25]**

Scores and evaluation methods

Many different kinds of scores and evaluation methods are available to approximately describe the wellbeing and condition of a patient after a distal radial fracture. These scores consist of a number of selected criteria which are usually assessed according to a numerical system.[27]

A commonly used score for a radial fracture in typical location [Fractur radii loco typico] is that of Gartland and Werley. It can also be used in a general way. As clinical and radiological score it is 30% subjective and 70% objective. Deformity, subjective patient assessment, examination (regarding mobility) and complications are evaluated.[27]

Another frequently used clinical and radiological score is the score according to Cooney et al. Besides its application in the case of wrist fractures it can also be used in a general way. This scoring method assesses pain, work [profession], range of motion and power. It uses 50% objective and 50% subjective criteria. [27]

In the commonly used evaluation system according to Lidstrøm a general application is not possible. This evaluation method distinguishes between functional, radiological and aesthetic criteria.[27]

The traditional wrist assessment score according to Krimmer, henceforth called Krimmer score, is a modification of the Cooney score and can be applied in a general way. It assesses power, mobility, pain and usability.[41] (cf. p. 43, 3.2.9)

With the frequently used DASH score (Disabilities of Arm, Shoulder and Hand Instrument; cf. p. 41, 3.2.7) a merely subjective assessment of the overall function of the upper extremity by the patient is available.[39]

In order to be able to describe the fractures in this study in a comprehensive way and thus make them objectively verifiable as well as to facilitate comparisons with other studies on this topic, the fractures will be classified according to the systematic, descriptive and worldwide used classification of the AO.

In addition, the fractures are also described according to the classification of Frykman because it also considers an accompanying avulsion of the Processus styloideus ulnae, which can be of interest.

In order to evaluate the results the internationally recognized DASH score is used. Since this score has only little local specificity regarding wrist problems, the Krimmer score is used as additional evaluation method.

## 2.5 Treatment of fractures in the 20th century

At the beginning of the 20th century, fractures were often treated in a slightly different way as Bilz describes:

> *"…the displaced or twisted part is moved into the correct, natural position. Thereupon the site of the fracture is lightly enwound 3 or 4 times with a 15 cm wide moistened bandage taking care that it is not too tight because of the developing swelling. 2 or 3 appropriately formed splints of thin wood or stiff cardboard are arranged on top of this dressing and fixed with straps. A triple layer of moistened fabric and a final layer of cotton wool and a flannel bandage are added. Then the patient is well covered and has to rest and in particular the fractured limb is left in complete peace and quiet."*[29]

Approximately 30 years later, Böhler mentions 3 basic rules in the treatment of fractures, namely positioning of the peripheral fragment to where the central fragment points; adjusting the fracture correspondingly under traction and counter-traction and successfully maintaining the correct alignment of the fragments until they are healed. Böhler also does not perceive a fracture to be only a disruption of continuity of the bone; he rather sees it as both an interruption and impairment of the surrounding tissues and of the entity of the respective part of the body. He writes:

> *"It was originally the doctors' reserved right to anatomize an entity and to arbitrarily treat only the bone or only the muscles or joints, as if everything was not really inextricably linked."*[30]

To diagnose distal radial fractures, Böhler uses X-rays from both "front and side views". Repositioning takes place under local anaesthetic with a forceful longitudinal traction carried out manually on the thumb and second to fourth fingers by an assistant. A plaster splint is fitted on the flexor side of the hand and forearm. The longitudinal traction is discontinued only after the hardening of the cast. Böhler describes a splitting of the plaster cast only in case of pronounced swelling and

[29] Bilz FE; Das Neue Naturheilverfahren, 82. Auflage, S 729; 1898
[30] Böhler L; Technik der Knochenbruchbehandlung, 2. Auflage; Maudrich 1930;S 6

paraesthesias. Younger patients have to wear the cast for approximately 3 weeks, while older patients need to wear it for 4-5 weeks. All other joints that have not been immobilized should be moved regularly from the beginning.

Twenty years later, the treatment of distal radial fractures described by Böhler has not changed very much. The plaster cast is right away split longitudinally and not only in the case of paraesthesia; circular plaster dressings are only added after one to two days; after 8 days the plaster cast is changed; the period of immobilization is indicated with 3-6 weeks. X-ray check-ups are carried out after the re-alignment and after one week; in cases of fractures involving serious dislocations the x-ray check-ups are repeated every week.[31]

According to Böhler, sustaining the correct position after the realignment is often extremely difficult. Possible consequences of a distal radial fracture are the loss of the arm due to gangrene, acampsia and impairment of movement, loss of muscle power, permanent pain, disfigurement of the hand and also ruptures of the tendon of the thumb extensor muscle. Although Böhler emphasizes the importance of moving the non-immobilized joints he does not mention any independent or additional therapies that could be carried out during the immobilization or after the removal of the cast. [31]

Only since 1952 Böhler has started to use finger traps and weight slings instead of manual traction to realign distal radial fractures.[32]

[31] Böhler L; Die Technik der Knochenbruchbehandlung; Band I, 12. und 13. Auflage; Maudrich 1951
[32] Böhler L, Böhler J; Die Technik der Knochenbruchbehandlung; Ergänzungsband zur 12./13. deutschen Auflage; Maudrich 1963

## 2.6 Standard conservative treatment of radial fractures at the Landesklinikum Thermenregion Baden

In the clinical evaluation the degree of swelling, pain on pressure, dislocation and loss of function of the carpal joint are assessed. In addition, the peripheral sensibility, circulation and motor function are evaluated. The diagnosis is established after x-rays in two planes (ap and lateral view) have been taken. The local anaesthesia in the fracture line is administered from the posterior forearm region. Before the local anaesthesia the fracture haematoma is aspired to reduce the pressure and pain.[33]

**Fig. 12: Extension**

For the application of traction on the fracture (cf. Fig. 12) the patient lies supine with the shoulder in 90° abduction and the elbow in 90° flexion. The extension is applied with a weight of 3-5 kg that is fixed with a sling around the upper arm and three finger traps (on the fingers 1, 2 and 4). The traction lasts for about 15 minutes. Afterwards the fracture is brought into alignment.

During the realignment manoeuvre the pathological position is first increased with a longitudinal traction before a maximum longitudinal traction is applied and the distal fragments are levered over the proximal part of the radius.[33]

The dorsal longuette (cf. Fig. 13) with palmar support extends at the extension side from the metacarpo-phalangeal joints to just before the ellbow joint at the radial side. It contains a dorsal and a dorsoradial indentation above the articular portion of the distal radius as direct support or an indentation above the proximal

[33] Jahna H, Wittich H; Konservative Methoden in der Frakturbehandlung; Urban & Schwarzenberg 1985

carpal row which again has an effect on the articular portion of the distal radius, via ligamentotaxis. The dorsal longuette is fitted with the arm still under traction.[33]

Following this procedure the position of the fracture is checked by means of x-ray. Within the next three days the cast is closed. The peripheral sensibility, circulation and motor function are re-evaluated on days 1, 7, 14, 28, 42 and 56 after the fracture happened. After one week another x-ray exam is carried out and if necessary the alignment of the fracture can be corrected under traction. Further x-ray check-ups are conducted after 2, 4, 6 and 8 weeks.

During the first period after the injury the immobilization is effected with a conventional cast. Once no major swelling can be expected – from the third week onwards – the fracture can be immobilized with a much more rigid but less moldable plastic dressing (e.g. Scotchcast®).

**Fig. 13: Fitting of the longuette**

The conservative management of distal radial fractures has essentially remained unchanged since its description by Böhler in 1930 (cf. p.26, 2.5). Also the complications or effects that can occur during or after the treatment (cf. p. 16, 2.2.1) are still more or less the same. Thus the question is whether an osteopathic treatment that is applied during the immobilzation can influence the healing process.

# 3 Methodology

## 3.1 Study design

This study is designed as an open, prospective, matched, controlled study. The study period comprised the period between August 2005 to May 2007; the period of follow-up examinations comprised the period between June 2007 to September 2007.

Originally the size of the osteopathy group and the control group was planned with 50 patients each. However, the number of patients set as target could not be recruited due to several reasons:

- Due to a relatively mild winter with only little black ice falls[22] happened less frequently and thus clearly fewer fractures occurred.
- On the part of the hospital this study was accompanied by a doctor of the hand injury outpatient ward. Patients who were not looked after by the hand injury outpatient ward were not registered in time and thus did not fulfil the inclusion criteria.

Therefore the two groups only comprised 16 patients each.

Since falls on even ground in particular of elderly patients are a frequent cause for distal radial fractures[22], this age group was chosen for this study. To avoid that previous fractures of the same forearm which possibly caused deviations of the axes or angles, instability or the formation of steps which could influence the measurements, patients with old fractures of the same forearm were excluded from the study. Since a normal healing (of the bones) cannot be expected in cases of pathological fractures in patients with severe osteoporosis or already existing dystrophic diseases or undergoing chemo- or radiation therapy[17], patients suffering from one or several of the just mentioned conditions or undergoing chemo- or radiation therapy were also excluded from the study. The same holds for patients with central or peripheral neurological problems. According to the World Medical

Association Declaration of Helsinki patients not having full legal capacity should also be excluded.[34]

Therefore the following **inclusion criteria** were established:

- fresh radial fracture
- aged > 45 years
- conservative medical treatment
- first fracture (trauma) of the forearm
- patient's declaration of consent

**Exclusion criteria** were:

- two or more bony fractures of the forearm
- pathological fractures & severe osteoporosis (> 2 fractures in one year)
- surgical treatment
- central and peripheral neurological problems
- chemo- or radiation therapy
- dystrophic disorders before immobilization
- psychological/mental diseases; patients without full legal capacity

**Planned procedure**

The conservative medical management is the same in both groups.

On the day of the start of the treatment (usually the day of the injury, only very rarely a later moment in time) a clinical examination of the patient is carried out. Afterwards an x-ray of the wrist is taken. The next step consists in the re-alignment of the fracture and immobilization with a cast. Another x-ray is taken to check the alignment of the fracture. Within the next three days the circulation is checked and the cast is fully closed. After one week another x-ray is taken and if necessary the alignment of the fracture can be corrected again and a new cast is fitted. Further checks of circulation, x-ray examinations and if necessary changes of the cast are carried out after two and four weeks. In each check-up from the fourth week onwards the

[34] World Medical Association Declaration of Helsinki, Ethical Principles for Medical Research Involving Human Subjects; 2004; http://www.wma.net/e/policy/b3.htm

patients have to rate their subjective pain perception on a visual analogue scale (VAS).

On the first, second or third day after the fracture the patients of the osteopathy group receive the first osteopathic treatment. After one, two, four and six weeks they receive further osteopathic treatments. All the osteopathic treatments are carried out after the medical management, i.e. after possibly necessary corrections of alignment or changes of the cast. The patients rate their subjective pain by means of the VAS each time before and after the osteopathic treatment.

After the removal of the cast after six weeks another x-ray control is carried out. The muscle power of both hands is measured by means of a Jamar® dynamometer. The active articular mobility of the right and left hand is assessed by means of a goniometer. The patients of the osteopathy group undergo another measurement of active articular mobility after the osteopathic treatment. They are also questioned once more about their subjective pain perception.

At the final control after eight weeks x-rays of both wrists are taken. On both sides the muscle power is measured with the Jamar® dynamometer and the active articular mobility with the goniometer.

At the final control after eight weeks every patient is asked to fill in a questionnaire which evaluates the overall function of the upper extremity (Disabilities for arm shoulder and hand instrument; DASH-questionnaire, cf. p. 41). On the basis of the values obtained through the measurement of mobility and power and the subjective ratings of the patients the Krimmer score (cf. p. 43) is calculated.

At a follow-up examination (NU), on average 13.16 months (3.83 – 24.13 months) after the fracture, the wrists of both hands are x-rayed again in two planes. The patients are also asked about pain at rest and during activity.

The active mobility is measured on both sides and the Kapandji index (cf. p.40) and fist closure, i.e. the finger tip to palm distance of the middle and ring fingers, are used for assessment. The gross measurement of power with the Jamar® dynamometer is also carried out on both sides. The patients are asked to fill in another DASH questionnaire and the Krimmer score is calculated again.

On the basis of the x-ray photographs the ulnar and palmar inclination in an ap and lateral plane and the ulnar variance are determined. The values of the x-rays taken immediately after the injury are compared with those obtained from the x-rays after re-alignment, after eight weeks and at the time of the follow-up examination. The values of the fractured side are also compared with those of the not affected side.

In both groups the evaluation and measurements of the x-ray photographs as well as the assessment of the joint, the joint mobility and power are carried out by a specialist in accident surgery. In the control group the patients are asked to rate their subjective pain perception on the VAS by a medical doctor, while the patients of the osteopathy group are questioned by an osteopath. The osteopathic treatment is carried out by an osteopath. The DASH questionnaire is filled in by the patients themselves.

| day (week) | normal medical treatment | osteopathy group | control group |
|---|---|---|---|
| **0 (injury)** | x-ray; repositioning + immobilization | | |
| **1** | clinical control, closure of the cast | osteopathic treatment 1<br>VAS | |
| **7<br>(1 week)** | x-ray; cast changing;<br>if necessary resetting | osteopathic treatment 2<br>VAS | |
| **14<br>(2 weeks)** | x-ray; clinical control;<br>cast changing if necessary | osteopathic treatment 3<br>VAS | |
| **28<br>(4 weeks)** | x-ray; clinical control;<br>cast changing | osteopathic treatment 4<br>VAS | VAS |
| **42<br>(6 weeks)** | x-ray<br>end of immobilization<br>cast removal | osteopathic treatment 5<br>VAS<br>power- + joint measurement | VAS<br>power- + joint measurement |
| **56<br>(8 weeks)** | x-ray<br>clinical control | VAS, DASH<br>power- + joint measurement | VAS, DASH,<br>Krimmer Score<br>power- + joint measurement |
| | x-ray<br>follow-up examination | VAS, DASH<br>power- + joint measurement | VAS, DASH,<br>Krimmer Score<br>power- + joint measurement |

**Tab. 6: Overview of treatments and measurements**

## 3.2 Materials / methods

### 3.2.1 Statistical analysis

Statistical significance is verified by means of the t-test with a significance level of 5% ($p<0.05$).

### 3.2.2 Osteopathic treatment

One of the fundamental ideas of osteopathy is to look at the patient as one entity and to not only to treat local problems but the whole body according to the patient’s individual needs. This means, however, that patients with the same clinical picture can be treated with sometimes quite varying approaches or techniques. In view of these aspects and considering the limited number of patients in this study a comparison between the two groups and also between the individual patients would be hardly or not at all possible. Since a good comparability should be achieved in this study, two osteopathic techniques were selected, which could be applied to all patients and even with the patients wearing a cast.

The osteopathic techniques chosen for this study are the balanced ligamentous technique (BLT) and the fascial unwinding. It has to be pointed out that the function and mode of action of both techniques are neither fully understood nor proven to date. Both techniques thus have to be regarded as models or ideas of treatment.

The model of ligamentous articular tension

In this model the ligaments around many joints, thus also in the carpal joint, have a strong influence on the movement of the muscles.[35] The wrist allows for a lot of movements even though among the muscles of the forearm only the M. flexor carpi ulnaris has an attachment on the pisiform bone and also on the hamate bone. All other muscles of the forearm have no direct attachment on the carpal bones.[10]

The model describes certain fulcrums (fixed points) which result from the position and tightness of the ligaments and around which the movements of the carpal bones occur. The reactive movements to the muscle action that are guided by the ligaments can be compared with those of pulleys, levers and straps. Carreiro writes that Sutherland used the term ligamentous articular mechanism for this kind of arrangement and that he assumed that there is a balanced tension among the ligaments. Damage to the ligaments or somatic dysfunctions disturb this balanced ligamentous tension around the joint and can thus lead to mechanical and anatomical strains. [35]

Balanced ligamentous tension techniques (BLT)

BLT is based on the assumption that the ligaments have the least tension in the physiological neutral position of a joint and that in this position the joint has the biggest play.

Further it is assumed that if there is a joint dysfunction, the position in which the ligaments have the least tension no longer corresponds to the physiological neutral position. Instead there is a new balance point at that moment in time.

When applying BLT the therapist tries to bring the joint exactly to this new balance point so that the tension in the ligaments is reduced to a minimum which facilitates a change or shift around this point.

The exact positioning to this fixed point should help the body to achieve a change through its inherent forces (e.g. breathing).[35]

Since the positioning to this fixed point often only needs very small movements it should be possible also when the patient is wearing a cast.

[35] Carreiro J; Balanced Ligamentous Tension Techniques in „Foundations for osteopathic medicine“: S 916+918; Lippincott 2003

The usual contact of the therapist, i.e. one contact proximal and one contact distal to the wrist, is only used in the treatment after the removal of the cast. While the patient is wearing the cast this contact is not possible. The therapist thus has to have one contact proximal to the cast on the dorsal elbow of the patient; the other hand has a contact with the fingers or the palm of the patient.

Fascial unwinding

The idea behind the unwinding technique is to establish a contact with the fascial level through slight pressure onto the tissues and when the tissues seem to start moving under the therapist's contact to follow these movements to the restriction. At this point the tissues are "held" until the tensions start to release. During the treatment the contact with the fascia should not be lost, i.e. a fine tension has to be maintained throughout the whole procedure. To achieve this, a slight compression or traction can be applied.

Once the tissues start to release the therapist can often notice an increase in temperature or an increased flow of energy in the tissues. Other noticeable changes are a deeper respiration of the patient or pain that can be perceived by the patient, which, however, quickly disappears. [36]

The hand contact of the therapist can vary. It has to be adapted to the specific situation. However, to guarantee that the technique in this study is applied in the most uniform way possible the hand contact is defined as follows:

One hand of the therapist has a contact proximal (i.e. dorsal on the elbow or dorsal on the distal upper arm of the patient), the other hand has a contact distal (i.e. with the fingers and/or palm of the patient's hand) to the cast around the forearm. The forearm of the patient is in a mid-position between pronation and supination. The same hand contact is applied after removal of the cast.

[36] Liem T; Kraniosakrale Osteopathie; Hippokrates 1998

### 3.2.3 Visual analog scale (VAS)

A visual analog scale is used to assess the subjective pain perception of the patients. The individual patient only sees the front side of the scale with its two ends. He/she can set the slider to the part of the scale that corresponds with his/her current pain perception. On the backside of the VAS, which the patients cannot see, there is a 0-100 scale which makes it possible to attribute a numerical value to the individual patient's pain perception. In this case 0 means "no pain" and 100 means "worst imaginable pain" (cf. Fig. 14 and 15).

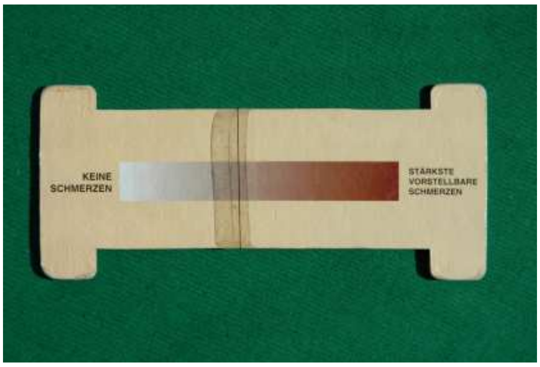



**Fig. 14: VAS front side**


**Fig. 15: VAS backside**

### 3.2.4 Jamar® dynamometer

The gross muscle power during fist closure is measured on both sides. It is carried out with a Jamar® dynamometer with three different finger positions (steps II, III and IV). Each step is measured once[37]. From the three values obtained through the measurement a mean value is calculated. Since the apparatus used for the measurement indicates the values in kilopond (kp), the values have to be converted into Newton (N), which is the SI (Système International des Unitès) unit of force, by multiplying them with the factor 9.81 (cf. Fig. 16).

**Fig. 16: Jamar® dynamometer, step III measurement**

[37] Crosby CA, Wehbé MA, Mawr B; Hand Strength: Normative Values; J Hand Surg 1994; 19A: 665-670

### 3.2.5 Goniometer

The neutral-0-method[15] is applied to measure the mobility of the wrist joint on both sides. With a goniometer the extension, flexion, radial and ulnar duction of the hand (cf. Fig. 17-20) as well as pronation and supination of the forearm are evaluated.

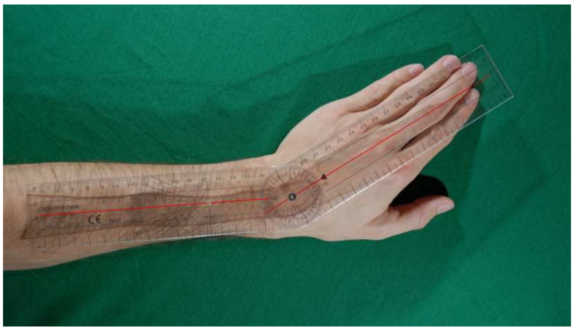


**Fig. 17: Ulnar duction**

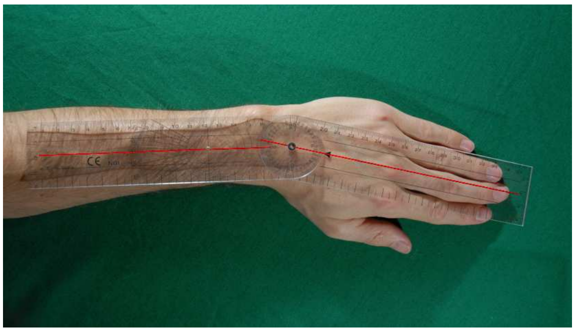


**Fig. 18: Radial duction**

The evaluation always looks at the general mobility in one plane, i.e. the values of flexion and extension are added for the sagittal plane, the values of radial and ulnar duction are added for the frontal plane, and the values of pronation and supination are added for the rotation plane.

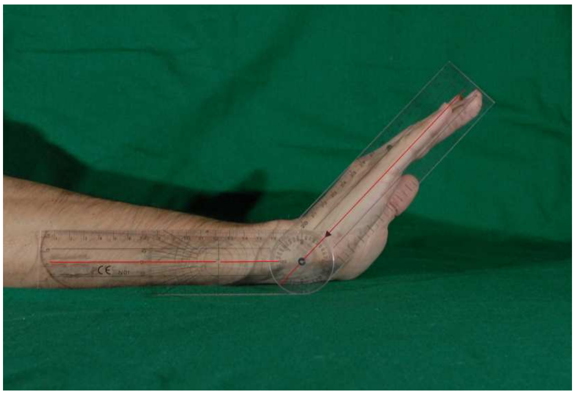


**Fig. 19: Extension**

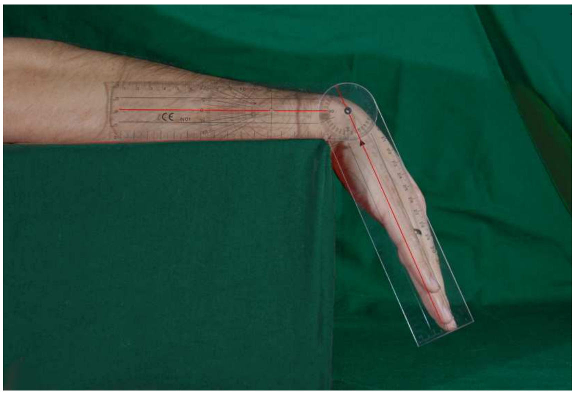


**Fig. 20: Flexion**

### 3.2.6 Kapandji index and fist closure

This index can be used for an assessment of the general function of the hand. It also is a method for the clinical evaluation of the opposition of the thumb. Regarding the evaluation criteria[38] cf. Tab. 7 and Fig. 21:

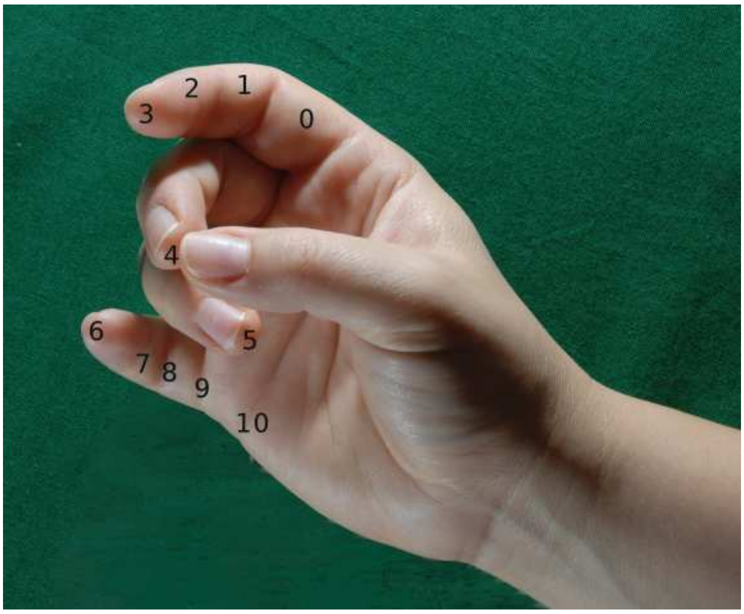



**Fig. 21: Kapandji-Index**

| Stage | |
|---|---|
| 0 | The tip of the thumb is located on the lateral aspect of the proximal phalanx of the index finger |
| 1 | The tip of the thumb is in contact with the lateral aspect of the middle phalanx of the index finger |
| 2 | The tip of the thumb is in contact with the lateral aspect of the distal phalanx of the index finger |
| 3 | Terminal pinch between the thumb and the index finger |
| 4 | Terminal pinch between the thumb and the middle finger |
| 5 | Terminal pinch between the thumb and the ring finger |
| 6 | Terminal pinch between the thumb and the little finger |
| 7 | The tip of the thumb is in contact with the distal interphalangeal crease of the little finger |
| 8 | The tip of the thumb is in contact with the proximal interphalangeal crease of the little finger |
| 9 | The tip of the thumb is in contact with the proximal crease of the little finger |
| 10 | Finally, the tip of the thumb reaches the distal palmar crease at the base of the little finger |

**Tab. 7: Kapandji index[38]**

Also the fist closure gives an overall impression of the general function of the hand and shows whether the second to fifth fingers flex simultaneously. The distance between the finger tips of the middle and ring finger to the palm of the hand (tip-to-palm distance) is measured. The measured values are indicated in millimetres.

[38] Tubiana R, Thomine JM, Mackin E; Examination of the Hand and Wrist; Martin Dunitz Ltd. 1998

### 3.2.7 Disabilities of the Arm, Shoulder and Hand Instrument = DASH questionnaire

The DASH questionnaire[39, 40] is used to obtain a subjective evaluation of the patients' complaints. Since this questionnaire belongs to the category of "self-report" questionnaires, it has to be completed by the patients themselves after eight weeks and at the time of the follow-up examination. The questionnaire looks at the overall function of the upper extremity. The first part contains 30 questions regarding the patients' current perception of the function of their arm, shoulder and hand and the signs and symptoms of the past week. The best function is attributed with one point, the worst with five points. The second and third parts of the questionnaire, the work and profession module and the sports and music module, contain four questions each, which can be answered optionally. Again the possible answers range from one to five points.

To analyse the first part of the questionnaires a maximum of 10% of the questions (3 questions) can remain unanswered. In this case a mean value can be deducted from the answers to the other questions, which can then be used for the missing value/s. If more than three questions are not answered the whole first part of the questionnaire cannot be evaluated. The second and third parts have to be answered completely to make an analysis possible.[40]

According to Germann the DASH value is calculated as follows:

> *"The formula to calculate the DASH values stipulates to establish the quotient of the total points minus the minimum score (30) divided by the so-called "score range" (1.2). A value of 0 corresponds to an optimum function without impairment; a value of 100 would correspond to a maximum impairment."*[39]

$$\frac{\textit{total points} - 30\ (\textit{minimum points})}{1.20\ (\textit{score range})} = \textit{DASH value}$$

An equivalent and in the case of lacking answers easier formula to calculate the DASH value, with "n" indicating the number of answered questions, is this one:

[39] Germann G, Wind G, Harth A; Der DASH-Fragebogen – Ein neues Instrument zur Beurteilung von Behandlungsergebnissen an der oberen Extremität; Handchir Mikrochir Plast Chir 1999; 31: 149-152
[40] Institute for Work & Health, www.dash.iwh.on.ca/assets/images/pdfs/DASH_German06.pdf

$$\text{DASH disability/symptome score} = \left[\frac{\text{(sum of n responses)}}{n} - 1\right] \times 25$$

In this paper only the first part of the DASH questionnaire was used and the values were calculated by means of the first formula.

Eight weeks after the fracture the patients were asked several other questions in addition to the DASH questionnaire. These questions were:

1. How would you describe your general state of health?
   Possible answers: excellent, very good, not so good, bad
2. How would you describe your general state of health in comparison with one year ago?
   Possible answers: much better, a little bit better, a little bit worse, much worse than one year ago
3. How bad was the pain you experienced over the past four weeks?
   Possible answers: no pain, minor pain, little pain, moderate pain, strong pain, very strong pain
4. In how far did the pain bother you in you daily activities over the past four weeks?
   Possible answers: not at all, a little bit, moderately, quite a lot, very much
5. How often did you take painkillers in the past week?
   Possible answers: never, once, every other day, once or twice per day, three times or more often per day

### 3.2.8 X-ray photographs

The x-ray photographs of the wrist immediately after the accident (UB), the photographs after repositioning (RB), the final photographs (EB) eight weeks after the fracture and the photographs taken at the follow-up examination (NU) are used for analysis. The ulnar variance and the ulnar and palmar inclination in the ap and lateral plane are measured and compared with the other, unaffected side.
Since there is no score in the literature for the evaluation of callus formation[27], a doctor specialized in accident surgery defined a classification for the callus formation (bone healing) that is visible on the x-ray photograph: 0 = none, 1 = little, 2 = moderate and 3 = pronounced callus formation.

### 3.2.9 Traditional carpal joint score according to Krimmer

This score or evaluation method for the wrist or carpal joint is a modification of the Cooney score. To facilitate the readability of this paper the information about the modification will henceforth be left out and the applied score will only be termed “Krimmer-Score”.

This paper wants to evaluate the function and usability of the hand. Therefore the Krimmer score was used in addition to the DASH questionnaire. The DASH questionnaire assesses the overall function of the upper extremity, hence it also includes the elbow and shoulder, while the Krimmer score focuses on the wrist joint only.
On the one hand the Krimmer score (cf. Tab. 8) contains objective parameters (power and mobility) and on the other hand subjective parameters (pain and usability of the hand). The highest possible score is 100 points, which means that there is no limitation or impairment at all. To calculate the value for mobility the points of extension/flexion, radial/ulnar duction and pronation/supination are added and then divided by three.[41]

[41] Krimmer H; Der posttraumatische karpale Kollaps, Entstehung und Therapiekonzept; hrsg. von Schweiberer L, Tscherne H in: Hefte zu Der Unfallchirurg; Springer 2001

Since the patients did not indicate their subjective pain verbally but on a visual analogue scale, the following points were attributed to the values on the scale:

- VAS 0-25 = 20 points
- VAS 26-50 = 15 points
- VAS 51-75 = 10 points
- VAS 76-100 = 0 points

| **power in % of the other side** | | | **points** |
|---|---|---|---|
| 0-25 | | | 0 |
| > 25-50 | | | 10 |
| > 50-75 | | | 20 |
| > 75-100 | | | 30 |
| **mobility** | | | |
| extension/flexion | radial/ulnar duction | pronation/supination | |
| ≤ 30° | ≤ 10° | ≤ 80° | 0 |
| > 30°-60° | > 10°-35° | > 80°-110° | 10 |
| > 60°-100° | > 35°-50° | > 110°-140° | 15 |
| > 100° | > 50° | > 140° | 20 |
| **pain** | verbal analogue scale | | |
| strong, intolerable | 4 | | 0 |
| pain during rest and strain | 3 | | 10 |
| pain only during strain | 2 | | 15 |
| painfree | 1 | | 20 |
| **usability** | | | |
| strong limitations in everyday life | | | 0 |
| considerable impairment | | | 10 |
| limited only in specific activities | | | 20 |
| normal, no limitations | | | 30 |
| **assessment** | | | |
| very good | | | > 80-100 |
| good | | | > 65-80 |
| satisfying | | | > 50-65 |
| bad | | | 0-50 |

**Tab. 8: Evaluation system of the wrist according to Krimmer[42]**

[42] Krimmer H, Wiemer P, Kalb K; Vergleichende Ergebnisbewertung am Handgelenk – mediokarpale Teilarthrodese und Totalarthrodese; Handchir Mikrochir Plast Chir 2000; 32(6): 369-374

# 4 Results

## 4.1 Patients, osteopathy & complications

A total of 32 patients (25 female and 7 male) participated in this study.

The osteopathy group comprised 16 patients (13 women and 3 men), their average age at the time of injury was 64.8 (47.7-85.5) years. 15 patients came to the hospital for treatment at the day of the injury, one patient on the day after.
The control group consisted of 16 patients (12 women and 4 men) with an average age at the time of injury of 74.0 (56.2-93.8) years. 12 patients of this group come to the hospital for treatment on the day of the injury, three patients did so on the day after, while one patient came only after two days.
13 patients of the osteopathy group returned for the follow-up examination. Three patients of this group did not report to the hospital even after several invitations. They neither could be reached by telephone. Regarding the control group 12 patients returned for the follow-up examination. Two female patients did not follow the invitation without indicating any reasons for that. Two other female patients fell seriously ill in the meantime thus the follow-up examination would not have been acceptable. In personal telephone conversations they described the function of their hand as good. Since only this statement was available from these two patients, they were not included in the analysis of the results of the follow-up examination.

<u>Osteopathy</u>
The osteopathic treatment was positively received by the patients. Five of the 16 patients in the osteopathy group stated not to have felt anything during the osteopathic treatment. The other eleven patients indicated a feeling of warmth in four cases, a reduction of pain in three cases and a throbbing or tingling sensation in four cases.
Also the choice of words of some of the patients' spontaneous statements during the osteopathic treatment was interesting, e.g.: “a flash of energy at the site of the fracture”, “the tissue becomes alive”, “the hand settles down”, “a scanning of the site of the fracture” and “a feeling of opening and closing”.

Complications in the osteopathy group

One of the female patients in the osteopathy group developed a reflex dystrophia.

Another female patient had to undergo surgery 20 months after the radial fracture because of post-traumatic carpal tunnel syndrome (CTS). Even though this patient had disturbed sensitivity in the region of the median nerve [N. medianus] already few weeks after the fracture, the diagnosis of carpal tunnel syndrome was established only 19 months after the injury.

Another female patient underwent surgery because of CTS, but she did not have any symptoms of a compression of the median nerve in the first months after the fracture. In her case it is thus not sure whether there is a causal relationship between the CTS and the radial fracture.

Complications in the control group

An osteotomy to shorten the ulna was carried out in one female patient of the control group.

Four months after the radial fracture another female patient had to undergo surgery because of post-traumatic carpal tunnel syndrome.

Another female patient has diastases of 5mm of the distal radio-ulnar joint, even though she indicated neither pain nor restrictions of movement or other functional impairments at the follow-up examination.

Thus the same number of complications could be observed in both groups.

## 4.2 Power and handedness

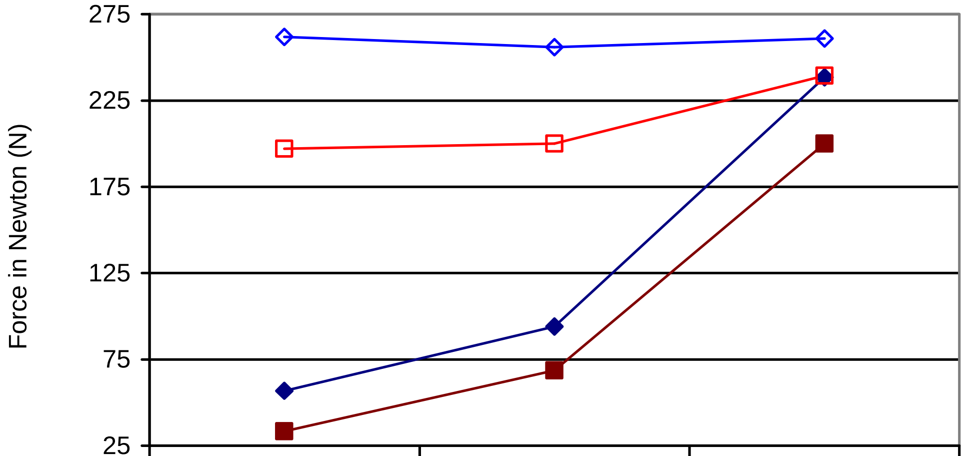
In the osteopathy group seven fractures occurred on the right and nine fractures on the left side; 14 patients indicated they were right-handed, two indicated that they were left-handed. In seven cases (6 right, 1 left) the dominant hand was affected by the fracture.
In the control group four fractures occurred on the right side, 12 on the left; 14 patients indicated to be right-handed, two indicated that their dominant hand was the left. In this group the dominant hand was affected by the fracture in six cases (4 right, 2 left).
Overall 11 fractures occurred on the right and 21 on the left side. In 13 patients the fracture affected the dominant side (10 right, 3 left).

The measurement of power was carried out on the right and left hand 6 and 8 weeks after the injury during the follow-up examinations.

A comparison of the measured values of the injured and the unaffected side showed that the osteopathy group achieved higher average values than the control group.
Six and eight weeks after the fracture the osteopathy group had significantly higher mean values on the injured side than the control group. However, it has to be considered that the osteopathy group also had significantly higher mean values on the unaffected side six and eight weeks after the fracture. At the follow-up examination the osteopathy group had also higher mean values than the control group both on the injured and on the unaffected side, but the difference was no longer significant. (cf. Tab 9 and Fig. 22).

| | **Osteopathy group** | | | | **Control group** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Injured side** | | **Unaffected side** | | **Injured side** | | **Unaffected side** | |
| **after 6 weeks** | 56.9 | (5.8) | 261.9 | (26.7) | 33.4 | (3.4) | 197.2 | (20.1) |
| **after 8 weeks** | 94.2 | (9.6) | 256.0 | (26.1) | 68.7 | (7.0) | 200.1 | (20.4) |
| **At the follow-up examination** | 238.4 | (24.3) | 260.9 | (26.6) | 200.1 | (20.4) | 239.4 | (24.4) |

**Tab. 9: Average power in N (kp)**

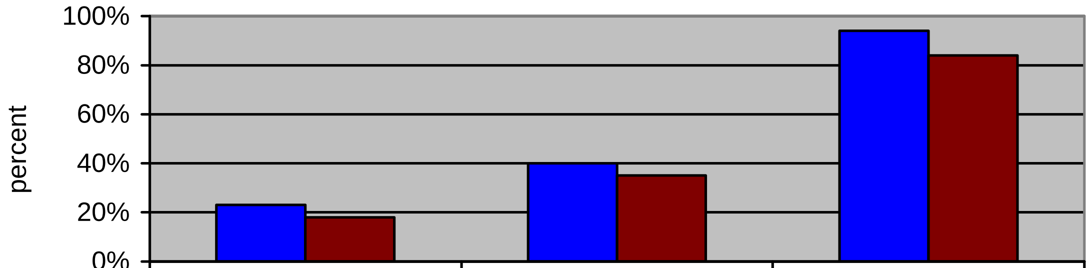



| | 6 weeks | 8 weeks | follow-up |
|---|---|---|---|
| osteopathy group, injured side | 56,9 | 94,2 | 238,4 |
| control group, injured side | 33,4 | 68,7 | 200,1 |
| osteopathy group, both sides compared | 261,9 | 256,0 | 260,9 |
| control group, both sides compared | 197,2 | 200,1 | 239,4 |

**Fig. 22: Development of power of the injured and unaffected sides**

To facilitate the comparison of the power of the injured hand with that of the unaffected side the value of the dominant hand is corrected by minus 10% for the subdominant hand. This means that e.g. a value of 20N for the dominant hand corresponds to a value of 18N for the subdominant hand. What is indicated is the power of the affected side in percent of the unaffected side. The values in parenthesis are the values without the above mentioned correction by 10%.

On average the osteopathy group achieved 23% (22%) of the power of the unaffected side after six weeks, 40% (39%) after eight weeks 94% (90%) at the follow-up examination, while the control group achieved 18% (17%) after six weeks, 35% (34%) after eight weeks and 84% (79%) at the follow-up examination (cf. Fig. 23).




| | 6 weeks | 8 weeks | follow-up |
|---|---|---|---|
| osteopathy group | 23% | 40% | 94% |
| control group | 18% | 35% | 84% |

**Fig. 23: power in percent of the unaffected side – with consideration of subdominance**

Also in this calculation no significant difference between the two groups could be demonstrated.

## 4.3 Mobility

The measurement of joint mobility immediately after the removal of the cast showed a significantly better mobility for the osteopathy group in the sagittal plane (S) with 51° and in the frontal plane (F) with 32° in comparison with the control group (42° in S and 18° in F). After another osteopathic treatment the difference in mobility was even more obvious: the osteopathy group achieved 63° in the sagittal plane and 38° in the frontal plane. The mobility in the rotation plane (R) also increased from 95° to 114° after the osteopathic treatment but neither before nor afterwards there was a significant difference to the control group, which achieved 94° (cf. Fig. 24-26).

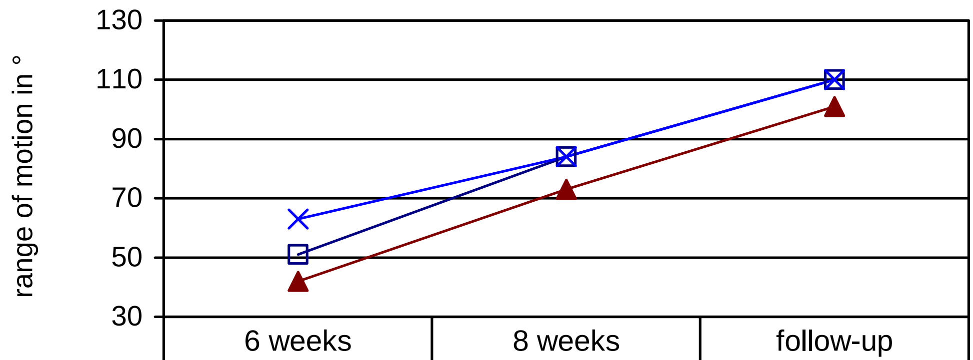
Eight weeks after the injury the osteopathy group had a mean range of motion of 84° in the sagittal plane and 43° in the frontal plane, while the control group had 73° in the sagittal plane and 34° in the frontal plane. This means that there was a significant difference between the two groups in the sagittal and in the frontal plane. At this moment in time the range of motion in the rotation plane was almost the same with 137° for the osteopathy group and 141° for the control group.

The mobility in the osteopathy group in comparison with the unaffected side is only reduced by 27° in the sagittal plane, 15° in the fr ontal plane and 27° in the rotation plane.
The mobility in the control group in comparison with the unaffected side is reduced by 35° in the sagittal plane, 19° in the frontal plane and 27° in the rotation plane (cf. Fig. 24-26).

At the follow-up examination the mean mobility of the injured and the unaffected sides is the same in all planes in the osteopathy group. In the control group the range of motion of the injured side is a little less than that of the other side in the sagittal plane and in the rotation plane. (cf. Tab. 10).

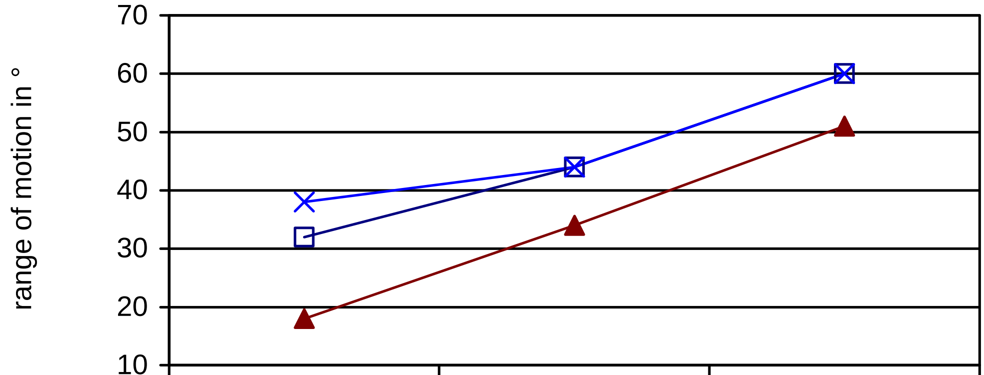
| | Osteopathy group | | | Control group | | |
|---|---|---|---|---|---|---|
| | **S** | **F** | **R** | **S** | **F** | **R** |
| **Injured side** | 110° | 60° | 162° | 101° | 51° | 160° |
| **Unaffected side** | 110° | 59° | 164° | 108° | 53° | 167° |

**Tab. 10: mean range of motion at the follow-up examination**



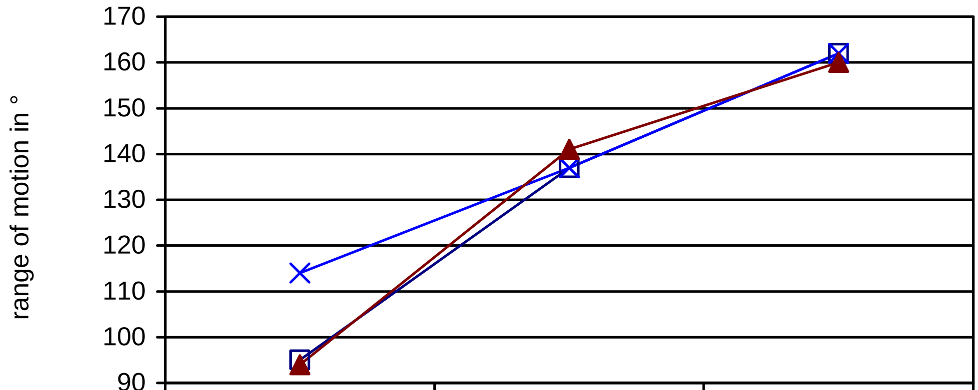

| | 6 weeks | 8 weeks | follow-up |
|---|---|---|---|
| osteopathy group before osteopathic treatment | 51 | 84 | 110 |
| osteopathy group after osteopathic treatment | 63 | 84 | 110 |
| control group | 42 | 73 | 101 |

**Fig. 24: Development of range of motion in the sagittal plane**




| | 6 weeks | 8 weeks | follow-up |
|---|---|---|---|
| osteopathy group before osteopathic treatment | 32 | 44 | 60 |
| osteopathy group after osteopathic treatment | 38 | 44 | 60 |
| control gorup | 18 | 34 | 51 |

**Fig. 25: Development of range of motion in the frontal plane**




| | 6 weeks | 8 weeks | follow-up |
|---|---|---|---|
| osteopathy group before osteoapthic treatment | 95 | 137 | 162 |
| osteopathy group after osteopathic treatment | 114 | 137 | 162 |
| control group | 94 | 141 | 160 |

**Fig. 26: Development of range of motion in the rotation plane**

All 25 patients achieved complete fist closure on both sides at the time of the follow-up examination. This means that all finger tips had contact with the palm of the hand and that the tip-to-palm distance of the middle and ring fingers was 0mm.

At the follow-up one female patient of the osteopathy group had a Kapandji index of 9 on both sides, all other patients had an index of 10 on both sides. In the control group eight patients had a Kapandji index of 10 on both sides. One female patient had a fresh injury on the right side at the time of the follow-up examination therefore the index could only be determined with 10 for her left hand. One patient, who had fractured his right radius, had a Kapandji index of 8 on the right and 9 on the left side. Another female patient, who had also fractured her right radius, achieved a Kapandji index of 10 on the right and 8 on the left side. One patient with a radius fracture on the left side obtained an index of 10 on the right and 9 on the left side.
Thus the Kapandji index that was determined at the follow-up examination did not show differences in the two groups.

## 4.4 DASH value, Krimmer score & pain

It has already been mentioned on page 40 that the DASH value was calculated with the formula:

$$\frac{\text{Total points} - 30 \text{ (minimum points)}}{1.20 \text{ (score range)}} = \text{DASH value}$$

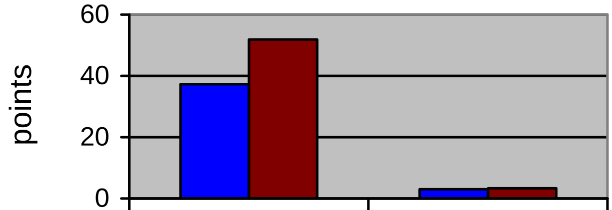
In cases of up to three non-answered questions the mean value of the other questions was used for the lacking answers and the above formula was used to calculate the value.

<u>DASH value and Krimmer score eight weeks after the injury</u>

Eight weeks after the injury all 16 patients of the osteopathy group and 14 of a total of 16 patients of the control group filled in the DASH questionnaire.

The results of the osteopathy group showed a minimum value of 4.17 and a maximum value of 76.48 points, with a mean value of 37.24 points.

The results of the control group were a minimum value of 0.83 and a maximum value of 83.58 points, with a mean value of 51.84 points (cf. Fig. 27).



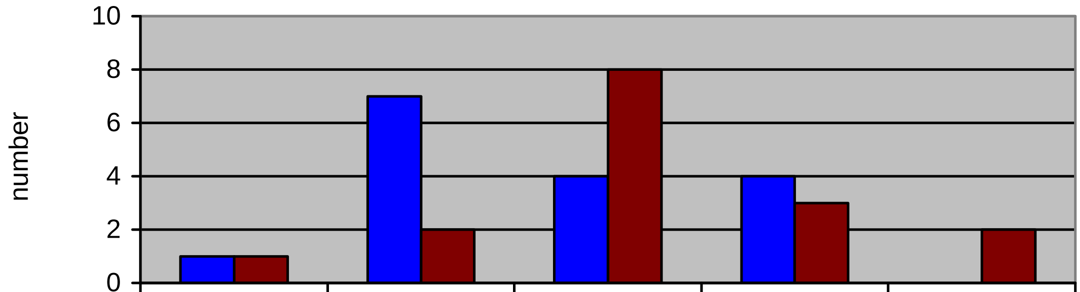

| | 8 weeks | follow-up |
|---|---|---|
| osteopathy group | 37,24 | 3,07 |
| control group | 51,84 | 3,34 |

**Fig. 27: DASH score mean values**

The Krimmer score could be calculated for all patients of the osteopathy group and for 14 (of a total of 16) patients of the control group.

In the osteopathy group eight very good or good and eight satisfying or bad results could be observed.

In the control group the patients obtained three very good or good, as well as eleven satisfying or bad results (cf. Fig. 28).




| | very good | good | satisfying | bad | no result |
|---|---|---|---|---|---|
| osteopathy group | 1 | 7 | 4 | 4 | 0 |
| control group | 1 | 2 | 8 | 3 | 2 |

**Fig. 28: Krimmer score results after eight weeks**

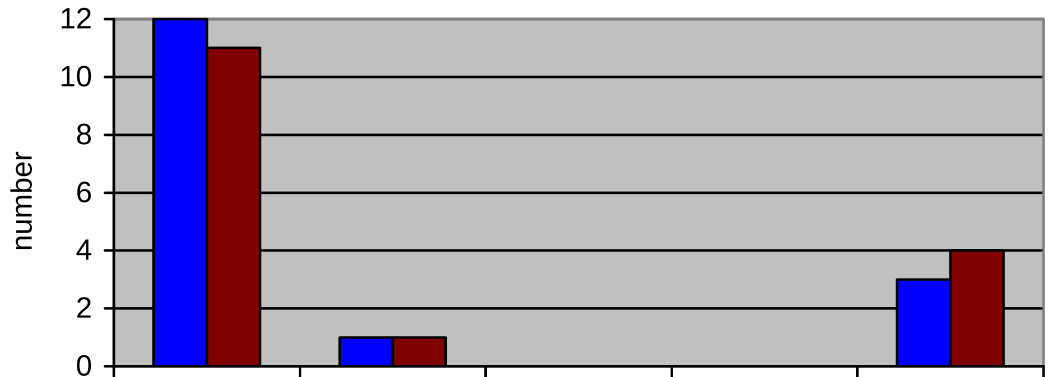
DASH value and Krimmer score at the follow-up examination

12 patients of the control group and 13 patients of the osteopathy group turned up at the follow-up examination. Since neurological problems had started in the mean time in one female patient of the osteopathy group the DASH questionnaire that had been completed by this patient was excluded from the analysis. However, her Krimmer score was used for further evaluation.

Before the follow-up examination an osteotomy of the ulna was performed on one female patient of the control group. In addition, two female patients of the osteopathy group and one female patient of the control group had to undergo surgery because of carpal tunnel syndrome. The four questionnaires of these patients, which show the results post surgery, have not been excluded from the overall analysis.

At the follow-up examination the mean DASH value of the osteopathy group was 3.07 points (0-20.69 points), the mean DASH value of the control group was 3.34 points (0-24.1 points), (cf. Fig. 27).

In the osteopathy group the Krimmer score indicated 12 very good and one good result. Thus it did not differ much from the results of the control group, where the patients comprised 11 very good and one good result. No results are available for three patients of the osteopathy group and four patients of the control group (cf. Fig. 29).




| | very good | good | satisfying | bad | no result |
|---|---|---|---|---|---|
| osteopathy group | 12 | 1 | 0 | 0 | 3 |
| control group | 11 | 1 | 0 | 0 | 4 |

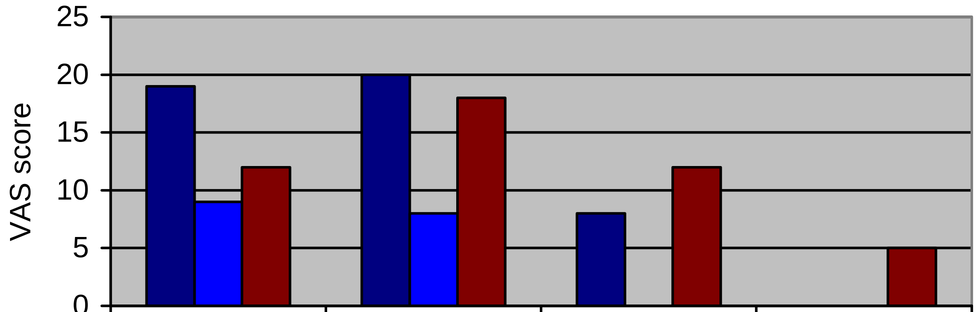
**Fig. 29: Krimmer score at the follow-up examination**

<u>Subjective pain perception – visual analog scale (VAS)</u>

Four weeks after the fracture the osteopathy group had a mean value of 19 (0-54) points on the VAS before osteopathic treatment, after the removal of the cast, six weeks after the fracture the value was 20 (0-60) points. After two more weeks (i.e. after a total of eight weeks after the injury) the mean value was 8 (0-42) points. At the follow-up examination no patient of the osteopathy group indicated any pain, i.e. the mean value was 0 points.

The measurement after the osteopathic treatment showed that the pain intensity was reduced; after four weeks the mean values ranged at only 9 (0-48) points and after six weeks at 8 (0-32) points. After eight weeks and at the follow up examination the patients did not receive an osteopathic treatment.

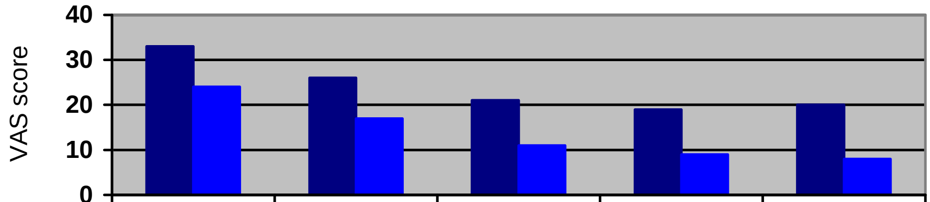
In the control group the mean values after four weeks were 12 (0-25) points, after six weeks 18 (0-90) points and after eight weeks 12 (0-40) points. Eight patients were pain free at the follow-up examination; four indicated minor pain (VAS 0-15). The mean value was 5 points (cf. Fig. 30).




| | 4 weeks | 6 weeks | 8 weeks | follow-up |
|---|---|---|---|---|
| osteopathy group | 19 | 20 | 8 | 0 |
| osteopathy group after osteopathic treatment | 9 | 8 | | |
| control group | 12 | 18 | 12 | 5 |

**Fig. 30: Development of VAS score**

A comparison of the VAS scores before and after the osteopathic treatment usually showed a clear reduction of pain. After the osteopathic treatment the patients usually indicated 10 points less on the VAS scale (cf. Fig. 31).




| | day 1 | 1 week | 2 weeks | 4 weeks | 6 weeks |
|---|---|---|---|---|---|
| before osteopathic treatment | 33 | 26 | 21 | 19 | 20 |
| after osteopathic treatment | 24 | 17 | 11 | 9 | 8 |

**Fig. 31: VAS score before and after the osteopathic treatment**

In total 76 osteopathic treatments were carried out. Four treatments could not be delivered due to diseases of the patients. The patients did not indicate an increase of the pain after any of the treatments. In 13 cases the patients indicated the same pain score on the VAS before and after the osteopathic treatment. After 36 of the overall 76 treatments the VAS score was 1-10 points better, after 18 treatments it was 11-20 points better, after 7 treatments the improvement was 21-30 points, after two treatments an improvement of 30 and 40 points respectively could be observed.

Additional questions eight weeks after the injury

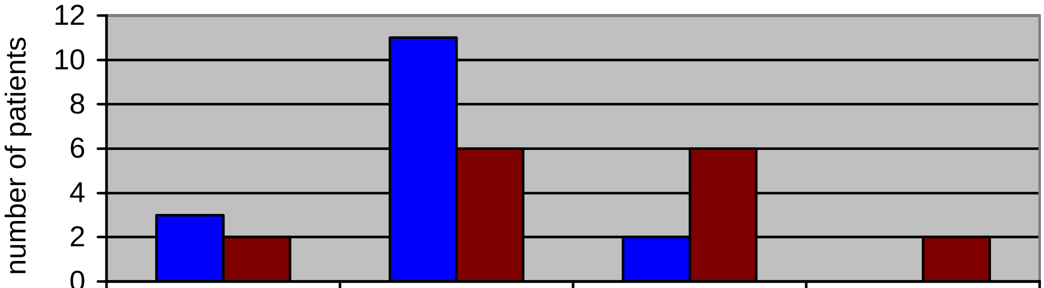
When the patients completed the first DASH questionnaire they were also asked some additional questions regarding their current general state of health, also in comparison with their state of health one year ago, their pain during the past four weeks, the degree of impairment during daily activities in the past four weeks and the intake of painkillers in the past week.

These additional questions were answered by all patients of the osteopathy group and by 14 patients of the control group.

The patients of both groups gave quite equal answers regarding the question about their general state of health. Three patients of the osteopathy group and two patients of the control group indicated an excellent or very good state of health. 10 patients of the osteopathy group and nine of the control group described their general state of health with good, while three patients of each group chose the answers not so good and bad.

When asked to compare their current state of health with that of one year ago the patients described a similar picture. One patient of each group estimated their state of health to be much better or better than one year ago. 12 patients of the osteopathy group and 7 of the control group indicated that their state of health had not changed, while three patients of the osteopathy group and six of the control group regarded their current general state of health as a little bit or much worse than one year ago.

Regarding the question about the pain experienced in the past four weeks three of the patients in the osteopathy group and two of the control group indicated that they had no or only minor pain. 11 patients of the osteopathy group and six of the control group mentioned little or moderate pain, while two patients of the osteopathy group and six patients of the control group described their pain as strong or very strong. (cf. Fig. 32).

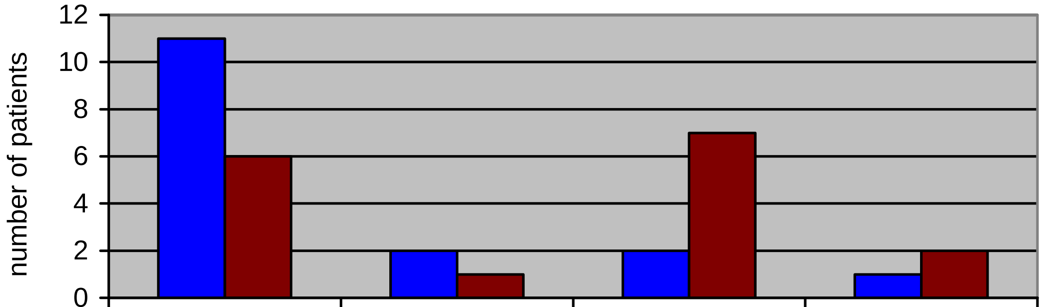



| | no /minor | little / moderate | strong / very strong | no answer |
|---|---|---|---|---|
| osteopathy group | 3 | 11 | 2 | 0 |
| control group | 2 | 6 | 6 | 2 |

**Fig. 32: Pain in the past four weeks (additional questions 8 weeks after the injury)**

Two of the patients in each group answered the question whether the pain had impaired them during their daily activities in the past four weeks with “not at all”, while ten patients of the osteopathy group and four patients of the control group chose the answers “a little bit” or “moderately”. The possible answers “quite a lot” and “very much” were chosen by four patients of each group. Three patients of the control group did not answer this question.

The question about the intake of painkillers in the in the past week showed that 11 patients of the osteopathy group and six of the control group did not take any analgesics. Two patients of the osteopathy group and one patient of the control group indicated that they had taken painkillers once per week or every couple of days, while two patients of the osteopathy group and seven of the control group said that they had taken painkillers once or twice or even (more than) three times per day. One patient of the osteopathy group and two of the control group did not answer this question (cf. Fig. 33).




| | none | 1x/week | daily | no answer |
|---|---|---|---|---|
| osteopathy group | 11 | 2 | 2 | 1 |
| control group | 6 | 1 | 7 | 2 |

**Fig. 33: intake of painkillers in the past week (additional questions 8 weeks after the injury)**

The answers to these questions showed that the tendency in the osteopathy group was that the patients indicated to experience less pain and took painkillers less often.

## 4.5 Radiology

Classification

According to the AO classification six patients had an A2, 13 an A3, one a C1, eight a C2 and four a C3 injury.

According to the Frykman classification six patients fell into the category Frykman 1, ten patients fell into the category Frykman 2, one had a Frykman 4 and another one a Frykman 5 injury, two could be attributed to the category Frykman 6, five fell into the category Frykman 7 and seven had a Frykman 8 injury (cf. Tab. 11 and 12).

| AO | total | Osteopathy group | Control group | | Osteopathy group | Control group |
|---|---|---|---|---|---|---|
| **A 2** | 6 | 4 | 2 | **A 2.1** | 1 | 1 |
| **A 3** | 13 | 5 | 8 | **A 2.2** | 3 | 1 |
| **C 1** | 1 | 0 | 1 | **A 3.1** | 0 | 1 |
| **C 2** | 8 | 6 | 2 | **A 3.2** | 5 | 6 |
| **C 3** | 4 | 1 | 3 | **A 3.3** | 0 | 1 |
| | | | | **C 1.2** | 0 | 1 |
| | | | | **C 2.1** | 4 | 0 |
| | | | | **C 2.2** | 2 | 2 |
| | | | | **C 3.1** | 1 | 2 |
| | | | | **C 3.2** | 0 | 1 |

**Tab. 11: Number of fractures in both groups according to the AO classification**

| Frykman | Total | Osteopathy group | Control group |
|---|---|---|---|
| **1** | 6 | 4 | 2 |
| **2** | 10 | 4 | 6 |
| **3** | 0 | 0 | 0 |
| **4** | 1 | 0 | 1 |
| **5** | 1 | 0 | 1 |
| **6** | 2 | 1 | 1 |
| **7** | 5 | 3 | 2 |
| **8** | 7 | 4 | 3 |

**Tab. 12: Number of fractures in both groups according to the Frykman classification**

Indications for surgery, additional injuries and injuries of the other side

Four patients of the osteopathy group and three patients of the control group showed indications for surgery, but six patients refused the surgical management of their injury and in the case of one female patient of the control group the doctors refrained from performing the surgery because of her age.

One patient of the control group with a radial fracture on the left side also had a fracture of the fourth metacarpal bone left. A female patient of the control group had also fractured her distal phalanx of the thumb on the other side.

One female patient of the control group had a radial fracture on both sides. This circumstance was not defined as exclusion criterion thus the patient was included in the study and the side of the fracture that was not dislocated was defined as the side used for comparison.

Three patients of the osteopathy group and one female patient in the control group had already had an older fracture of the other side.

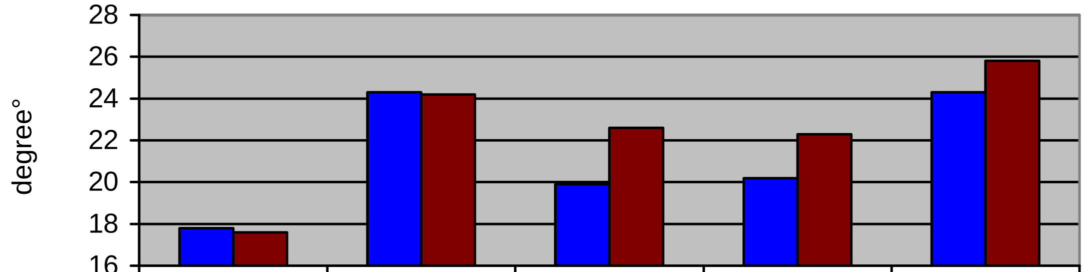
In the case of one female patient of the osteopathy group no x-rays of the unaffected side are available.

Callus formation

To facilitate a comparison of the callus formation a doctor specialized in accident surgery defined a classification ranging from zero (= no visible callus) to three (= pronounced callus formation). The values deducted from the x-ray photographs are evenly distributed. The mean values for the callus formation are 1.71 for the control group and 1.87 for the osteopathy group and thus do not differ very much.

Ulnar inclination

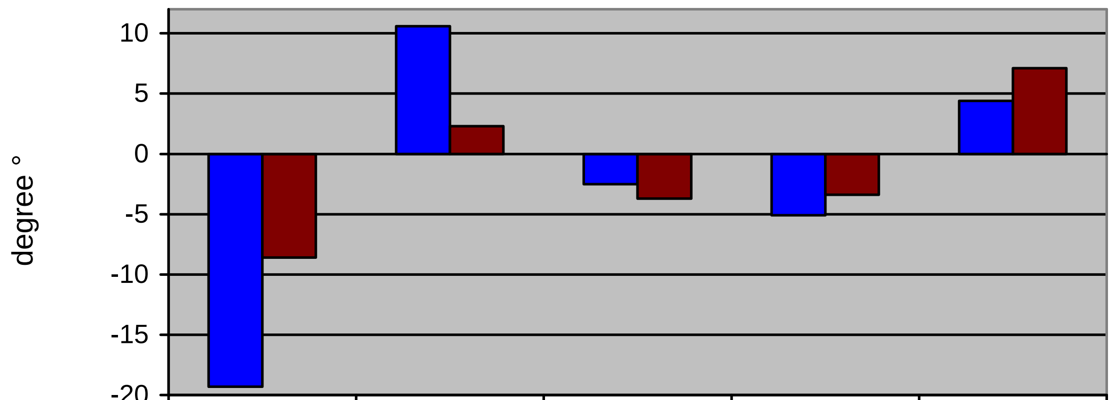
The mean values of the ulnar inclination measured in the accident x-rays (UB), reposition x-rays (RB), final x-rays (EB, after eight weeks) and follow-up x-rays (NB) no significant difference could be observed between the two groups. A comparison of the mean values between the NB and the x-ray photographs of the opposite side showed a difference of 4.1° in the osteopathy group and 3.5° in the control group (cf. Fig. 34).




| | accident x-ray | reposition x-ray | final x-ray week 8 | follow-up | comparison of both sides |
|---|---|---|---|---|---|
| osteopathy group | 17,8 | 24,3 | 19,9 | 20,2 | 24,3 |
| control group | 17,6 | 24,2 | 22,6 | 22,3 | 25,8 |

**Fig. 34: Development of the angle of ulnar inclination**

Palmar inclination



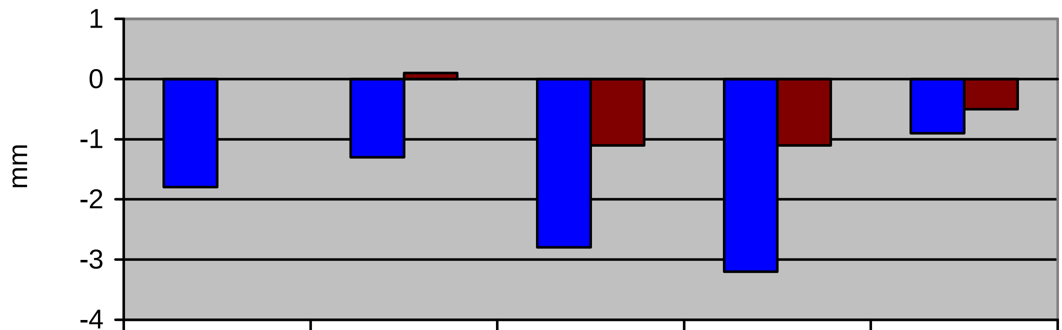

| | accident x-ray | reposition x-ray | final x-ray week 8 | follow-up | comparison of both sides |
|---|---|---|---|---|---|
| osteopathy group | -19,3 | 10,6 | -2,5 | -5,1 | 4,4 |
| control group | -8,6 | 2,3 | -3,7 | -3,4 | 7,1 |

**Fig. 35: Development of the angle of palmar inclination**

The initial situation was clearly more disadvantageous in the osteopathy group than in the control group with a mean palmar inclination of –19.3° in the accident x-rays for the former and –8.6° for the latter. After repositi oning the mean lateral SSGW was 10.6° in the osteopathy group. By the time the foll ow-up (NB) photographs were taken the angle had decreased to –5.1°. A different development could be observed in the control group, where the palmar inclination was 2.3° after repositioning and decreased to –3.4°. A comparison of the mean value s of the NB photographs and the x-rays of the unaffected side showed a difference of 9.5° for the osteopathy group and 10.5° for the control group (cf. Fig. 35).

<u>Ulnar variance</u>

The mean value of ulnar variance showed a slightly worse initial situation in the osteopathy group (–1.8mm) than in the control group (0mm). After repositioning the mean value remind more or less the same with –1.3mm for the osteopathy group and 0.1mm for the control group. At the follow-up examination the values were –3.2mm for the osteopathy group and –1.1mm for the control group. The comparison of the mean values of the NB and the opposite side showed a difference of 2.3mm in the osteopathy group and 0.6mm in the control group (cf. Fig. 36).




| | accident x-ray | reposition x-ray | final x-ray week 8 | follow-up | comparison of both sides |
|---|---|---|---|---|---|
| osteopathy group | -1,8 | -1,3 | -2,8 | -3,2 | -0,9 |
| control group | 0 | 0,1 | -1,1 | -1,1 | -0,5 |

**Fig. 36: Development of the ulnar variance**

# 5 Discussion

Fractures of the distal radius have been a common problem with implications that have remained unchanged for years. With a share of 25% of all fractures they belong to the most frequent fractures among patients. Even though imaging techniques have improved and thus accompanying injuries can be recognized earlier[43] and therefore treated accordingly, the results of the management of some fractures are still not satisfying or even bad.

The most common causes are accidents involving falls[44,45], sports injuries, traffic accidents or falls from heights.
Pechlaner et al. describe highly significant correlations between the age of the patients and the cause of the injury: in the age group between 19 and 39 years-of age the main causes of the injury are falls from heights, sports injuries and traffic accidents, among the patients older than 60 falls in general are the main cause[22]. With increasing age more women than men are affected by fractures of the distal radius[2,22,46,47,48]. It is interesting that radial fractures occur more often on the left than on the right side[1,48,49].

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[43] Meier R, Krettek C, Krimmer H; Bildgebende Verfahren am Handgelenk; Unfallchirurg 2003; 106: 999-1009
[44] Arora R, Lutz M, Zimmermann R, Krappinger D, Gabl M, Pechlaner S; Grenzen der palmaren winkelstabilen Plattenosteosynthese bei instabilen distalen Radiusfrakturen; Handchir Mikrochir Plast Chir 2007; 39:34-41
[45] Felderhoff J, Wiemer P, Dronsella J, Weber U; Operative Versorgung der distalen, instabilen Radiusfraktur mit der dorsalen/palmaren Abstützplatte; Der Orthopäde 1999; 28: 853-863
[46] Pillukat T, van Schoonhoven J, Prommersberger KJ; Ist die Korrekturosteotomie der fehlverheilten distalen Radiusfraktur auch beim älteren Menschen indiziert?; Handchir Mikrochir Plast Chir 2007; 39: 42-48
[47] Kwasny O, Barisani GR, Schabus R, Hertz H; Ergebnisse und Analyse von Misserfolgen der konservativen Therapie bei distaler Radiusfraktur; Handchir Mikrochir Plast Chir 1991; 23: 240-244
[48] Langenberg R; Die konservative Behandlung von distalen Radiusfrakturen, Ergebnisse einer retrospektiven Studie; Der Unfallchirurg 1989; 92:1-5
[49] Jakob M, Mielke S, Keller H, Metzger U; Therapieergebnisse nach primär konservativer Versorgung distaler Radiusfrakturen bei Patienten im Alter von über 65 Jahren; Handchir Mikrochir Plast Chir 1999; 31: 241-245

## 5.1 Classification and scores

Distal radial fractures have many different forms thus a detailed and comprehensive description is quite difficult. There are various methods for a radiological classification of distal radius fractures which focus on different aspects of the fracture. The classification according to Frykman takes accompanying fractures of the distal ulna (Processus styloideus ulnae) into account; the systematic classification according to the AO describes the degree and stability of the fracture[26], while the classification according to Pechlaner considers the direction of dislocation of the peripheral fragment. The Mayo classification differentiates between the forms of the intra-articular fractures[22]. The classification according to Fernandez considers the present forms of the fracture in the context of the mechanism that let to the injury.[25,50]
The traditional scores or assessment methods are as numerous as the classification methods. They consist of subjective and objective criteria, which are attributed different importance. Without taking into account the DASH score, the share of subjective criteria is indicated as ranging between 30 and 50% (depending on the scoring method), while the share of objective criteria ranges between 50 and 100% (also depending on the scoring method).
The contents of the various scoring methods make it difficult to compare the different methods: the scoring method according to Gartland and Werley comprises the criteria deformity, subjective evaluation by the patient, function and complications; the scoring method according to Cooney et al. contains the criteria pain, work, range of movement and power; the Krimmer score (a modification of the Cooney method) uses the criterion “usability” instead of “work”[41]. The scoring method according to Lidstrøm differentiates functional, radiological and aesthetic aspects. The DASH questionnaire provides information about the subjective assessment by the patients themselves.[40]
This selection of commonly used classification, scoring and assessment methods[27] already shows that distal radial fractures can be looked at from a variety of different angles. It is thus difficult to compare individual works and treatment strategies because of the different choice of assessment criteria and also the weighting of their importance. There is not one assessment method that fulfils all requirements

[50] Ilyas AM, Jupiter JB; Distal Radius Fractures – Classification of Treatment and Indications for Surgery; Orthop Clin N Am 38 (2007) 167-173

regarding the rating and classification of the fractures. At the moment the DASH score[22,46,51] and the classification according to the AO[2,22,47] are usually used by various authors.

## 5.2 Conservative and surgical medical management

The conservative management of distal radial fractures has not changed much since its description by Böhler[30,31,32]: A manual repositioning is carried out after a longitudinal traction, the fracture is immobilized first with a dorsal longuette, later with a closed cast. The immobilization period usually lasts 4-8 weeks. During this time (in the case of problems over a longer period of time) repeated radiological and clinical check-ups are carried out.[33] If possible and as soon as it is possible the cast is replaced by a plastic splint, which cannot be moulded so well but is lighter as the cast while providing the same stability.

A problem that occurs quite frequently in the conservative management of radial fractures is that even after exact primary repositioning the achieved realignment cannot be preserved.[31] The degree of subsequent dislocation depends among other things on the level of the compression strain, the number of fracture fragments and the position of the fragments in relation to each other. A new dislocation of the fracture usually occurs within the first two weeks after the injury, but it can also be observed after the end of the immobilization period. [23]

Even if distal radial fractures heal in the anatomical position there can be a persistent instability of the distal radio-ulnar joint.[52] The same holds for fractures that were not dislocated, where accordingly bad results can be observed.[53]

Kwasny et al. describe that the primary repositioning has a decisive influence on the final result and that there is a close correlation between the functional and the anatomical result.[47] Other authors indicate that bad radiological results do not

[51] Lutz M, Arora R, Smekal V, Krappinger D, Gschwentner M, Rieger M, Pechlaner S; Langzeitergebnisse operativ versorgter distal intraartikulärer Speichenfrakturen; Handchir Mikrochir Plast Chir 2007; 39: 54-59

[52] van Schoonhoven J, Prommersberger KJ, Lanz U; Die Bedeutung des distalen Radioulnargelenks bei rekonstruktiven Eingriffen nach fehlverheilten körperfernen Speichenbrüchen; Der Orthopäde 1999; 28: 864-871

[53] Leone J, Bhandari M, Adili A, McKenzie S, Moro JK, Dunlop RB; Predictors of early and late instability following conservative treatment of extra-articular distal radius fractures; Arch Orthop Trauma Surg 2004; 124: 38-41

necessarily lead to bad subjective or functional results[51,54,55]. Also in this study one female patient had a very good subjective and functional result with a palmar inclination of –30° despite a shortening of the rad ius by 9mm. (note: the patient decidedly refused both primary surgical management and an osteotomy which was suggested several times for correction). However, this only means that in some patients the correlation between the functional and the anatomical results cannot be confirmed. Among other things defective torsion positions of the distal radius fragment, which can reduce the resulting incongruence in the DRUJ, and/or variations in the form of the ulnar head [Caput ulnae] can be responsible for that. [24,52]

As a matter of principle an optimum result has to be aimed at for all patients, because one can never know in advance how well the individual patient tolerates what kind of defective position in the region of the wrist.[56]

Chung et al. point out that demographic and socio-economic factors have an influence on the results after surgical treatment of distal radial fractures. One year after the surgery they found a significant correlation between the age and income of the patient and the results of the treatment.[57]

Defects in the metaphysis lead to a shortening and thus incongruence in the distal radio-ulnar joint, while intra-articular steps in the joint cannot only be seen as pre-arthritic deformities but can also lead to restrictions of movement.[51,52] Measures like re-establishing the integrity of the joint surfaces and avoiding a shortening of the radius usually have more influence on the treatment result than defective positions of ulnar and palmar inclination. [2,22]

The three-column model of the wrist (in which the ulnar column facilitates the stability of the wrist and the transmission of force, while the intermedial column absorbs compression forces in the case of fractures[14]) helps to explain why more degenerative changes in the region of the TFCC occur with increasing age and why a shortening of the radius due to fracture affects the TFCC. Since in this case the ulna

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[54] Anzarut A, Johnson JA, Rowe BH, Lambert R, Blitz S, Majumdar SR; Radiologic and Patient-Reported Functional Outcomes in an Elderly Cohort With Conservatively Treated Distal Radius Fractures; J Hand Surg 2004; Vol 29A No.6 Nov 2004; 1121-1127

[55] Jaremko JL, Lambert RGW, Rowe BH, Johnson JA, Majumdar SR; Do radiographic indices of distal radius fracture reduction predict outcomes in older adults receiving conservative treatment?; Clinical radiology 2007; 62, 65-72

[56] Prommersberger KJ, Kalb K, van Schoonhoven J; Die fehlverheilte distale Radiusfraktur – Biomechanik und operative Behandlungsmöglichkeiten; Handchir Mikrochir Plast Chir 2007; 39: 9-18

[57] Chung KC, Kotsis SV, Kim HM; Predictors of Functional Outcomes After Surgical Treatment of Distal Radius Fractures; J Hand Surg 2007; 32A: 76-83

is too long from a functional point of view, more pressure is transferred via the TFCC.[58] Not only this increase in pressure but also an instability/incongruence in the region of the DRUJ or dysfunctions in the TFCC can play an (additional) role in causing ulno-carpal pain.[52]

Another common injury accompanying a distal radial fracture is an avulsion of the disc on the ulnar side. It often occurs simultaneously with a fracture of the Processus styloideus ulnae. Injuries in the region of the TFCC are also taken into account more and more often and thus arthroscopies to restore the affected structures are carried out at an early stage.[59,60]

With a conservative management of the injury about 5% of the patients develop reflex dystrophia. Its occurrence is facilitated by (repeated) repositioning.[47] Jakob et al. observed that a reflex dystrophia occurred in 4% of all patients even though no additional manipulation was carried out after the primary repositioning.[49] In the case of surgical management a reflex dystrophia occurred with about the same frequency.[44] According to Turner et al. pain syndromes after distal radial fractures occur with a frequency of 0.3-8%. However, their indication does not differentiate between reflex dystrophia, shoulder-arm syndrome and persisting pain.[61]

Compression syndromes of the median nerve [N. medianus], in particular carpal tunnel syndrome (CTS) are described in the case of conservative and also surgical management of a distal radial fracture[2,44]. However, carpal tunnel syndrome also occurs in up to 10% of the population without a previous trauma. CTS mainly affects middle-aged and elderly people, with women being three to four times as often affected than men.[62] This means that CTS mainly concerns elderly women, i.e. the same group of population that is mostly affected by distal radial fractures.

Thus it is absolutely possible that the CTS was already present (maybe unrecognized) some time before the radial fracture even though it is implicated to be a consequence of the fracture and seen as post-surgical CTS. The questions whether the trauma was the cause or trigger, whether an already existing CTS

[58] Lanz U; Der Ulnavorschub nach distalen Radiusfrakturen in „Handgelenksverletzungen“ Hrsg. Nigst H; Hippokrates 1988; 126-134

[59] Rikli DA, Babst R, Jupiter JB; Distale Radiusfraktur: neue Konzepte als Basis für die operative Therapie; Handchir Mikrochir Plast Chir 2007; 39:2-8

[60] Beyermann K, Krimmer H, Lanz U; TFCC-Läsionen Diagnostik und Therapie; Der Orthopäde 1999; 28: 891-898

[61] Turner RG, Faber KJ, Athwal GS; Complications of Distal Radius Fractures; Orthop Clin N Am 38 (2007) 217-228

[62] Assmus H; Nervenkompressionssyndrome, Diagnostik und Chirurgie ; Springer 2003

became noticeable through it or within what period of time one can speak of post-traumatic CTS remain unanswered.

More than half of the cases of distal radial fractures are still treated conservatively[22]. Nevertheless the number of fractures that are treated surgically increases among younger and also older patients. The possibilities range from closed repositioning with percutaneous wire fixation, percutaneous screw osteosynthesis and/or an external fixator to open repositioning with plate osteosynthesis from the palmar or dorsal side or any combination of these methods. In these cases fixed-angle plate systems[46,51] and a palmar surgical access are used increasingly.[44] Regarding the surgical management of distal radial fractures there are many recommendations and many treatment strategies are available. The necessity and advantages of the individual methods are evaluated in different ways.[22]

One of the advantages of surgical management is that the immobilization period is usually shorter, e.g. after osteosynthesis with plates the injury has to be immobilized until wound healing and only in cases of insufficient stability and accompanying soft tissue or ligament injuries for a period of up to four weeks[22]; another advantage is an early functional follow-up treatment. This can have a noticeable alleviating effect for the patients. However, the surgical management of the fracture also includes the whole range of risks involved in anaesthesia and surgical interventions.
Besides the complications already mentioned in the context of conservative treatment the postoperative complications include infections of bones or soft tissues, irritations and ruptures of tendons[2,44,51], excessive formation of scar tissue or dehiscence of the scar as well as implant failure like loosening, shifting, breaking or misalignment[51]. A dislocation of the fracture is also described after surgical intervention[44,56] but it occurs more rarely in stable osteosyntheses than in temporary stabilizations. [2,22]

Besides a conservative or surgical management of distal radial fractures various additional accompanying therapeutic approaches like physical therapy, occupational therapy, homeopathy, acupuncture, osteopathy etc. are hardly or not at all taken into account. Langenberg mentions that part of the patients (17.5%) that were assessed in a follow-up examination received physical therapy but he does not provide any additional information nor does he explain whether this factor was considered in any of the assessments.[48] Jakob et al. present an interesting view of physical therapy. They write: *“however [...] it should be considered in the analysis of the therapy success and in the comparison with the results of other studies that this evaluation looked at patients of advanced age where physical therapy measures or measures to promote power and mobility are more difficult to be applied than in younger patients.”*[49] This is the only sentence in which physical therapy is mentioned. Thus it is probable that such measures are not taken into account in any of the assessments. There is also no explanation of why physical therapy measures and techniques to increase power and mobility would be in general more difficult to be carried out in older patients. Usually such therapeutic measures cannot be applied easily in cases where one or several additional diseases or complaints are present. However, this can be age-related but it does not necessarily have to be.

## 5.3 Osteopathic treatment

Osteopathy is regarded as a method of treatment which is aimed at supporting the body to heal itself. Basically, its tenet is not only to treat a “problem X” but to look at and treat the body as an entity. To this end the practitioner can choose from a number of different treatment techniques and approaches.

If osteopathy actually is able to improve the self-healing forces of the body, this should also be noticeable in cases of bony fractures.

However, this study could not highlight a significant difference between the two groups of patients neither with regard to power nor with regard to the radiological criteria.

Also regarding the mobility in the rotation plane no significant difference between the two groups could be detected. Only the mobility in the sagittal and frontal planes after removal of the cast was significantly better in the osteopathy group. In addition, the patients in the osteopathy group indicated less pain.

During the immobilization phase complications like reflex dystrophia or carpal tunnel syndrome also occurred in the group of patients who received the additional osteopathic treatment. Due to the small number of patients in each group no conclusion can be drawn whether the frequency of the occurrence of such complications could be reduced through the application of osteopathy.

Descriptions of the application of the techniques used in this study (Balanced ligamentous tension techniques, BLT[35] and fascial unwinding[36]) are available, however a recognized biomechanical or neurological explanation model is still lacking.

Some biomechanical research results indicate a certain joint play[63], different states of tension of individual ligaments[64,65] or the intra-osseous membrane[8] and the guiding and bridling influence of the ligaments on the complex movements of the carpal bones[66]. Nevertheless, there is no evidence indicating that there is a balanced tension of these ligaments as explained by Carreiro (who describes the BLT according to Sutherland).

In addition, a contradiction can be found in Carreiro's description of BLT: On the one hand she says *"that when the wrist is flexed neither the dorsal ligaments are stretched nor the palmar ligaments are relaxed*[35]", on the other hand she explains that "*if a joint reaches the end of its range of movement the tensions in the ligaments increase*[35]*"*. And she says that during the positioning of a joint when applying BLT *"all tensions within the ligaments are reduced to an absolute minimum*[35]*."* It seems to be impossible to fulfill both claims simultaneously.

The description of the BLT further points out that after the fixed point is reached the body can effect the change through its inherent forces. However, it remains unclear what kind of change this is or could be and thus also how the body can achieve it.

In the field of neurology a possible explanation regarding the way BLT works can be found. Greenman writes:

> *„A dysfunction leads to neuroreflectory changes which cause mechanoreceptors and nociceptors to send out pathological afferent impulses. These are relayed in the spinal cord with the reflex pathways running locally at the segmental level*

[63] Klein P, Sommerfeld P; Biomechanik der menschlichen Gelenke; Urban und Fischer 2004
[64] DiTano O, Trumble TE, Tencer AF; Biomechanical function of the distal radioulnar and ulnocarpal wrist ligaments; J Hand Surg 2003; 28A(4): 622-7
[65] Weaver L, Tencer AF, Trumble TE; Tensions in the palmar ligaments of the wrist. I. The normal wrist; J Hand Surg 1994; 19A(3): 464-74
[66] Berger RA; The Anatomy of the Ligaments of the Wrist and Distal Radioulnar Joints; Clin Orthop Relat Res 2001 Feb; (383): 32-40

*and centrally via ascending and descending pathways. Faulty afferences lead to faulty efferences, [...]*
*Functional techniques can be defined as neuroreflectory techniques with the aim to reduce pathological afferences."*[67]

In this context the fact that Greenman refers to receptors in the muscles and not the ligaments has to be considered. Nevertheless, a similar kind of interconnection can be assumed for the ligaments, because also other authors indicate the interconnection between the neurological supply of ligaments and the resulting function: According to a study by Tomita et al. the nerve ends in a ligament follow a distinct pattern. This could be the background for a better understanding of the physiological and pathological function of the wrist and its neurological control. [68]

Osteopathy claims that every patient should be regarded as an entity. Thus every patient should receive an individual treatment tailored to his/her specific needs – even if the clinical picture seems to be the same. To create the best possible, i.e. most similar, preconditions to facilitate the comparison of the results only two approaches (BLT and fascial unwinding) were used in this paper. This method seemed to make sense even though it contradicts the above mentioned basic principle of osteopathy.

Despite the many unclarities regarding the way BLT and fascial unwinding work, it is astonishing that eleven of the 16 patients who received an osteopathic treatment reported different perceptions. In general the patients describe the treatment as comfortable.
Some patients described a throbbing or tingling sensation. This is often the case in the context of radial fractures but usually this sensation occurs at the beginning of the treatment and it stops at the end of the treatment. It can be that this sensation is directly linked with the osteopathic intervention.
Spontaneous descriptions by the patients were a feeling of "warmth" or "flowing" or even a sensation of "calming down". Liem[36] mentions similar sensations in his descriptions of fascial unwinding.

[67] Greenman, PE; Lehrbuch der Osteopathischen Medizin; Haug Verlag 2003; S 125
[68] Tomita K, Berger E, Berger RA, Kraisarin J, An K-N; Distribution of Nerve Endings in the Human Dorsal Radiocarpal Ligament; J Hand Surg 2007; 32A(4): 466-73

## 5.4 DASH, Krimmer-score and pain

The German version of the DASH questionnaire is used as a validated and standardized instrument to evaluate the overall function of the upper extremity.[69]

Even though the DASH questionnaire in general renders a good service it has been shown that some patients in this study were irritated by some of the questions. These questions included “difficult homework“ (e.g. washing walls, cleaning the floor), “work in the garden or yard“, “leisure time activities during which your arm, shoulder or hand is subject to push or pull“ (e.g. golf, hammering, tennis, etc), “leisure time activities during which you move your arm freely” (e.g. badminton, frisbee), “sexual activities” and “handling means of transportation (to get from one place to another)“[40]. The irritation arose because the patients would have deemed some of the questions “not relevant” but this answer was not listed among the possible answers. Thus the patients usually did not answer these questions at all or only after they had received an additional explanation by a physician or osteopath.

The strategy of “not answering” such questions can lead to the result that more than 10% of the questions are not answered, which means that the whole DASH questionnaire cannot be evaluated.

In the analysis of the DASH questionnaire the origin of the present problems is not taken into account. It can be that diseases or dysfunctions outside the upper extremity can influence the DASH score. It is also difficult if not impossible to differentiate and to make a statement regarding the wrist only if there are simultaneous problems in the shoulder and/or elbow.

In some cases therefore only little can be said with regard to the present local problem. In this context Gabl et al. talk about a limited local sensibility of the DASH questionnaire.[70] Ring et al. mention that in cases of radial fractures with depression or other conditions of the elbow and hand the DASH score is also correlated with pain anxiety.[71]

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[69] Jester A, Harth A, Wind G, Germann G, Sauerbier M; Ersetzt der Disability of Arm, Shoulder and Hand Questionnaire (DASH-Fragebogen) die Erfassung von Bewegungsausmaß und Kraft bei der Bewertung von Ergebnissen?; Handchir Mikrochir Plast Chir 2005; 37: 126-130

[70] Gabl M, Krappinger D, Arora R, Zimmermann R, Angermann P, Pechlaner S; Zur Akzeptanz der patientenbezogenen Bewertung der Handgelenkfunktion nach distaler Radiusfraktur (DRF); Handchir Mikrochir Plast Chir 2007; 39: 68-72

[71] Ring D, Kadzielski J, Fabian L, Zurakowski D, Malhotra LR, Jupiter JB; Self-Reported Upper Extremity Health Status Correlates with Depression; J Bone Joint Surgery 2006; 88A(9):1983-8

The mean value of the DASH score eight weeks after the injury shows clearly better results for the osteopathy group with a score of 37.24 points in comparison with the control group and its score of 51.84 points. However, no difference can be seen in the scores of the follow-up examination with 3.07 points for the osteopathy group and 3.34 points for the control group.

The results of the Krimmer score eight weeks after the injury are only marginally better for the osteopathy group than for the control group. The final results of this score in the follow-up examination show almost exclusively very good assessments (23 out of 25), which is rather unusual.

On the one hand the results were influenced in a positive way by the fact that in the period up to the follow-up examination three patients underwent surgery because of carpal tunnel syndrome of the affected wrist while one patient had a successful osteotomy to shorten the ulna, on the other hand a sample size of overall 32 patients only has limited significance. In addition, also the fact that seven patients did not come to the follow-up examination has to be taken into account. All seven of these patients were contacted by phone to find out why they had not come. Two of them explained that they felt the function of their hand was good. The other five patients could not be contacted successfully thus their results cannot be considered. It could be that the patients felt the result of the treatment was not satisfying and thus decided not to come to the follow-up examination.

Many authors in the literature describe in part quite varying results. Schneiders et al. report 90% excellent or good results according to the Dresdner score[2] after conservative management. Kramer et al. indicate 78% very good or good anatomical (according to the categories of Lidstrøm) and functional results but the percentage drops to 69% if the data of patients under the age of 15 are not included[1]. Langenberg uses the categories according to Lidstrøm in combination with a not specified subjective evaluation by the patients and describes 60-70% good results for conservatively treated distal radial fractures.[48] Kwasny et al. use the evaluation method according to Sarmiento and indicate 78% very good or good results for patients with type A fractures (AO classification) but only 50% for patients with type C fractures (for those cases that are conservatively treated).[47] Possible causes for this great variability include the application of the different evaluation and classification methods as well as differences in the patient samples (e.g. age and cause of injury)

In the control group the patients were asked by a physician about their subjective pain perception, while the patients in the osteopathy group were questioned by an osteopath before and after the osteopathic treatment. It could be noted that the subjective assessment by some of the patients depended on the person asking the question, with the factors profession (therapist/physician) and gender (male/female) playing a role in this context.
Some patients had the tendency to indicate more pain when they were asked by the female osteopath than when they were questioned by the male doctor. For instance, some female patients explained to the male doctor that they were free of complaints, while indicating values between 40 and 55 on the visual analogue scale (VAS) in the presence of the female osteopath. It is hard to imagine that with a VAS value of 50 points (maximum 100) these patients had no complaints.
Due to this fact it cannot be excluded that the VAS values of the patients in the osteopathy group are slightly too high in comparison with the values of the control group.
Nevertheless the VAS values of the osteopathy group show a more pronounced reduction of pain after each of the five treatments, i.e. by an average of about 10 units on the visual analogue scale. Since this clear and continuous reduction of pain became noticeable only in an intermediate calculation during the work on this paper, some of the related values that might have been of interest could not be collected or described separately without changing the structure of the paper. But it would have been interesting to find out whether the pain reduction was persistent or how long the pain reduction lasted or even what caused the pain to increase again and how did the patient perceive its intensity.
Whether the applied techniques really have a pain-reducing effect or whether it is the touch and the care for the patient that influence the subjective pain perception or whether there are other causes for the decrease in pain, cannot be said clearly.
It could be noticed that the patients of the osteopathy group took less analgesics in the week following the removal of the cast and that they had the tendency to indicate less pain during the past four weeks. Whether this effect has a direct causative relationship with the osteopathic treatment cannot be identified because many other

factors may play a role in this context (e.g. social circumstances; and also the small number of patients).

## 5.5 Power and mobility

Similar observations can be made regarding the measurements of muscle power. In all measurements of the injured side the results of the osteopathy group were by 19.6–39 .2N (2–4kp) better than those of the control group. The measurement of the injured side immediately after the removal of the cast showed a result of 33.4N (3.4kp) for the control group, which on average is 58% of the power of the osteopathy group with 56.9N (5.8kp). At the follow-up examination the control group had a power of 200.1N (20,4kp) which is about 84% of the power of the osteopathy group with 238.4N (24.3kp).

When the power of the injured side is compared with the other side (in percent) a difference of 10% between the dominant and the subdominant hand is taken into account. This difference can be found in the majority of the right-handed population. It is interesting, however, that this does not automatically apply to left-handed persons. Left-handed persons often do not show a difference in the grip power between the left and the right hand; sometimes the left hand is even weaker than the right hand. One reason for that could be that many objects that are used in daily life are designed for right-handed users so that left-handed persons use and thus exercise their right hand more often just like right-handed persons.[37] Therefore the ratio of the measured values is also indicated without the 10% correction in this paper.

The osteopathy group showed more power than the control group in all measurements, i.e. also in the comparison of the unaffected sides. Taking this into account one cannot suppose an improvement in power due to the osteopathic treatment.

The measurement of the active mobility immediately after the removal of the cast but also eight weeks later showed that the osteopathy group had a significantly better

mobility than the control group both in the sagittal plane and in the frontal plane, but not in the rotation plane. It is not clear why this was the case.
At the follow-up examination the osteopathy group had the same range of movement in all planes in comparison with the unaffected side. The control group had the same range of movement in the frontal plane, while in the sagittal plane and in the rotation plane the mobility was slightly less (about 6°) than on the not affected side.
The osteopathic treatment immediately after the removal of the cast increased the average range of movement by about 10° in the sagittal plane, by about 5° in the frontal plane and by about 15° in the rotation plane. This means that in the first two weeks after the removal of the cast the patients of the osteopathy group had a bigger range of movement from the beginning in the frontal and sagittal planes and after the osteopathic treatment also in the rotation plane than the patients in the control group.

Whether the patients of the osteopathy group also regained the full range of movement before the control group cannot be determined because no additional check-ups and thus no measurements were carried out in the time up to the follow-up examination. In addition, the patients were recommended to have a physical therapy or occupational therapy treatment after the eighth week. Since this decision can eventually only be made by the patient and since the treatment was not carried out at the Landesklinikum, a continuing monitoring in this respect was not possible.

## 5.6 Radiology

The unaffected other side was chosen as reference in this paper. The radiological parameter of the right and left wrist can be quite different in any individual and thus reduce the validity of an assertion.

The osteopathic treatment seemed to have no influence at all on the radiological parameters. No difference could be observed between the two groups with regard to callus formation. The analysis of the joint angles on the x-ray photographs also showed that the applied osteopathic techniques were not able to prevent a tilt in the sagittal plane or a shortening of the radius. The question whether this would be

different if the osteopathic treatment was not limited to two techniques only but include all possible osteopathic approaches and strategies cannot be answered with this paper.
Nevertheless, it has to be pointed out that the osteopathy group had a much worse starting value of the palmar inclination with –19.3° than the control group with –8.6°, while the values at the follow-up examination did not differ that much with –5.1° for the osteopathy group and –3.4° for the control grou p. It has to be pointed out that in the osteopathy group the palmar inclination achieved through repositioning was clearly better in the osteopathy group (10.6°) than in the control group (2.3°).
Also the ulnar variance showed that at the follow-up examination the osteopathy group had a larger ulnar protrusion with a mean value of –3.2mm than the control group with a mean value of –1.1mm. From the moment of injury until the follow-up examination the shortening of the radius increased by 1.4mm (from –1.8mm to –3.2mm) in the osteopathy group and by 1.1mm (from 0mm to –1.1mm) in the control group. Under this aspect there is practically no difference between the two groups.
The ulnar inclination of both groups did not differ much in the x-ray photographs taken immediately after the injury, after the reposition, at the final examination and follow-up examination.

The follow-up period of 13 months on average is too short to talk about a long-term monitoring. Some changes (like arthritis in the wrist) which may occur after distal radial fractures often only occur after a longer period of time. Whether the osteopathic treatment had effected some kind of change in this respect cannot be determined. However, since the osteopathic treatment had no influence on the radiological parameters, one cannot assume that it could prevent the occurrence of arthritic changes due to some kind of misalignment.

## 5.7 Osteopathy – quantifyable with scientific methods?

The osteopathic treatment is perceived as pleasant by the patients. It can achieve an improvement of mobility in the first weeks after the removal of the cast and probably can also facilitate a reduction of pain. However, it cannot achieve any measurable long-term improvement. Similar results are reported by Maciel et al.[72] who looked at active physical therapy after distal radial fractures and could not detect significant long-term changes in comparison with the control group.

In view of all this the question arises in how far osteopathy can be scientifically understood or measured. Assuming that osteopathy is not only a collection of techniques but a special way of approaching a patient with all his/her problems, desires and ideas, which has the aim of achieving the best possible balance between all those aspects, it is hard to imagine that osteopathy can somehow be proven or measured. Of course, certain individual techniques can be selected and "tested" (like in this study), but this does not correspond to the already described osteopathic philosophy of treatment. Then again it is difficult or only possible to a certain extent to compare results if patients are treated individually and thus probably with very different methods.

An interesting fact is that the principle to treat the human being as an entity is not new and can also be found in conventional medicine. Böhler, for instance, points out the entity of bones and the surrounding tissues (cf. p. 26).[30]

Also the question of when a bony fracture has "healed" can hardly be answered. From the point of view of conventional medicine it might be possible to say that a fracture has healed once the bone is solid and a further change can practically not be expected. From an osteopathic point of view one might say that a fracture has healed once the bone is solid and all tissues that are involved as well as the patient as a whole have regained a (relative) balance.

Since conventional medicine always is subject to economic interests and therefore takes or has to take factors like treatment costs into account, parameters like a shorter treatment period or a shorter immobilization period etc. are quite important. Just like mobility or power these parameters can be measured and described quite well. This is much more difficult when it comes to qualitative components and subjective well-being. Criteria like how smooth a movement is or how afraid a patient is of possible pain during the movement or maximum muscle tension or even how good the coordination of the structures that participate in the movement is and what the feeling or the movement of the patient is like can only hardly or not at all be

[72] Maciel JS, Taylor NF, McIlveen C; A randomised clinical trial of activity-focussed physiotherapy on patients with distal radius fractures; Arch Orthop Trauma Surg 2005; 125: 515-520

measured. If osteopathy had an effect on such qualitative criteria they could not be made visible.

In addition, the verbal description of perceptions is difficult for the patients and it is hard for anybody who needs to document these perceptions. One example is the doctors' descriptions of the pain perception of the patients, which was gathered in addition to the VAS assessment. These descriptions ranged from "clear pain (on movement)" via "diffuse pain", "moderate pain on movement", "massive pain" to "no significant pain", "mild complaints", "basically free of complaints", "subjectively free of complaints" and "residual pain in some movements" or "residual pain in the region of the fracture". These quotes show clearly how difficult it is to find the right words for subjective perceptions.

Based on these considerations further questions arise:

What criteria could describe qualitative and quantitative components sufficiently well? What would the result be if the osteopathic treatment was not limited to two techniques but was applied individually according to the osteopathic philosophy? How can the changes in the tissues that were perceived by eleven patients in the osteopathy group be explained? If it is really the BLT that is responsible for the pain reduction, how long does it last and how did it work? Is this pain relief as good as the effect of pain killers?

This paper can only provide a first insight into the possible application of osteopathy in the case of bone injuries or fractures in addition to conventional methods. In order to give more detailed explanations and to answer the questions that have arisen numerous other studies involving larger patient samples will be necessary.

# 6 Summary

An increasing number of patients resort to osteopathic treatments which can be applied with regard to numerous indications, also in the case of fractures.
This paper looked at the question whether patients benefit from osteopathic treatment applied during the immobilization period after distal radial fractures.

The study included 32 patients with fresh distal radial fractures and a minimum age of 45 years. All patients were treated conservatively, including repositioning under longitudinal traction, immobilization through a cast and repeated clinical and radiological check-ups as well as subsequent new repositioning and changes of the cast if necessary. The duration of immobilization ranged around 6 weeks. Half of the patients received additional osteopathic treatments on the days 1, 7, 14, 28 and 42 after the injury.
Ulnar and palmar inclination, ulnar variance and callus formation were chosen as radiological parameters. Measurement of gross power with a Jamar® dynamometer and measurements of the joint with a goniometer were carried out on both sides six and eight weeks after the injury and within the framework of a follow-up examination. The visual analogue scale was used to assess the patients' subjective pain perception. The instruments used to evaluate function eight weeks after the injury and at the follow-up examination were the DASH questionnaire (Disabilities of Arm Shoulder and Hand Instrument) and the Krimmer score.

It seemed that the osteopathic treatment did not have any influence on the radiological parameters since neither the ulnar or palmar inclination nor the ulnar variance or the callus formation showed a difference between the two groups. In both groups a dislocation after repositioning could be observed in some cases. In the osteopathy group two patients developed carpal tunnel syndrome and one patient suffered from reflex dystrophia. In the control group one patient developed carpal tunnel syndrome, one patient a 5mm diastasis of the distal radioulnar joint and another patient had to undergo an osteotomy to shorten the ulna.
Regarding the mesurement of power the osteopathy group always showed higher mean values than the control group. In the measurements six and eight weeks after

the fracture the osteopathy group even had significantly higher mean values. However, this also could be observed on the not affected side.

Within the first two weeks after the removal of the cast the patients who had received the osteopathic treatment showed a better mobility than the patients of the control group in the sagittal and frontal planes. However, it is not clear why such difference could not be observed in the rotation plane. At the follow-up examination the mobility was the same in both groups in all planes.

The osteopathic treatment had a direct pain-reducing effect. However, it was not assessed how long this effect lasted. In general, the patients of the osteopathy group stated to experience less pain and to take fewer painkillers. The majority of the patients who received osteopathic treatments described feelings of warmth, a sensation of flowing and the reduction of tension and pain.

Eight weeks after the injury the patients of the control group had a mean DASH value of 51.8 points and in three cases a good or very good Krimmer score. The patients of the osteopathy group had a mean DASH value of 37.2 points and in eight cases a good or very good Krimmer score.

At the follow-up examination the results of the DASH questionnaire and the Krimmer score were similar in both groups.

# 7 List of references & sources of pictures


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| Die verwendeten Röntgenbilder (Fig. 3, 7–9 und in der Bearbeitung von Fig. 1,2 und 4–6) wurden dankenswerter Weise vom Landesklinikum Thermenregion Baden zur Verfügung gestellt. | |

# 8 Annex

The principles of osteopathy

Still, the founder of osteopathy, emphasized the interrelation between the mobility of individual structures ("life is motion"), the circulation of all fluids in the body ("the rule of the artery") and the reciprocal influence of the body's structure and function ("the structure governs the function and the function forms the structure"). Basically, a good interaction of these components ("the body works as an entity") helps the body to achieve health through its self-regulating mechanisms ("self-healing mechanisms").[73]

Validity and reliability of the used materials/methods

According to Lefevre-Colau et al. the modified Kapandji index has a good validity and reliability in clinical practice. However, the authors also recommend further studies regarding its application in the field of hand surgery.[74]

Bellace et al. describe the Jamar® dynamometer for the measurement of gross power as very reliable and valid[75], while Mathiowetz talks about a good reliability and validity of the Jamar® dynamometers in comparison with the Rolyan® dynamometer.[76]

The not validated Krimmer and Cooney scores show a good correlation with the DASH questionnaire and can thus be replaced by the DASH according to Jester et al. No correlation could be found between the DASH and the range of motion. Only in a few diagnoses a small correlation could be observed between the DASH and power.[69]

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According to a study by Westphal the German version of the DASH questionnaire is an appropriate means to find restrictions of mobility in patients with distal radial fractures.[77] Beaton et al. found out that the DASH is valid and reliable to assess disturbed functions in the region of the proximal and also distal upper extremity.[78]

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