‘Broken collarbone, new design for proper alignment’

January 13

2011

[A bachelor assignment by Annemarie Tibbe, s0117129]

[Bachelor Assignment IDE / BMT, University of Twente]

‘Broken collarbone, new design for proper alignment’

Author:
Annemarie Tibbe
S0117129
IDE
13-01-‘11
University of Twente

Andre de Boer
Bart Verkerke
Edsko Hekman

Abstract

In this report a new design solution for properly aligning a fractured clavicle is realized.

The objective of the assignment was;
'To design a solution for properly aligning a fractured clavicle.'

Due to current methods of repairing a fractured clavicle people suffer from problems later on in life. The fractured clavicle leaves a bump because the two bone parts are not aligned properly. To verify that this causes problems later on, this has been researched in this Bachelor Assignment. The first part is the theoretical research part. The collarbone has been evaluated in general and there was research on the current methods of repairing. The steps of action taken after breaking one have also been looked at. To confirm that there is a problem there has been talked to experts like physiotherapists and traumatology surgeons, about their experiences. It became clear that there is no direct need for an internal solution for a fractured clavicle. This conclusion has resulted in designing external solutions in the second part of the assignment.

The second part describes the design process, aiming at designing a product that properly tries to align a broken collarbone externally. To support the communication with users and experts, two designs were tested with a prototype.

The conclusion of the report is that the most feasible option to better align a fractured clavicle externally is to pull the injured shoulder backwards. It turns out not to be possible to align a fractured clavicle from the outside, but some progress can be achieved by improving the position of the shoulder.

Table of contents

1. Assignment

1.1. Subject

The subject of this Bachelor Assignment is: 'Fractured clavicle, new design for proper alignment.'

Assignment description

It has been said that people with broken collarbones experience pain or other issues later on in their life. This might be due to the current methods of repairing the injury. For instance when a fracture is not too severe, rest is the common cure at this moment. The collarbone grows together but leaves a bump.

Goal of the project was to create a new design for realigning a fractured clavicle.

The next questions functioned as guidelines for this assignment:

1.2. Guiding questions:

Research part:

1) *What types of collarbone fractures occur?*
    - How severe are the injuries?
    - What are the main causes?
    - What can be said on the subjects who suffer these injuries? (age, sex)
    - How are the fractures categorized?

2) *What are the present methods of treatment?*
    - Summon and define the different methods for repairing a broken collarbone.
    - Give the pro's en cons per method.

3) *Do people suffer later on in life from a previous collarbone fracture?*
    - Interview experts (traumatology, physiotherapists) with experience on the subject.
        - Do patients ever come back after a previous injury?
        - What would you like to see improved?
    - Study, literature on the topic.

4) *Evaluate what the best suitable group is for a new design solution.*
    - Who will benefit the most in comparison with current methods of treatment?

Design part:

5) *Come up with new design solutions for the chosen group.*
    - Make a problem analysis and define objectives.
    - Define main and sub functions.
    - Make a schedule of requirements.
    - Brainstorm and sketching.

- Look at different materials and methods.
- Set apart at least one design idea.
- Finish with a prototype or model.

6) *What is the conclusion?*
   - Check for feedback on the model with experts.
   - Conclusions and recommendations.

1.3. Approach

The assignment started with a short introduction on the clavicle. The bone's functions, structure and classification were looked at. After that there has been be an explanation about bone fractures in general. Then after a short part about the general bone healing process it was specifically focused on fractured clavicles (question 1). From a combination of expert input and research material it has become clear what types of fractures occur, with what incidence and to whom.

The current methods were reviewed and statements could be made to answer research question 2; 'What are the present methods of treatment?'

By talking to experts in the field, like a traumatologist and a physiotherapist, real life experiences and advice were taken into consideration for question 3, about the outcome of treatment methods. It became clear that there is a problem with patients coming back after previous treatments. Also the personal opinion of the experts on improvement of the subject has been noted.

In the design part of the assignment the chosen method (following from the evaluation in question 4) has been further investigated before coming up with one or more new design solutions. A requirements list was made and several designs were created. One of the designs was selected and made into a prototype to get feedback from experts who were included in the process. Finally the design was evaluated.

2. Introduction

2.1. An introduction to the clavicle

The clavicle, or collarbone, is a slender, doubly curved bone that makes up part of the shoulder girdle (see figure 1, 2). Its name comes from the Latin word for 'little key', because of the rotating movement the bone makes when you lift an arm. The clavicle connects the arm to the body between the breastbone (sternum) and shoulder blade (scapula).

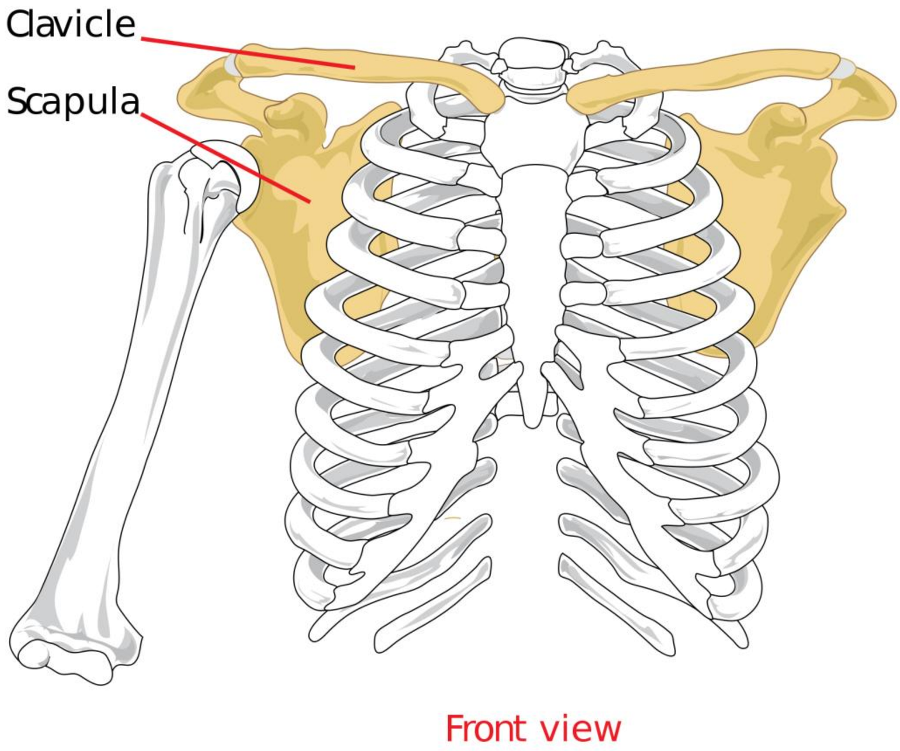


Figure 1; Clavicle, front view

Functions of the clavicle:

- anchoring muscles
- act as brace; hold the arm and scapula away from the thorax (upper body)
- transfer impacts from the arm to the axial skeleton
- cover important underlying structures

Collarbones are likely to fracture; approximately 4 to 5% of all fractures in adults concern the collarbone according to the Arnhem medical centre information guide.[1]
Because of their curved shape, they almost always collapse outwards. If they were to collapse inwards, bone splinters would damage the arteries below.

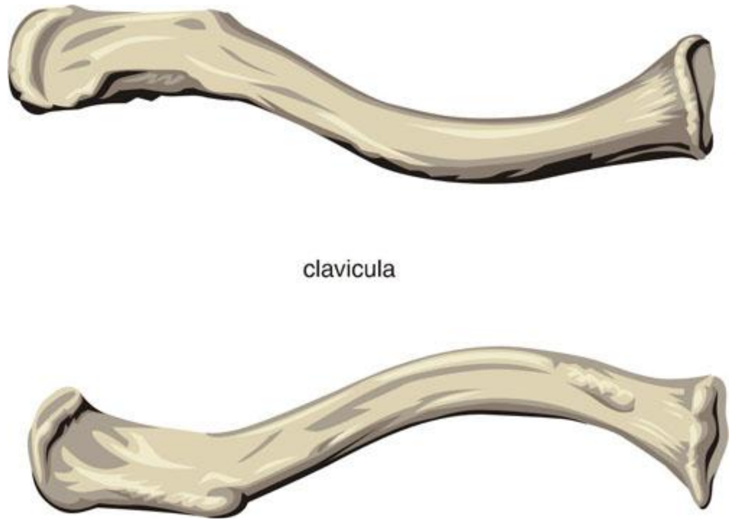


Figure 2; Clavicle curves, top view, bottom view.

To emphasize the difficult location of the clavicle in the body when fractured there needs to be an understanding of the surrounding and underlying tissue and muscles. Three muscles originate on the clavicle, and 3 muscles insert on the clavicle. The muscles that take their origin from the clavicle are the sternohyoid, the pectoralis major, and the deltoid. The muscles that insert on the clavicle are the sternocleidomastoid, the subclavius, and the trapezius. These muscles become deforming forces, for example as in figure 3 on the clavicle when it fractures. Many other important structures are in extremely close contact with the clavicle and are thus subject to injury with clavicle fractures. The subclavian artery and vein are both in close proximity to the middle portion of the clavicle. Additionally, the brachial plexus also passes behind the clavicle posterolateral to the subclavian vessels and is at risk. The subclavius muscle lies between the clavicle and these neurovascular structures, and it is believed to prevent more frequent damage to these structures. Injuries to the apices of the lung can also happen.[2]

To understand the movement the clavicle bone makes, see picture 4[3]. It moves with every movement of the arm.

A) With full overhead elevation, the clavicle rises 35 degrees.
B) With adduction and extension, the clavicle displaces anteriorly and posteriorly 35 degrees.
C) The clavicle rotates on its long axis 45 degrees as the arm is elevated to the full overhead position.

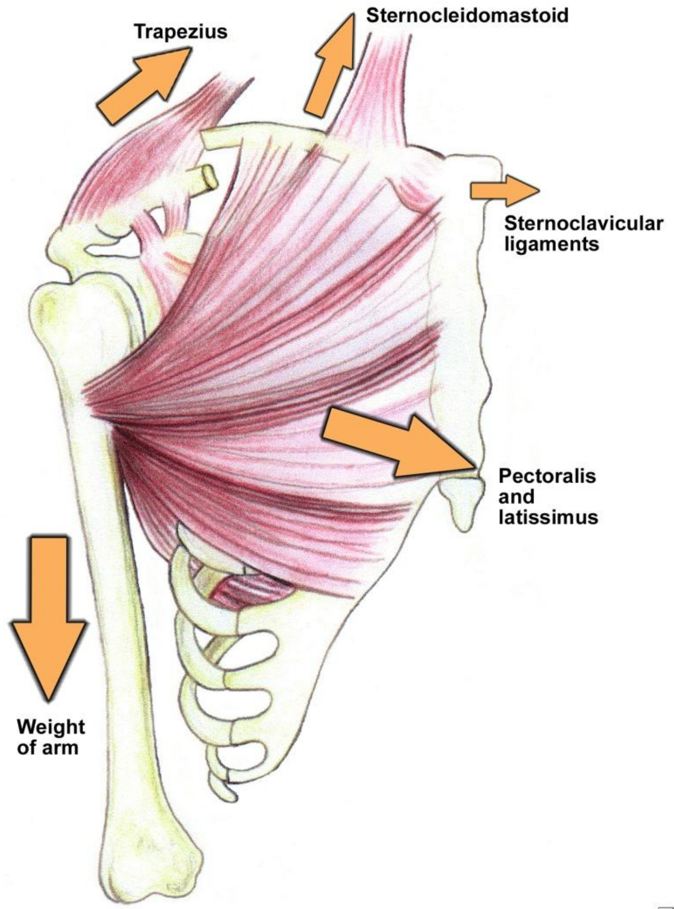


Figure 3; Example of deforming forces on a fractured clavicle

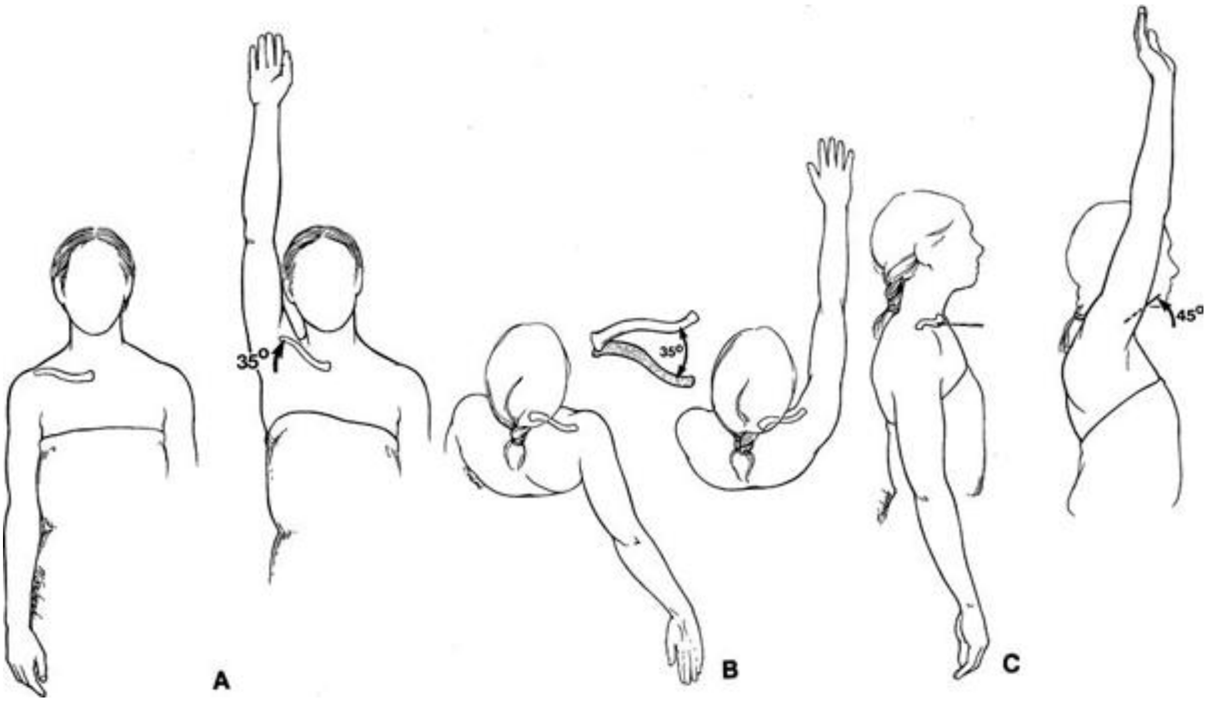


Figure 4; Motions of the clavicle and the sternoclavicular joint

2.2. Bone classification

The clavicles belong to the so called appendicular group of bones. This means that it belongs to the system of motion. Most bones can be classified as either long, short, flat or irregular. The clavicle is classified as a 'long' bone, even though it is not very long, but because of its structure.

2.3. Basic bone structure

All bones on the outside have bone markings of some kind. They show projections from muscle attachment stresses and depressions for nerves and blood vessels. Every bone has a dense layer on the outside called 'compact bone'. Internal to this is 'spongy bone'. The spaces in the spongy bone are filled with red or yellow bone marrow.

Despite being classified as a long bone, the clavicle unlike all others, does not have bone marrow and thus is not involved in the production of red blood cells. The clavicle consists of spongy tissue (cancellous tissue), enveloped by a compact layer, which is much thicker in the intermediate part than at the extremities of the bone.

2.4. Bone fractures

Even though bones are flexible and strong, they can fracture. When this happens, the fracture can be classified in different ways.
Basic classification of fractures[4]:
1) Position; nondisplaced/displaced fracture
    In a nondisplaced fracture, the bone fragments are all still aligned as before.
2) Completeness of fracture; complete/incomplete
    The bone can be broken entirely through, or incomplete.
3) Orientation relative to the long axis of the bone; linear/transverse
4) Penetration of the skin; open/closed fracture

2.5. The healing stages of a bone fracture

Most fractures are treated with reduction, the realignment of the broken bone ends. If this can be done by hand, it is a closed reduction. If this requires surgery, it is called an open reduction.

There are 3 main stages of bone repair in case of a fracture[4]:
1) Reactive phase
    - A hematoma forms
2) Reparative phase
    - Fibro cartilaginous callus forms (after a few days)
    - Bony callus forms (1 week)
3) Remodeling phase
    - Bone remodeling occurs (continuing for several months after fracture)

2.6. Clavicle classification

The most used classification system for fractured clavicles has always been the Allman system[5]. This system divides the clavicle into thirds. The system has since been revised by Neer and is being used nowadays as follows:

- Group I - Fracture of middle third
- Group II - Fracture of the distal third
    - Type I - Minimally displaced/interligamentous
    - Type II - Displaced due to fracture medial to the coracoclavicular ligaments
        - IIA - Both the conoid and trapezoid remain attached to distal fragment
        - IIB - Either the conoid is torn or both the conoid and trapezoid are torn
    - Type III - Fractures involving articular surface
    - Type IV - Ligaments intact to the periosteum with displacement of the proximal fragment
    - Type V - Comminuted
- Group III - Fracture of the proximal third
    - Type I - Minimal displacement
    - Type II - Displaced
    - Type III - Intraarticular
    - Type IV - Epiphyseal separation (observed in patients aged 25 y and younger)
    - Type V – Comminuted

2.7. The incidence of fractures of the clavicle

There has been much research on broken collarbones. According to Charles F. Preston, and Kenneth A. Egol[6], clavicle fractures can represent up to 12% of all fractures and between 44% and 66% of all shoulder fractures. Approximately two-thirds of the clavicle fractures are midshaft fractures.
According to C.M. Robinson[7] the greatest group that fractures a clavicle is males between 13 and 20. He researched 1000 patients who came in with a fractured clavicle.

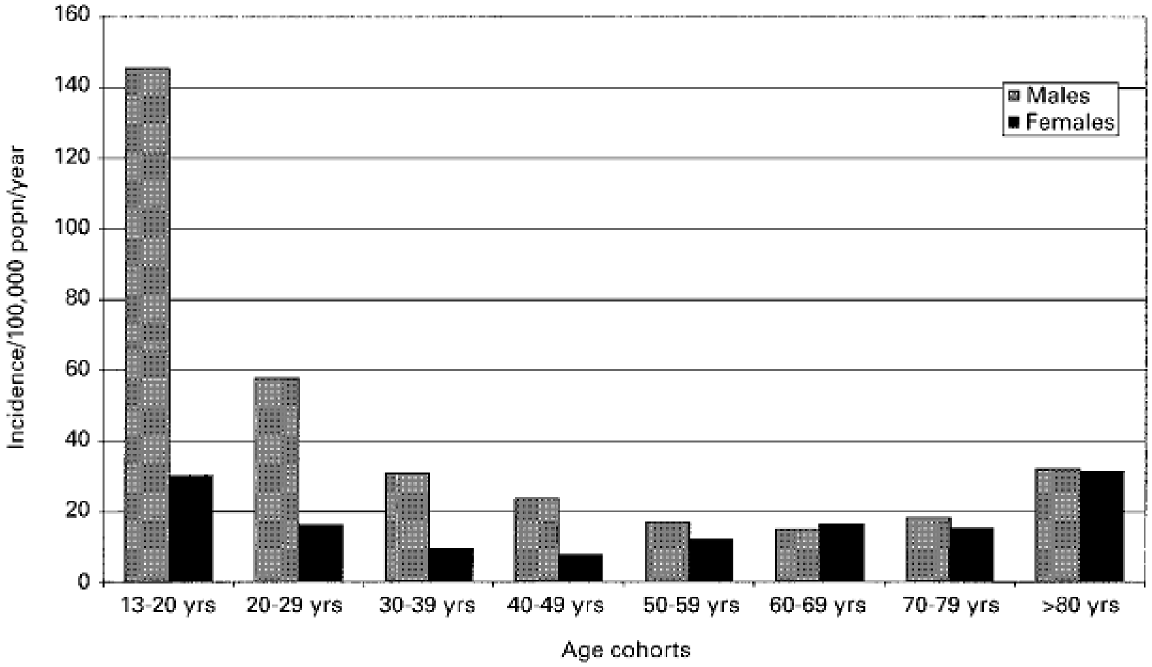


Figure 5; Fracture incidence in relation to age and gender cohorts.

From figure 5 it becomes clear that fractures remain constant in females, in contradiction to males. The mean age for men and woman is respectively 29.2 and 45 years.
Also according to C.M. Robinson, sport was the most common cause of fracture in the young, with a mean age of 21.2. Fractures due to simple falls had a mean age of 46.3.

In figure 6 the so-called 'Mechanisms' of injury are set out for the 1000 people with fractured clavicles from his experiment.

Mechanism	Number	Mean age in yr (range)	Male	Female	M:F ratio*
Simple fall	309	46.3 (13 to 96)	186	123	1.5:1
Fall from a height	108	34.5 (13 to 94)	68	40	1.7:1
Sport	234	21.2 (13 to 74)	204	30	6.8:1
RTA	272	30.1 (13 to 85)	208	64	3.3:1
Direct violence	46	31.9 (13 to 83)	36	10	3.6:1
Other	31	30.9 (13 to 85)	18	13	1.4:1
Total	1000	33.6 (13 to 96)	720	280	2.6:1

* male-to-female ratio

Figure 6; Mechanism of injury in 1000 fractures.

(RTA = Road Traffic Accidents)

From figure 7 it becomes clear that men are significantly more likely to fracture a clavicle. The male / female ratio is 2.6 to 1. The most common cause was a simple fall.

There has also been a lot of research on the subject on the type of clavicle fractures that occur. C.M. Robinson and the Royal Infirmary of Edinburgh Scotland developed a new classification system based on radiological reviews of the injuries. This system provides good insight because of the visual representation. Figure 8 presents an overview of the classification.
The new classification works with three different areas; diaphysis (type 1), medial (type 2) and lateral (type 3) ends. Besides that, the fractures were also divided into subgroups A and B, depending on the amount of displacement of major fragments. Then there was also division between intra- and extra-articular and on presence of angulation.

Fracture subtypes	**Number of fractures (% of popn)**	**Incidence (/100 000 popn/year)**	**Mean age (yr; range)**	**Male**	**Female**	**M:F ratio***
1A1	17 (*1.7*)	0.5	34.1 (15 to 78)	15	2	7.5:1
1A2	6 (*0.6*)	0.17	39.6 (14 to 67)	3	3	1.0:1
1B1	2 (*0.2*)	0.06	20.5 (13 to 67)	2	0	2.0:0
1B2	3 (*0.3*)	0.09	38.0 (14 to 87)	2	1	2.0:1
All type 1	28 (*2.8*)	0.82	37.2 (13 to 78)	22	6	3.7:1
2A1	54 (*5.4*)	1.57	27.8 (13 to 89)	42	12	3.5:1
2A2	135 (*13.5*)	3.93	19.0 (13 to 45)	109	26	4.2:1
2B1	375 (*37.5*)	10.93	31.1 (13 to 96)	273	102	2.7:1
2B2	128 (*12.8*)	3.73	35.1 (13 to 89)	105	23	4.6:1
All type 2	692 (*69.2*)	20.17	29.3 (13 to 96)	529	163	3.3:1
3A1	162 (*16.2*)	4.72	46.7 (14 to 95)	92	70	1.3:1
3A2	19 (*1.9*)	0.55	48.7 (15 to 95)	9	10	0.9:1
3B1	85 (*8.5*)	2.48	43.6 (13 to 94)	61	24	2.5:1
3B2	14 (*1.4*)	0.41	49.2 (19 to 84)	7	7	1.0:1
All type 3	280 (*28.0*)	8.16	45.3 (13 to 95)	169	111	1.5:1
Total population	1000	29.14	33.6 (13 to 96)	720	280	2.6:1

* male-to-female ratio

Figure 7; Details of fracture subgroups.

In figure 7 it can be seen that approximately 70% of all fractures are midsection fractures. The fracture type that is the least common is type 1, fractures on the proximal side of the collarbone. Again it becomes clear that men are more likely to break a collarbone. In some types of fractures the male / female ratio is as high as 4.6 to 1.

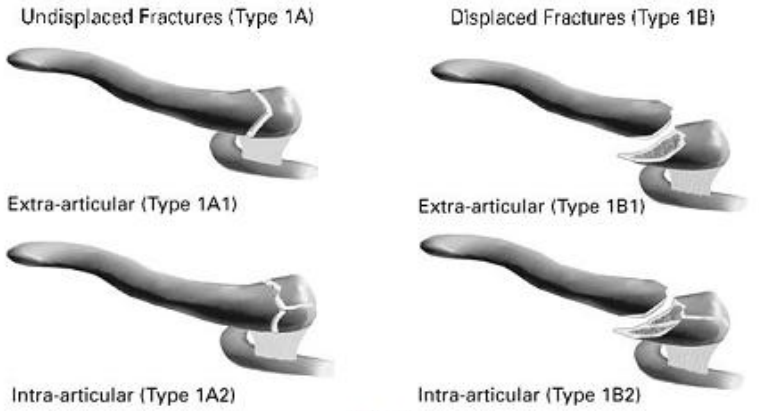


Fig. 1a

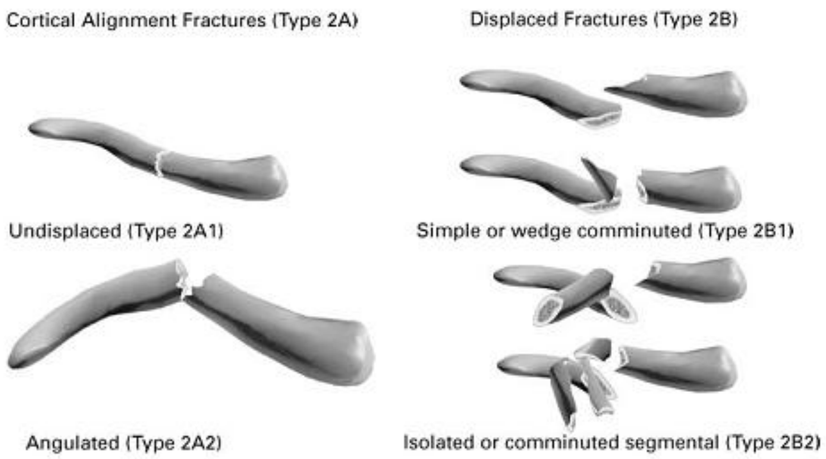


Fig. 1b

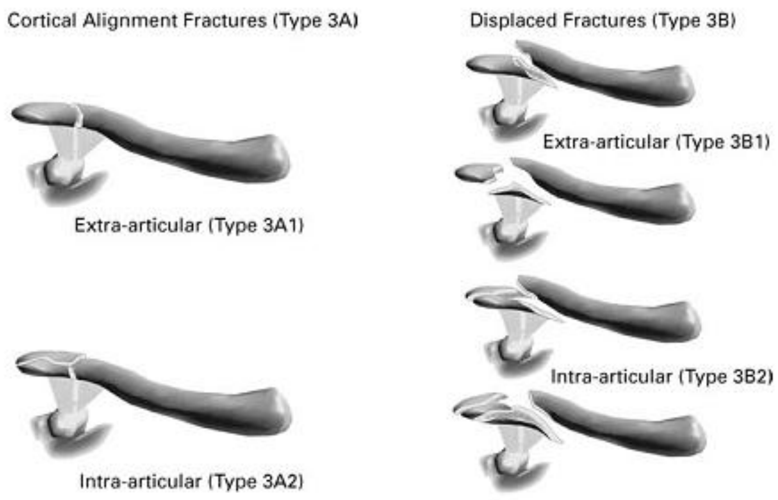


Fig. 1c

Figure 8; Diagram of type-1 (a), type-2 (b) and type-3 (c) clavicular fractures.

From the same research it turned out that type 3 fractures mostly happen in relatively simple falls (50%+), type 2 mostly during sports, and type 1 mostly in a simple fall or a traffic accident.

3. Repairing a fractured clavicle

3.1. Methods of repairing a fractured clavicle

There are two main treatment options for repairing a fractured clavicle;

1) Osteosynthesis; A surgical procedure that stabilizes and joins the ends of fractured bones by mechanical devices such as metal plates, pins, rods, wires or screws.
2) Conservative approach, rest the arm in a sling for about 6 weeks.

Option 1, osteosynthesis

After the accident, the patient may come in for an x-ray. Different hospitals use different indications for deciding whether to operate or treat conservatively. In the Netherlands for example, according to Dr van Walsum[8], the general guidelines are as follows:

Indications for surgery:

- Open fracture, or multiple fractures fracture.
- Polytrauma, a multiple injured patient, requires surgery for other injuries, so the collarbone is stabilized surgically immediately to benefit overall survival chances.
- Occupational requirements, i.e. models, professional athletes.
- The displacement horizontally is too large; 25+ mm shortening of the clavicle.
- The displacement vertically is too large; more than one clavicle-width between two parts divided.
- Underlying tissue may have been damaged.
- Symptomatic nonunion, the bone still has not healed after weeks.

Depending on the type of fracture there are a number of methods that can be used for repairing the clavicle. Some examples of recent methods and new developments are:

A) Pin or plate.


Figure 9; Acumed[9] Locking clavicle plate system, Rockwood Clavicle Pin[10]

In the MST Enschede, almost only plates are being used. Because of the wide variety of different sizes and shapes available, a fit is almost always guaranteed. If a patient doesn't find any discomfort from the plate, removal is even not necessary. A plate like the Acumed locking clavicle plate (figure 9) can be used for most fractures in the middle third. The use of a pin is minimal, because of the lack of stability it provides to the fracture.

B) Clavicle hook plate

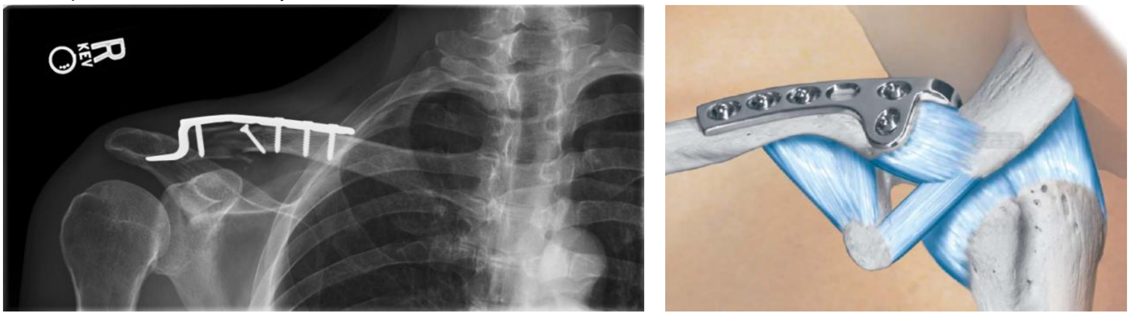


Figure 10; Synthes clavicle hook plate[11]

A clavicle hook plate (figure 10) is used for lateral clavicle fractures or acromioclavicular dislocations. The hook provides the additional support the fracture needs.

C) Kirshner wire

Figure 11; Kirshner wire, attached to the scapula

The K-wire (figure 11) can be inserted through the skin into the bone. Disadvantage is the minimal amount of support to the fracture. They can be fixed intramedulary in the clavicle if the fracture is small. A more common application is temporary fixation during surgery.

D) Claviculectomy or partial resection

Figure 12; partial resection of the clavicle

A claviculectomy or a partial resection (figure 12) is mostly performed when there is cancer involved. In this case no other option remains but to remove a part or the entire clavicle. Patients are perfectly capable to live without a clavicle, but off course arm and shoulder movement is drastically reduced and problems may occur later on with damaged nerves or muscles.

E) Sonoma CRx Clavicle Fracture Repair Device[12]

Figure 13; SonomaCRx, with WaviBody technology, that forms to the curve of the clavicle

The Sonoma CRx (figure 13) is a new device that is not (yet?) being used in surgery. The idea is to present a least invasive solution in order to decrease recovery time and pain. The device is intramedulary placed and requires only a minimal amount of incisions.
After checking the MST Enschede it turns out that this is not yet in use in the Netherlands, but it certainly appeals to the curiosity.

Then option 2, a conservative approach. About 95 % of all clavicle fractures are treated nonoperatively.

If all the surgical indications are not valid, the patient will be treated conservatively. This normally means wearing the arm in a sling for about 6 weeks. During this period the patient can receive physiotherapy to keep moving the arm.

Different types of existing slings (for example from Omnimed[9]) have been evaluated critically by a team of physiotherapists[12].
NB: All advantages are given by the company itself.

1)

Figure 14; Clavicle fracture sling 1

Indications:

- *Fractures of the clavicles*
- *Capsular ligament injuries in the area of the acromio-clavicular joint*
- *Sternal subluxation/luxation*

Features:

- *Textile base material with padded shoulder caps, connected to a dorsal pad with straps*
- *Fastening with Velcro D-ring strap*

Advantages:

- *No pressure on the injured part of the collarbone*
- *Eudermic, breathable material*

According to the experts:
'This is the preferred choice. The pressure on the shoulders is equally divided, and the posture is corrected from a stabile midpoint on the back. Range of motion is being kept very high, which is important during the healing process. Also the pressure is not directly on the clavicle, see figure 14.'

To emphasize the importance of divided pressure, figure 15 shows a similar example that is not preferred. Pressure here is not spread over the entire shoulder, therefore causing pain on the fracture.

Figure 15; Clavicle fracture sling 2

2)

Figure 16; Clavicle fracture sling 3

Indications:

- *Post-traumatic after shoulder contusion*
- *Post-operative immobilization*
- *Inflammable conditions in the shoulder area*

Features:

- *Stable straps for positioning the arm in 2 slings*
- *Length adjustable with clasps*

Advantages:

- *Quick and easy application*
- *Fashionable appearance*

Expert on 2:

'The brace in figure 16 immobilizes you too much. Recovery is too passive, like with an ordinary sling. Besides that it gives pressure on the collarbone, which would be very uncomfortable or even painfully.'

3)

Figure 17; Clavicle fracture sling 4

Indications:

- *Conservative treatment of fractures of the proximal humerus and the scapula*
- *Post-traumatic after contusion/luxation*
- *Post-operative after shoulder surgery*

Features:

- *Stocking with shoulder cap, connected with padded straps for fixation of the thorax*
- *Velcro fasteners*
- *Separate Velcro elements for securing the arm's positions*

Advantages:

- *Eudermic and breathable material*
- *Quick application and removal*
-

Expert on 3:
'Too immobilizing. This might even give you a so called 'frozen shoulder', a condition in which the shoulder capsule becomes stiff and inflamed, restricting motion and causing chronic pain.'

4)

Figure 18; Clavicle brace

Indications:

- *Faulty forward shoulder and upper back posture*
- *Post clavicle fracture*
- *Internal rotation of shoulder*

Features:

- *Lightweight*
- *Helps keep a good posture and pulls the shoulders back.*
- *Two straps attach in front of the body*

Advantages:

- *Tension on the straps can be easily adjusted in the front to provide the appropriate corrective adjustments.*
- *The waist strap provides mild abdominal support that helps redirect stress away from the clavicle/upper back for a more normalized posture.*
-

Expert on 4:

‘We wonder how good that will stay in position. Depending on the shape of the patient this might work, but more as a posture corrector.’

3.2 Outcome of a repaired clavicle

After looking at the incidence of a clavicle fracture and the methods used to repair one, the outcome of the repair action was viewed by interviewing experts and studying literature.

First the nonoperative treatment;
According to the previously mentioned research of C.M. Robinson, in figure 19, 89% of all fractures treated conservatively heals uneventfully. About 6% of all fractures required surgery later on. This research does not look at actual statistics concerning range of motion or strength in the injured shoulder and might give the impression that 89% actually heals uncomplicated and without further complaints later on.

Subtypes	Uncomplicated fracture union	Delayed union	Nonunion treated non-operatively	Nonunion treated operatively	Other surgery*	Refracture
1A1	16 (*94.1*)	0	0	0	1 BP (*5.9*)	0
1A2	6 (*100*)	0	0	0	0	0
1B1	2 (*100*)	0	0	0	0	0
1B2	3 (*100*)	0	0	0	0	0
All type 1	27 (*96.4*)	0	0	0	1 (*3.6*)	0
2A1	52 (*96.3*)	0	0	0	0	2 (*3.7*)
2A2	123 (*91.1*)	0	0	0	7 BP, 2 SC (*6.7*)	3 (*2.2*)
2B1	341 (*90.9*)	8 (*2.1*)	1 (*0.3*)	16 (*4.3*)	1 SC, 2 OF, 2 BP (*1.3*)	4 (*1.1*)
2B2	104 (*81.3*)	8 (*6.3*)	0	12 (*9.4*)	2 BP (*1.6*)	2 (*1.6*)
All type 2	620 (*89.6*)	16 (*2.3*)	1 (*0.2*)	28 (*4.1*)	16 (*2.3*)	11 (*1.6*)
3A1	160 (*98.8*)	0	0	1 (*0.6*)	0	1 (*0.6*)
3A2	17 (*89.5*)	0	0	0	2 OA (*10.5*)	0
3B1	61 (*71.8*)	10 (*11.8*)	7 (*8.2*)	6 (*7.1*)	0	1 (*1.2*)
3B2	5 (*35.7*)	1 (*7.1*)	2 (*14.3*)	3 (*21.4*)	3 OA (*21.4*)	0
All type 3	243 (*86.8*)	11 (*3.9*)	9 (*3.2*)	10 (*3.6*)	5 (*1.8*)	2 (*0.7*)
Total population	890 (*89*)	27 (*2.7*)	10 (*1.0*)	38 (*3.8*)	22 (*2.2*)	13 (*1.3*)

* BP, surgery for bony prominence; SC, surgery for skin compromise; OF, surgery for open fracture; OA, surgery for symptomatic osteoarthritis of the acromioclavicular joint

Figure 19; Outcome in the fracture subgroups, by number and percentage

In 2006, McKee and colleagues made a report on the functional out-come of healed displaced midshaft clavicle fractures. The team reported on the results of 30 healed displaced clavicle fractures at an average of 55 months. In this study, Constant and DASH scores were measured, as was objective strength testing of the effected shoulder.[14,15]

The Constant score (short for Relative Constant-Murley Shoulder Score) is the most commonly used measurement for assessing the outcome of treatment of a shoulder disorder. The score includes a pain score, a functional assessment, range of motion and strength measures. Both the right and left shoulder are evaluated to compare. The two subjective variables pain and ADL (Activities of Daily Life) represent a total maximum of 35 points. The objective variables range of motion and strength give 65 points. Recommendations of the ESSES[16] can be found at www.shoulderdoc.co.uk. This site also provides an accurate online Constant Score calculator.

The DASH score[17] (Disabilities of the Arm, Shoulder and Hand), is a thirty-item, questionnaire, designed to measure function and symptoms in people with any upper limb disorders. The score was developed by the American Academy of Orthopedic Surgeons (AAOS) to provide a single reliable instrument for clinicians and researchers to assess joints.

In the McKee research, the range of motion of the injured shoulder was similar to the other side. However, the injured shoulder had strength and endurance scores 60% to 80% in various planes of motion when compared to the opposite side. The Constant and DASH scores were significantly worse than for the other shoulder, signifying a relative disability in the clavicle fractured shoulder.

Andersen[18] et all, performed a randomized study evaluating a sling versus a figure-of-eight bandage to treat clavicle fractures. The sling was maintained until pain allowed it to be removed and the figure-of-eight bandage was worn for 3 weeks. The team reported on 61 patients that followed-up from the initial study group of 79.
They found no difference in union rate or time to union, but there was a significant increase in dissatisfaction in the patients treated in a figure-of-eight bandage.
This proves that directly after the fracture, a sling and preferably not a figure-of-eight sling, can be used. It will be with later measures that a significant decrease in strength can be found, thus proving that a sling conservative treatment will cause problems later on.

Physiotherapists also see a lot of patients with shoulder complaints. Usually about once a week, the Polman clinic in Enschede[13] sees a patient with vague complaints that later on can be addressed to a previously broken collarbone. Time in between the actual fracturing and the complaints can be more than ten years. Most seen complaints are numbness in the fingers, a reduced strength in the arm, a constrained ability to move the shoulder or a tingling sensation in the arm or hand.

After the first initial examination it turns out more and more frequently that the patient had a previous conservatively treated collarbone injury.

According to the Polman physiotherapy team, there is a definite need for improvement in the early stages after the accident, to prevent all these complaints later on. Most patients receive a regular sling for about six weeks. This sling constrains the arm movement and does not put the shoulder in the right place. Tape is a good alternative, but only if they have started taping the shoulder within a week after the accident. It is believed that the collarbone will then heal with rest and exercise to keep the arm mobile.
Because of the position of the collarbone in the standard sling method, the bone segments grow slightly over each other. This causes a shortening in the bone, with the typical slightly visible bump that people keep after healing. Nowadays, the slight shortening of the bone turns out to be a potential problem causer later on in life.

Concerning the operational methods of healing a fractured clavicle;
In 1999, Shen and colleagues reported on plating for displaced midclavicular fractures.[19] The team plated all displaced fractures presented to their institution. The study included 232 fractures that underwent a mixture of plating techniques dependent on the fracture characteristics. The union rate was 97% with a single deep infection and four superficial infections. All patients were followed-up with a phone interview to document any residual symptoms and their overall satisfaction rate. No patients had a perceived deformity or deficit in strength or range of motion, and the satisfaction rate with the procedure was 94%.

More recently, a randomized clinical trial comparing nonoperative treatment with plate fixation of displaced midshaft clavicle fractures was performed. 111 of the 132 patients randomized completed the one year follow-up. There were 62 patients in the plate group and 49 patients in the sling group. Outcome measures included radiographic union, Constant Shoulder Scores, DASH scores, and an overall satisfaction survey.
The mean time to union was significantly improved in the operative group as was the nonunion rate (3% vs 15%). The Constant scores were significantly superior in the operative group at all time points utilized in the study. The DASH scores were also significantly superior in the operative group[20].

3.3 Conclusion

The first part of the assignment included answers to the main questions for the research part:

Research part:
1) What types of collarbone fractures occur?

- How severe are the injuries?
- What are the main causes?
- What can be said on the subjects who suffer these injuries? (age, sex)
- How are the fractures categorized?

2) What are the going methods of treatment?

- Summon and define the different methods for repairing a broken collarbone.
- Give the pro's en cons per method.

3) Do people suffer later on in life from a previous collarbone fracture?

- Interview experts with experience on the subject.
    - Do patients ever come back after a previous injury?
    - What would you like to see improved?
- Traumatology, physiotherapists, literature.

4) Evaluate what the best suitable group is for a new design solution.

- Who will benefit the most in comparison with current methods of treatment?

It could be concluded that people do suffer from previous collarbone injuries. After research and after talking to several experts (two physiotherapists, one traumatologist) who deal with broken collarbones on a frequent basis, it was concluded that the group that will benefit the most from a new solution is the group that do not get any operative treatment. This is the largest group and almost everyone in this group has a broken collarbone that is treated by wearing a sling. The main reason for focusing on this group is having found that the sling is a proper solution for patients, but it does not provide a correct posture for the collarbone to heal in the best possible way.

Although traumatology surgeons feel like their indication system for operating on a broken collarbone is near to perfect, physiotherapists see patients on a weekly base with complaints that can be attributed to it. Traumatologists do show a great interest in these findings, because they hardly ever see patients back. This might indicate that there is a need for more operative indications, but after talking to physiotherapists it was decided to aim the second part of the assignment on designing a sling used as nonoperative treatment that provides better alignment for the bone fragments. The progress on operative treatments is really good at this moment, and the group that is treated nonoperatively is by far the largest that can benefit.

4. Design part

In the design part the following questions were answered:

Design part:

5) *Come up with new design solutions for the chosen group.*
    - Make a problem analysis and define objectives.
    - Define main and sub functions.
    - Make a schedule of requirements.
    - Brainstorm and sketching.
    - Look at different materials and methods.
    - Set apart at least one design idea.
    - Finish with a prototype or model.

6) *What is the conclusion?*
    - Check for feedback on the model with experts.
    - Conclusions and recommendations.

4.1 Problem analysis

The fundamental problem that arose from part one is that the current internal methods for repairing a fractured clavicle are sufficient. This left the external methods to be researched. The goal for the second part of the report is to design an external solution for repairing a fractured clavicle. The design solution will be defined by functions and requirements.

4.2 Functions and requirements

To come up with new design suggestions a schedule of requirements, functions and morphological analyses were made. The functions are the things the design should 'do'. The requirements are the things the design should satisfy to.

Main function:

- *The design must realign the bone fragments.*

Sub functions:

- *The design must provide the energy for moving the bone fragments.*
- *The design must move the bone fragments to the correct position.*
- *The design must 'know' when the bone fragments are in correct position.*
- *The design must exercise two forces on the body.*
- *The design must fixate the bone fragments.*

Schedule of requirements:

- *Be a non-invasive solution; do not penetrate the skin in any way.*

- *Be adjustable to different people (m/f), between 1.60 and 2.00 m in height, and weighing between 50 and 100 kg.*
- *Comfortably wearable.*
- *Suitable for at least 4 weeks use while remaining the same amount of functionality.*
- *Realize bone fragment alignment, with a minimal deviation of 2 mm horizontally and no more than a 5 degree angle in alignment of the two parts. (check with surgeon!)*
- *The device can not cause any discomfort on other parts of the body, for example back pain etc.*
- *Installable by one person.*
- *Cannot weigh more than 0.5 kg.*

Wishes:

- *Be appliable by the user self.*
- *Cannot be more expensive than current solutions.*
- *Be hand washable.*
-

4.3 Morphological analysis

After establishing the functions of the design, a morphological analysis was made. For each sub function several solutions were suggested. Below the sub functions with explanation and options:

- ***The design must provide the energy for moving the bone fragments.***

Something must provide energy as input for the system. To move the two bone fragments to the right position energy is needed. Possible ways of providing this energy input are by means of:

- Engine
- Human force
- Spring force
- Gravitation
-

If a kind of engine would be used, this would have to be implemented in the device. This could make it heavy and expensive. A third person as human force can provide energy for moving the two bone parts. This would make the function no longer a function of the design though. Spring force might be in the form of tension being put on the two fragments, but in both the engine and the spring force option, a person has to perform an action to activate the device. Gravitation is a form of energy that obviously only requires a form of weight. The bone fragments could be moved by the sheer weight of the arm itself, if projected in the right direction.

- ***The design must move the bone fragments to the correct position.***

With energy input in the system, it can move the bone fragments to the correct position. Possible ways to move the bone fragments are:

- Human pushes them in place
- Pull muscles
- Bench-vice
-

The human providing the energy for the movement can also move the bones by himself. The function then again is not a function of the system. The design can pull some muscles attached to the bone fragments to pull them into place. Some sort of bench-vice could also bring the bone fragments together. The actual movement thus can be done by the system, while the input is human, and not a system function.

- ***The design must 'know' when the bone fragments are in correct position.***

When is the correct position reached? How can you check whether the bone is correctly aligned again? The design moves the bones to the correct position, but also needs some feedback to check when this is reached. The correct position needs to be within the limits of the schedule of requirements. Possible ways to check the position are:

- Human check
- Only fit when in correct position
- Make use of a mould
-

A specialist can check with an x-ray whether the two clavicle fragments are in a correct position. It might be possible for him to check externally by look or feel. Another solution might be for the design to check itself. The design would only work if there is a correct fit. Because the clavicle bone lies very superficial in some people, it might be possible to use a mould to put over the bone externally, and if it fits, to conclude that the fragments are correctly lined out. You could think of a solution that only works when it is correctly placed on the bone structure.

- **The design must exercise two forces on the body**

To accomplish the movement of the bone fragments to the correct position, there have to be at least two forces on the body. Possible ways of putting the forces on the bone are:

- Bandage
- Use a weight
- Tension
- Pressure point
- Glue
-

A bandage can be used to provide the pressure needed. The use of a weight can also be used as a force on a bone. Tension is also an option. For instance if you would choose to have a spring as input for your energy in the design, the spring can force the bone fragments back in place. The use of a pressure point to absorb all force is also a possibility. At last, glue can exercise force.

- **The design must fixate the bone fragments.**

To make sure that the bone fragments will stay in the correct position, a fixation method is needed. The solution should be a non-invasive solution, following from the research part. Possible fixation methods are:

- Put a clamp on
- Bandage
- Maintain pressure
- Immobilize the bone
- Immobilize shoulder

- Glue
- Weight on the body
-

Clamping the bone might be possible even though there is skin in between, because of the superficial position of the bone. A bandage is a method currently used by a physiotherapist. The bandage pulls the shoulder back to position the bone better. Current use of a bandage however does not fixate the bone fragments in the correct position. To immobilize the entire shoulder or to immobilize just the clavicle is an option. A form of glue could possibly hold the parts together, but it might turn out to be necessary to glue directly to the bone. A seemingly simple solution, such as a weight on the body, could possibly hold down the bone fragments by sheer weight.

4.4 Morphological analysis schedules and sketching

The previous suggestions for sub functions have resulted in three morphological analysis schedules.

Main function: The design must realign the bone fragments.		
Subfunctions: The design must...	*provide the energy for moving the bone fragments*	*move the bone fragments to the correct position*
Solutions	Engine	Human pushes them in place
	Human force	Pull muscles
	Spring force	Bench-vice
	Gravitation	
Subfunctions: The design must...	*'know' when the bone fragments are in correct position*	*exercise two forces on the body*
Solutions	Human check	Bandage
	Only fit when in correct position	Use a weight
	Make use of a mould	Tension
		Pressure point
		Glue
Subfunctions: The design must...	*fixate the bone fragments*	
Solutions	Put a clamp on	
	Bandage	
	Maintain pressure	
	Immobilize the bone	
	Immobilize shoulder	
	Glue	
	Weight on the body	

Figure 20; Morphological analysis 1

In figure 20 the analysis consists of a human force that moves the bone fragments with a bench-vice to the correct position. With some sort of pressure point, transferred by a clamp the bone is fixated.

Sketches:

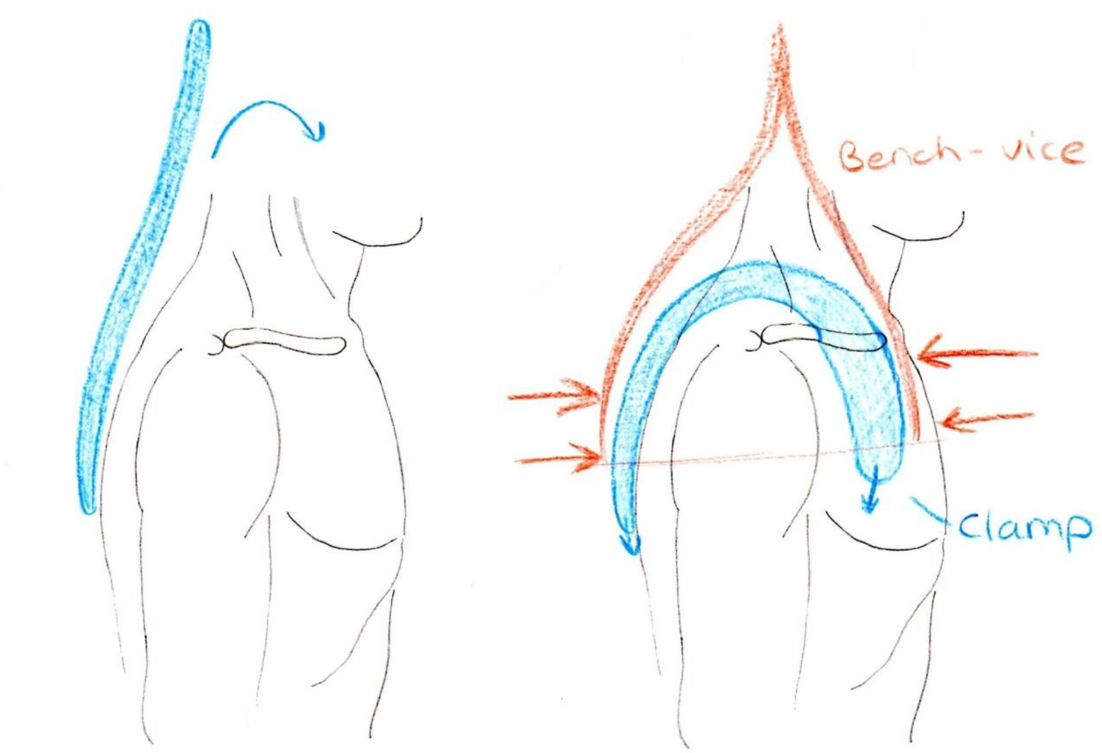


Figure 21; Sketch 1

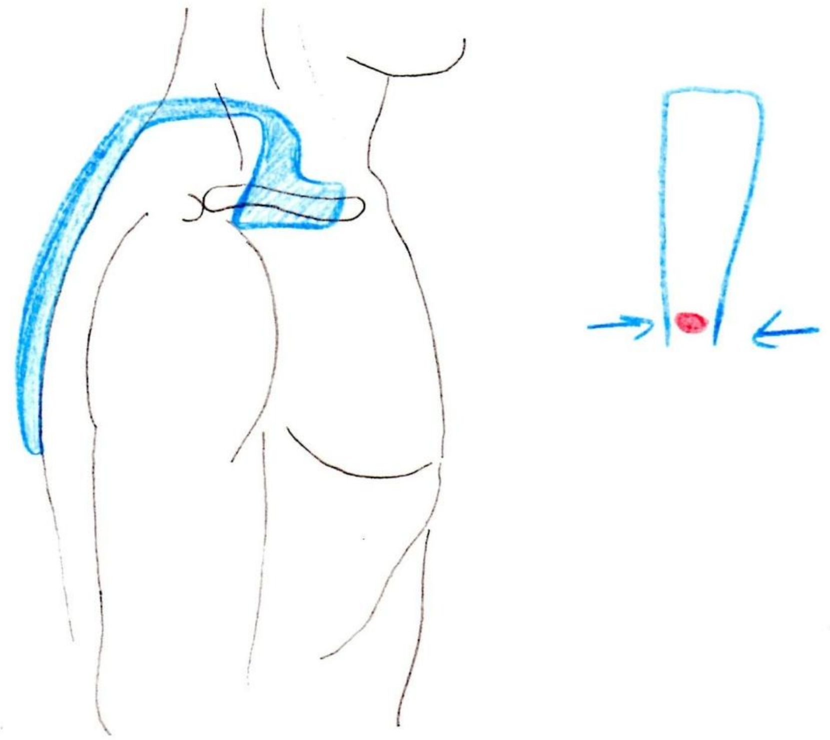


Figure 22; Sketch 2

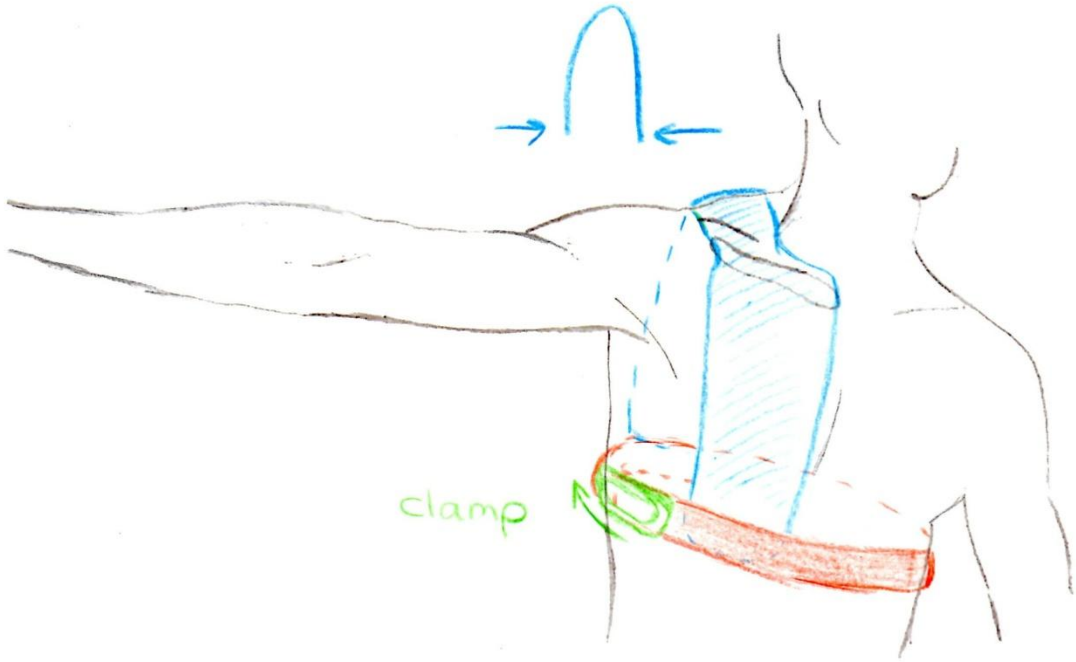


Figure 23; Sketch 3

Main function: The design must realign the bone fragments.		
Subfunctions: The design must…	*provide the energy for moving the bone fragments*	*move the bone fragments to the correct position*
Solutions	Engine	Human pushes them in place
	Human force	Pull muscles
	Spring force	Bench-vice
	Gravitation	
Subfunctions: The design must…	*'know' when the bone fragments are in correct position*	*exercise two forces on the body*
Solutions	Human check	Bandage
	Only fit when in correct position	Use a weight
	Make use of a mould	Tension
		Pressure point
		Glue
Subfunctions: The design must…	*fixate the bone fragments*	
Solutions	Put a clamp on	
	Bandage	
	Maintain pressure	
	Immobilize the bone	
	Immobilize shoulder	
	Glue	
	Weight on the body	

Figure 24; Morphological analysis 2

In figure 25, 26 and 27 a mould is being used to 'know when the bone fragments are in correct position', and also keep them there. In figure 28 only the 'immobilize shoulder' function was looked at, and in figure 29 both were combined.

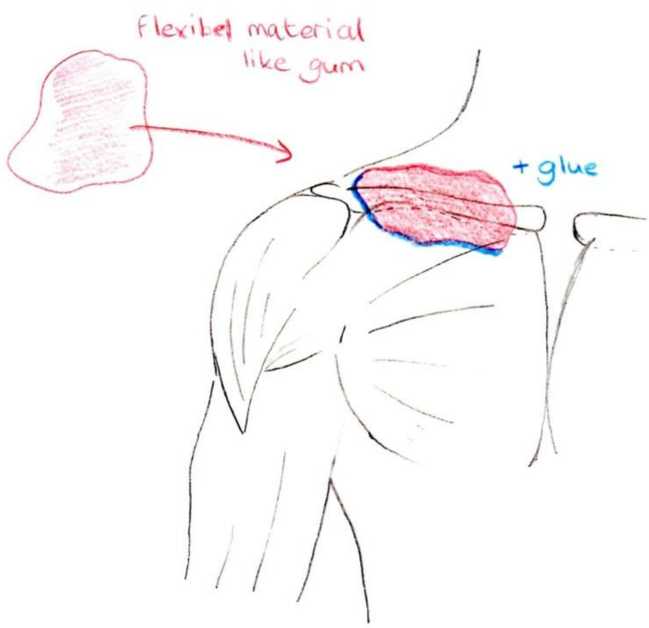


Figure 25; Sketch 1

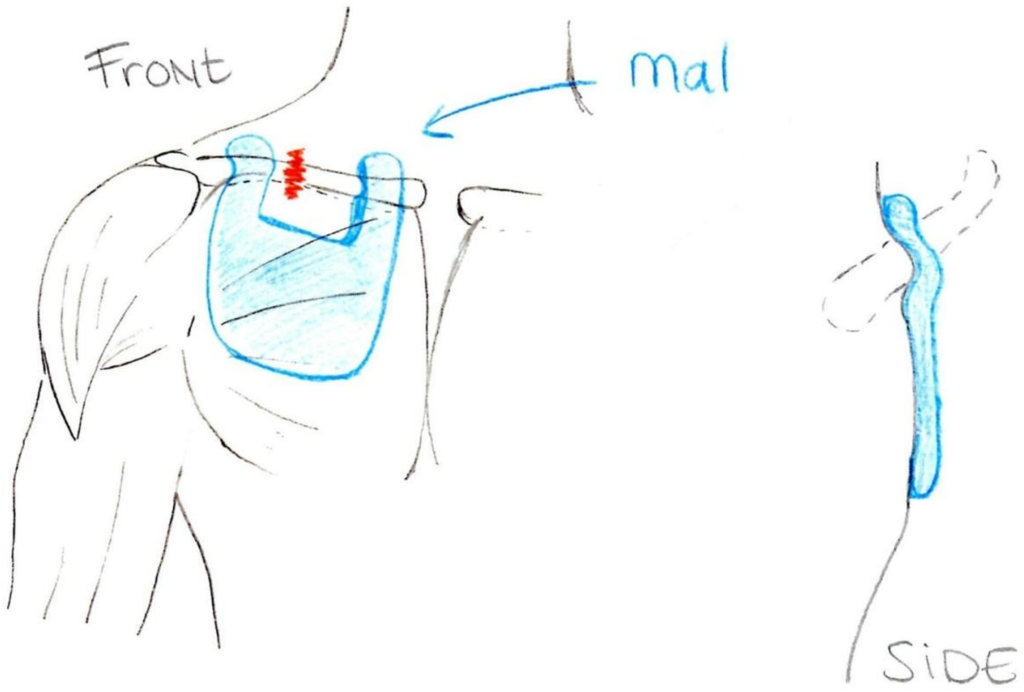


Figure 26; Sketch 2

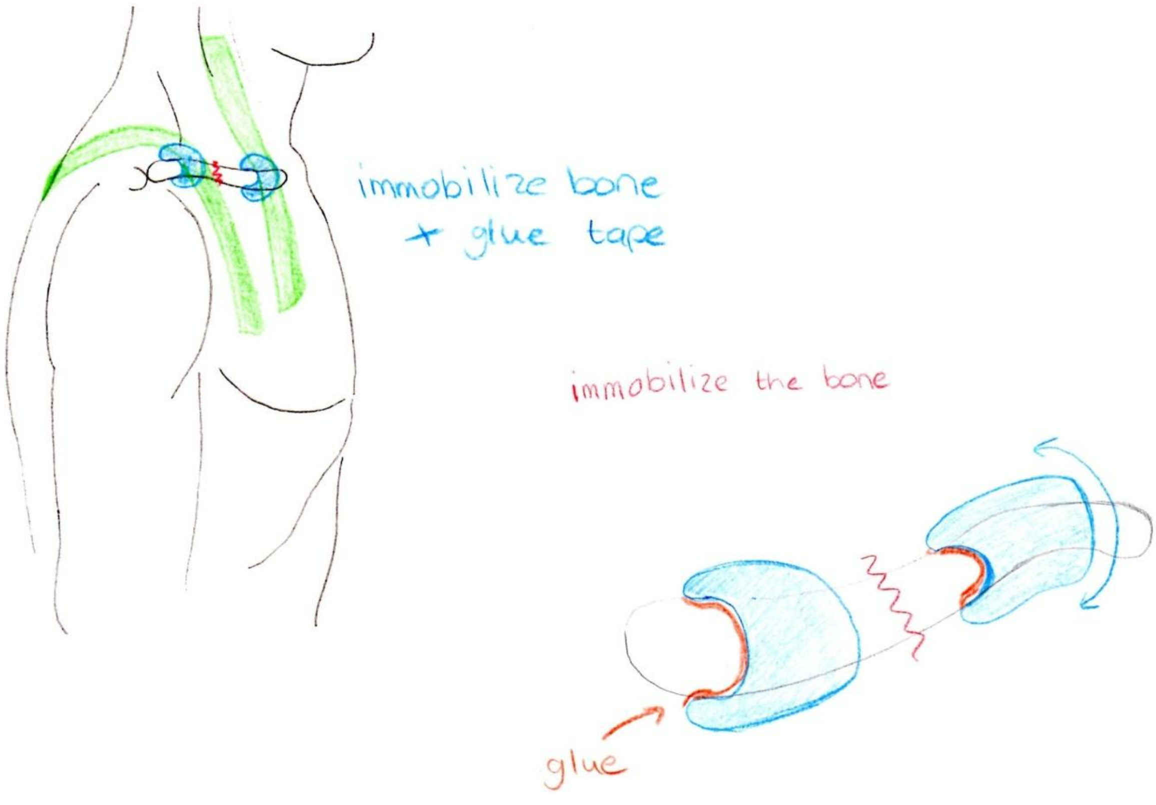
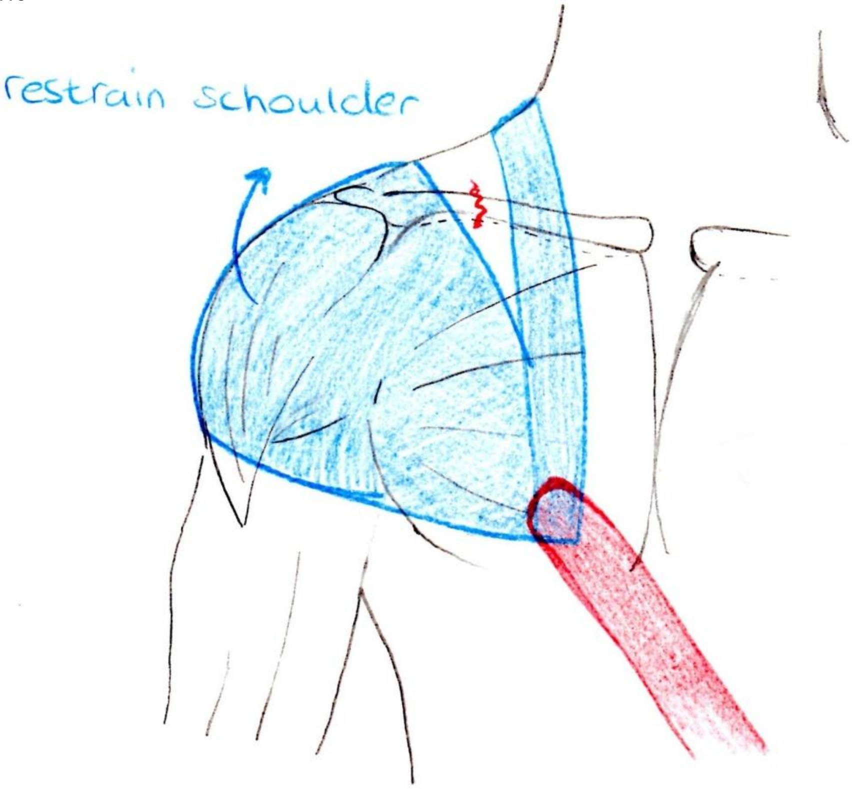


Figure 27; Sketch 3

Front



Back

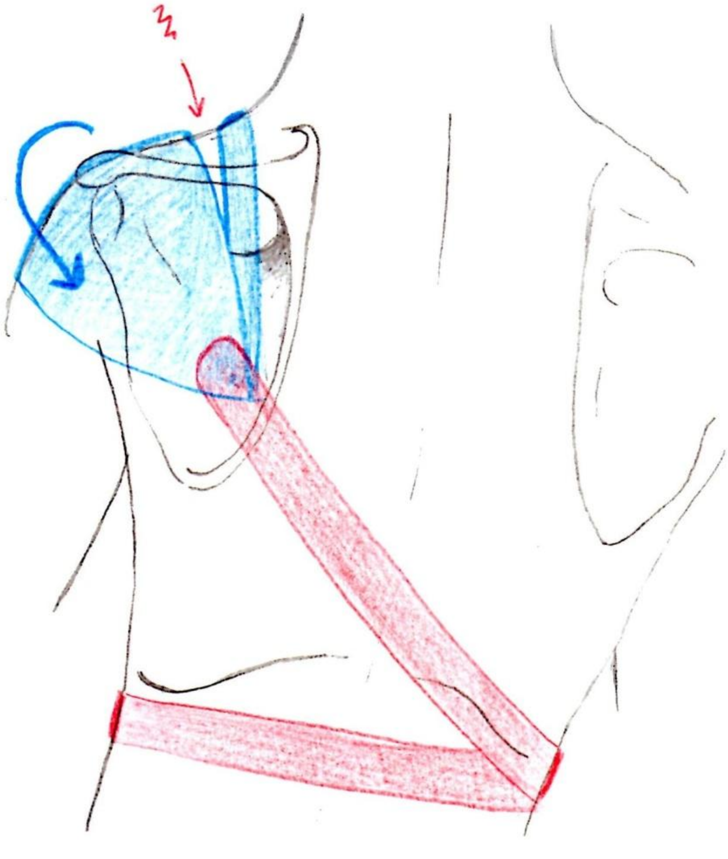
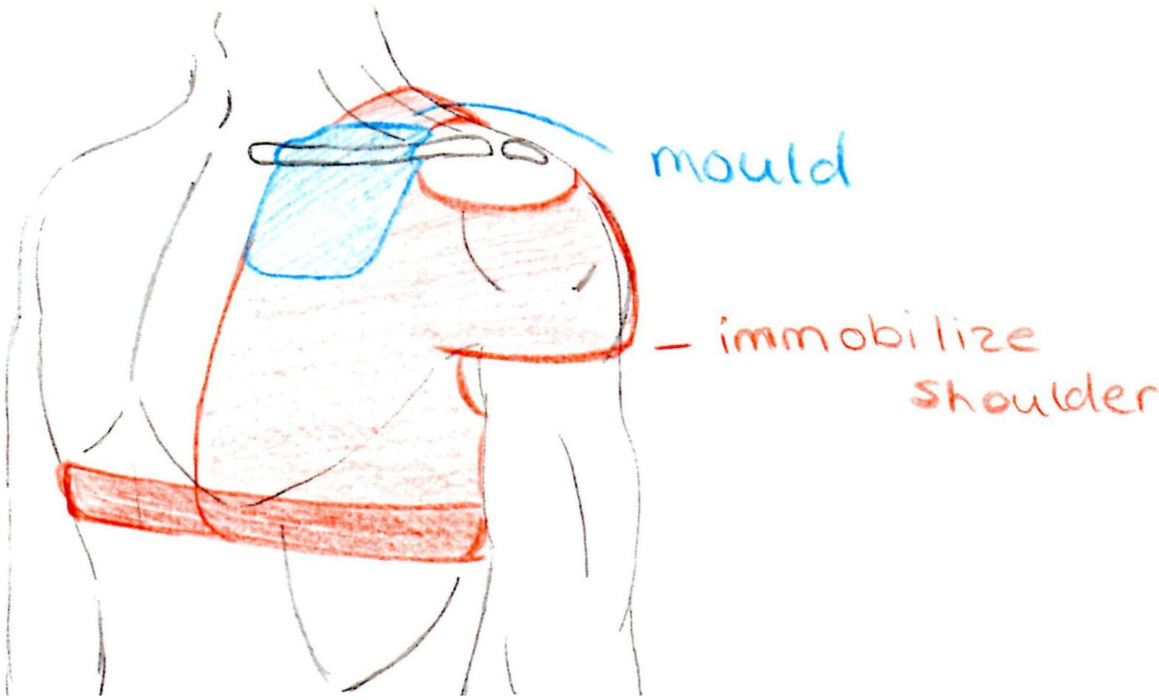


Figure 28; Sketch 4

Front



Back

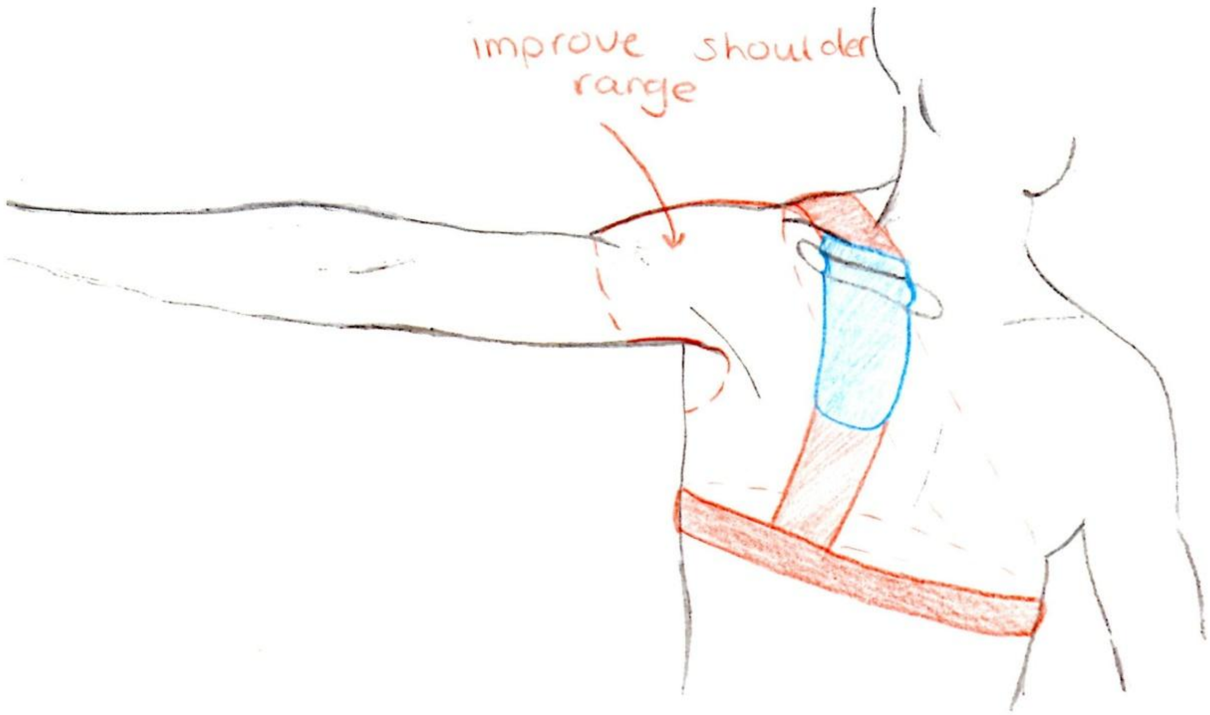


Figure 29; Sketch 5

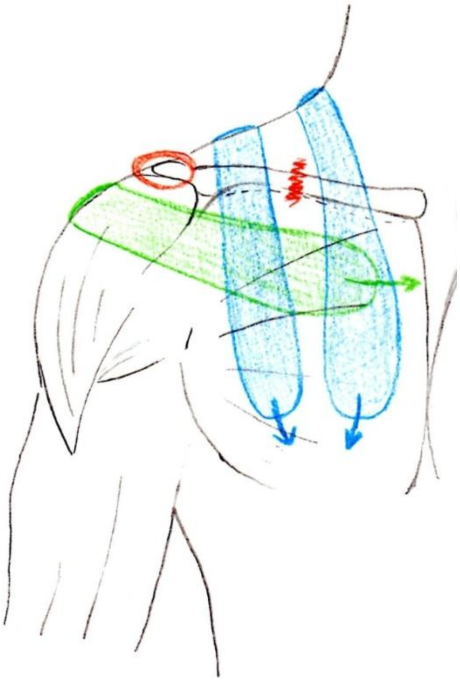
Figure 30; Morphological analysis 3

In figure 30 the third option is shown. This time only bandages are being used. A human force will do all the moving and checking parts and a bandage with glue will keep the bone fragments in correct aligned position. Figure 31 and 32 show possible taping suggestions.

Main function: The design must realign the bone fragments.		
Subfunctions: The design must…	*provide the energy for moving the bone fragments*	*move the bone fragments to the correct position*
Solutions	Engine	Human pushes them in place
	Human force	Pull muscles
	Spring force	Bench-vice
	Gravitation	
Subfunctions: The design must…	*'know' when the bone fragments are in correct position*	*exercise two forces on the body*
Solutions	Human check	Bandage
	Only fit when in correct position	Use a weight
	Make use of a mould	Tension
		Pressure point
		Glue
Subfunctions: The design must…	*fixate the bone fragments*	
Solutions	Put a clamp on	
	Bandage	
	Maintain pressure	
	Immobilize the bone	
	Immobilize shoulder	
	Glue	
	Weight on the body	

Figure 30; Morphological analysis 2

Front



Back

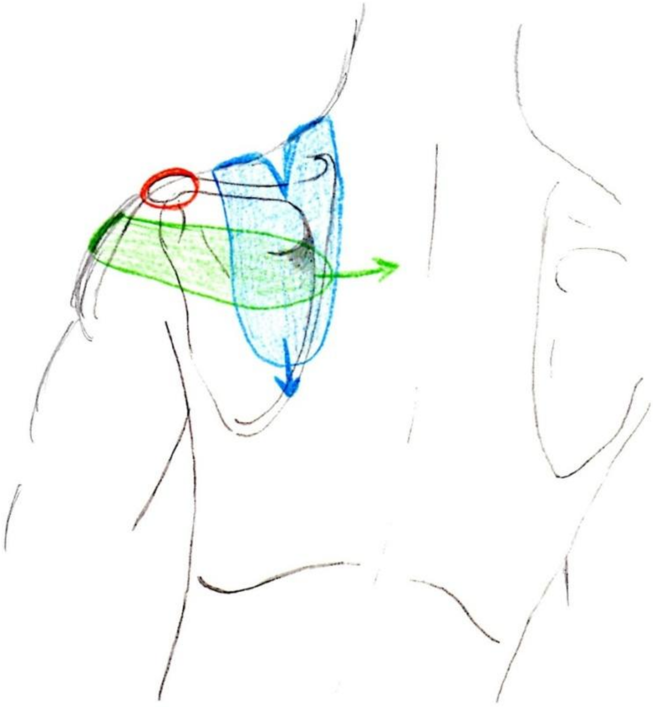
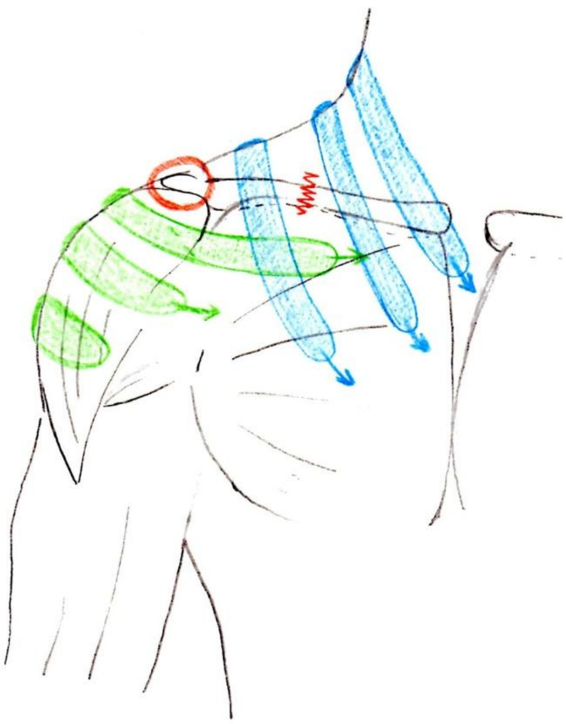


Figure 31; Sketch 1

Front



Back

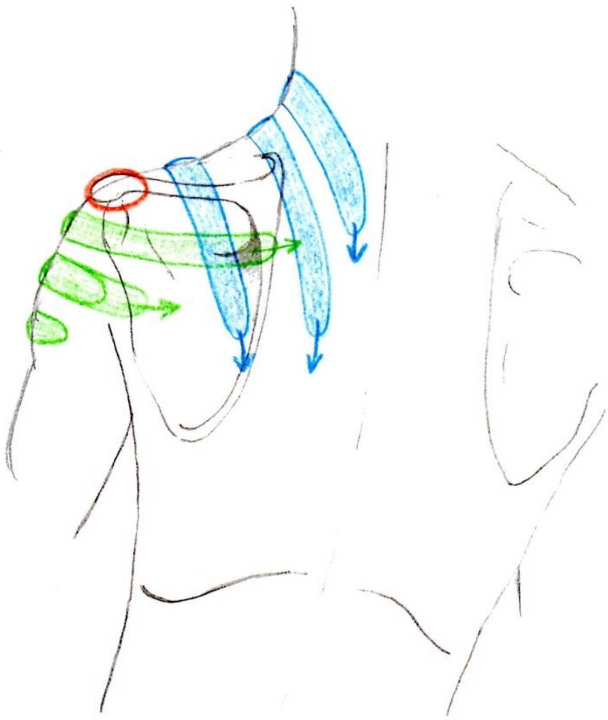


Figure 32; Sketch 2

For some feedback on the sketches, another surgeon has been consulted. Dr. Tomas Winkelhorst from the Enschede MST traumatology, took a look at the functions and the sketches that arose from them. There were some very important questions that needed answering before proceeding to making a model. The interview recap can be found in appendix C. The key questions asked were:

1) Can a fractured clavicle be properly realigned externally?
2) How can it be checked if the bone fragments are properly aligned from the outside?

In short in his opinion it is not possible to externally realign a fractured clavicle. It is too risky not too see all the underlying structures and besides that the forces needed cannot be provided externally.

4.5 Conclusion

Taking the opinion of the questioned surgeon into important consideration, all functions could basically be discarded. If the clavicle cannot be repositioned from the outside, the only possible improvement concerns improving the alignment of the bone fragments. This can still be achieved by improving the posture of the patient by restraining the shoulder in a backwards position. In comparison with a regular arm sling, this should provide a bit more space for the clavicle to heal less shortened. This leaves only two options to be tested;

1) Taping the patient, to test if tape can improve the posture of the shoulder to ensure a better healing of the clavicle fracture.
2) Using a mould, not to keep the bone fragments in place, but to keep the shoulder in a better position.

Both options have been tested and recommendations were made.
Option 1 with tape has been tested on two test subjects with different taping methods.
Option 2 has been tested with one test subject and by using an OrthoThermoplastic material that was deformable at higher temperatures.

To be able to compare the test options with the previously stated functions, requirements and wishes, these have been adjusted to a new realistic main function.

Main function:

- *The design must improve the realignment of the bone fragments externally.*

Sub functions:

- *The design must provide the energy for moving the bone fragments.*
- *The design must pull the shoulder backwards.*
- *The design must exercise two forces on the body.*
-

Schedule of requirements:

- *Be a non-invasive solution; do not penetrate the skin in any way.*
- *Be adjustable to different people (m/f), between 1.60 and 2.00 m in height, and weighing between 50 and 100 kg.*
- *Comfortably wearable.*
- *Suitable for at least 4 weeks use while remaining the same amount of functionality.*
- *The device can not cause any discomfort on other parts of the body, for example back pain etc.*
- *Installable by one person.*
- *Cannot weigh more than 0.5 kg.*
- *Cannot be in direct contact with the fracture site.*

Wishes:

- *Be appliable by the user self.*
- *Cannot be more expensive than current solutions.*
- *Be hand washable.*

Because of the change from aligning the total fracture to improving the position of the fragments during repair, some functions were no longer useful. To evaluate the two chosen options these corrected functions and requirements were used.

5. Prototype

5.1 Option 1, taping the patient

To test if taping the patient is effective, 4 different methods were tested.

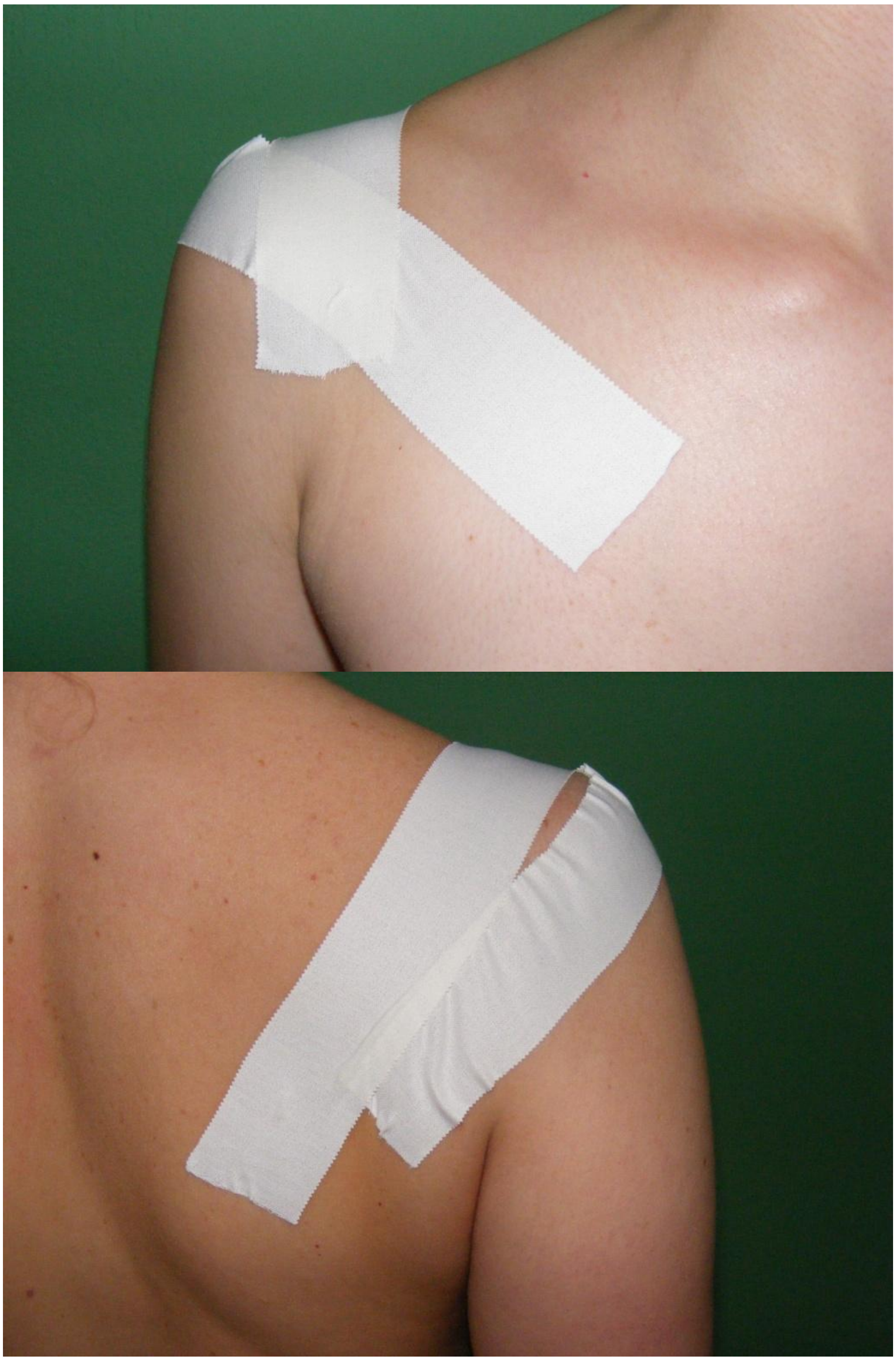


Figure 33; Bandage option 1

Option 1:
In this situation the shoulder is being pushed down by the forces of the tape. Because of the placement of the tape on top of the shoulder there is no force pulling the shoulder backwards. Option 1 therefore is not a solution.

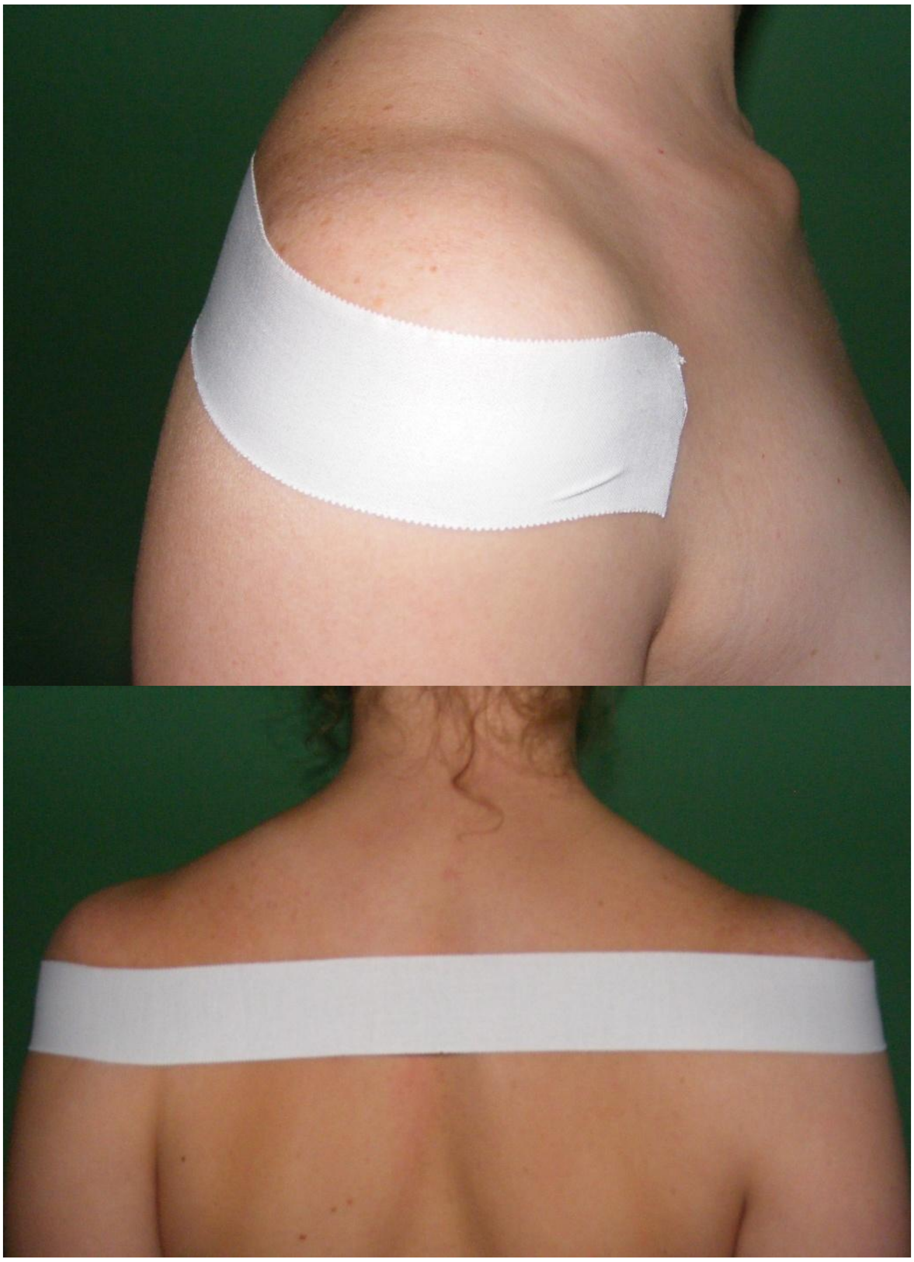


Figure 34; Bandage option 2

Option 2:
With option 2 a bandage has been used over the entire length of the back of test subject 1. Both shoulders were indeed positioned in a better backwards position. A disadvantage in this taping method is the inclusion of the 'other' shoulder in the process. Test subject 1 wore this for a reasonable amount of time during one day, but concluded that it was very restraining on daily activities. Both arms could not be lifted above approximately 30 degrees. When she got hungry the test was abandoned.

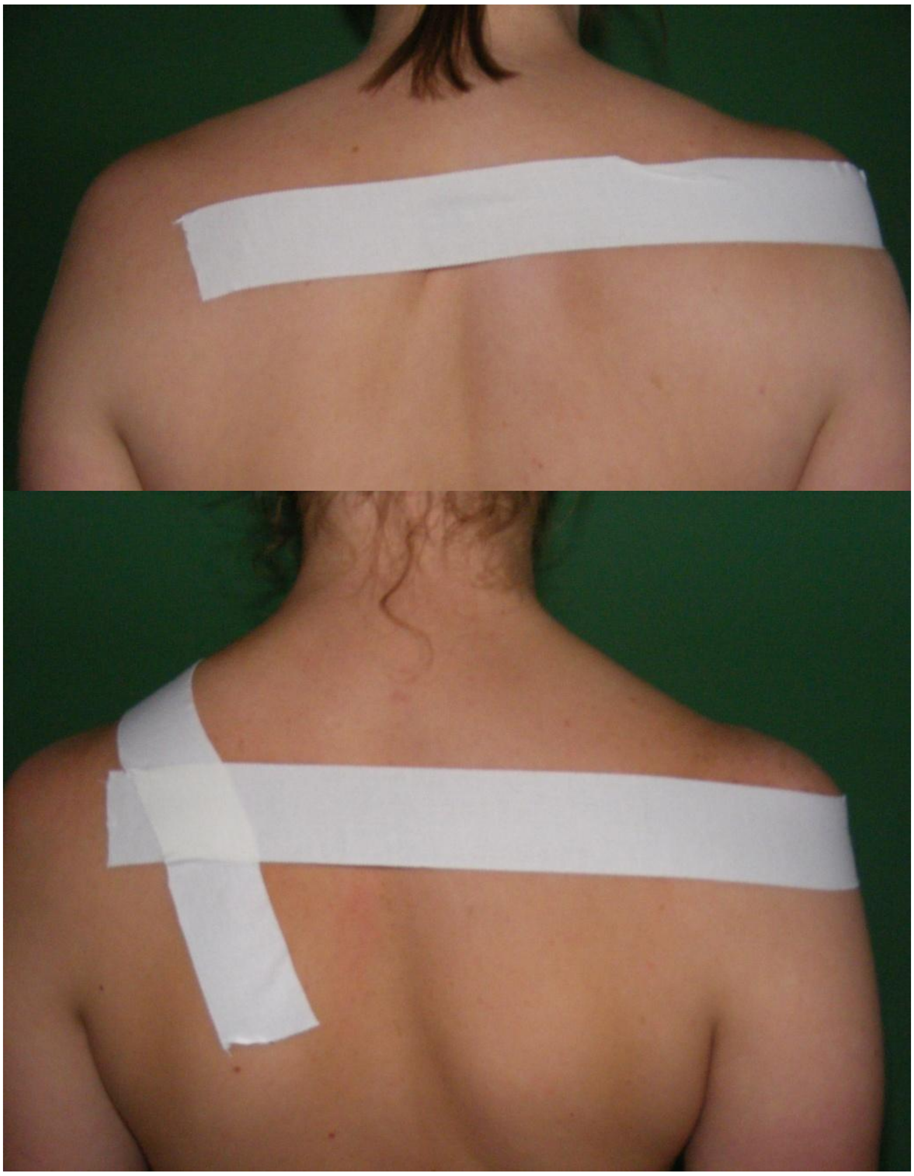


Figure 35; Bandage option 3

Option 3:
With bandage option 3 only the concerned shoulder is taped. Disadvantage is that the bandage works better if both shoulders are involved. To compensate some additional tape was used. The disadvantage at the same time is also the positive feature of this method; only the injured shoulder is treated. Testing this method resulted in the premature release of the bandages, probably because of the great forces pulling on it.

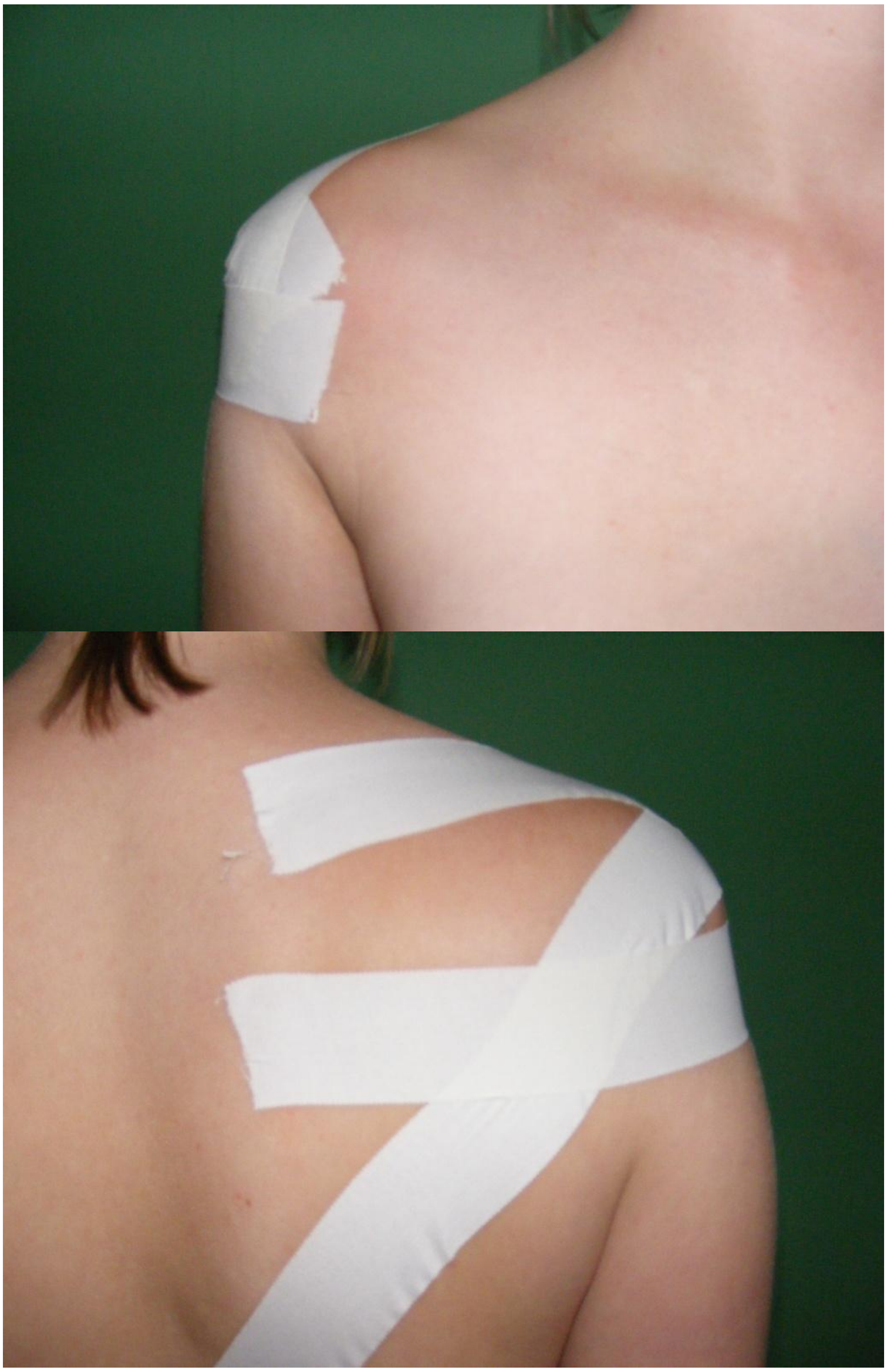


Figure 36; Bandage option 4

Option 4:
The fourth option is a combination of all previous methods. The injured shoulder is being pulled backwards by three strings of bandage. Tape over the top of the shoulder is avoided. This combination turned out to give the best result. The shoulder was put in a backwards position creating a better posture for the clavicle to heal less shortened. A disadvantage was the noting of a tingling sensation in the fingers by the test subject after one hour. Possibly the bandages were too tight or pinching an underlying nerve.

For the second suitable design solution 'using a mould to keep the shoulder in a backwards position', a material had to be found. The idea is based on restraining the shoulder by using a flexible material that perfectly fits around the subject and hardens out. Many materials exist that do such a thing, but have problems with temperature.

The material that was used for the second prototype test is called Ortho Thermoplast. It is a plastic material, that when heated becomes deformable. The material used was 4 mm thick, and had to be warmed in water to +- 70 degrees. The material then becomes deformable en transparent. After taking it out of the water it can be applied on a person after about ten seconds. It is now still deformable en can easily be folded around for instance a clavicle. After hardening the mould is still exactly the shape of the patient.

The following sketches were used to describe the idea:

Front Back

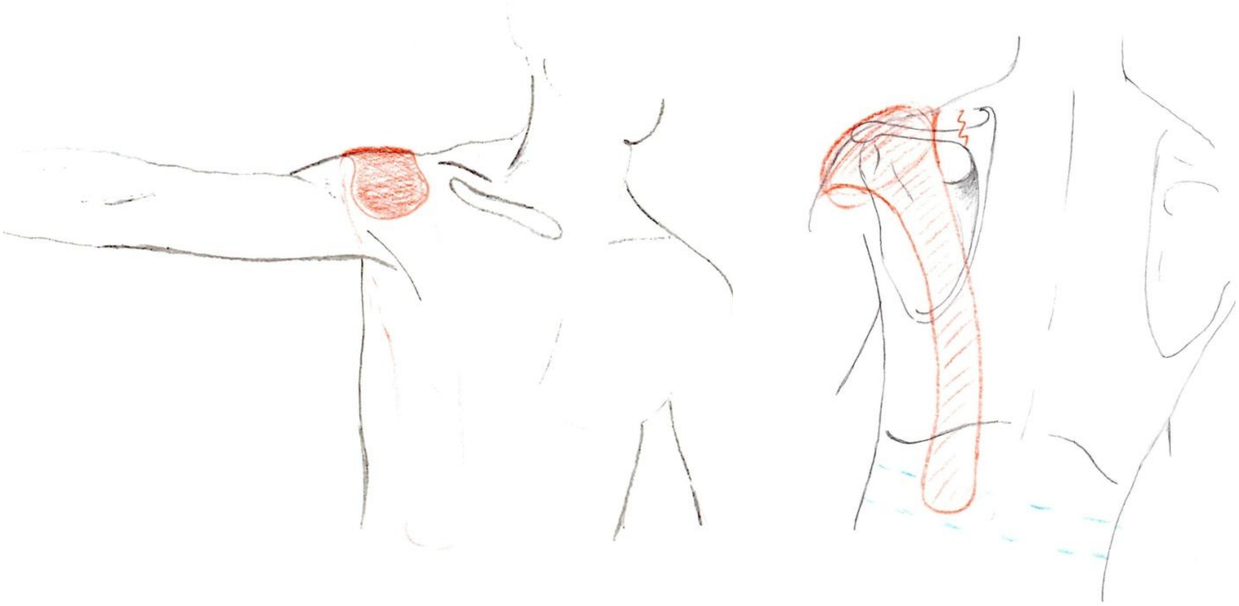


Figure 37; Prototype sketch

The final prototype with the Ortho Thermoplast material runs over the clavicle, because in reality is turned out to be difficult to form the material as in figure 37 over the shoulder.

A picture of the final prototype can be seen in picture 38. The material has been cut into the correct shape, shaped on a test subject, treated with barn paper, and polished with car polish.

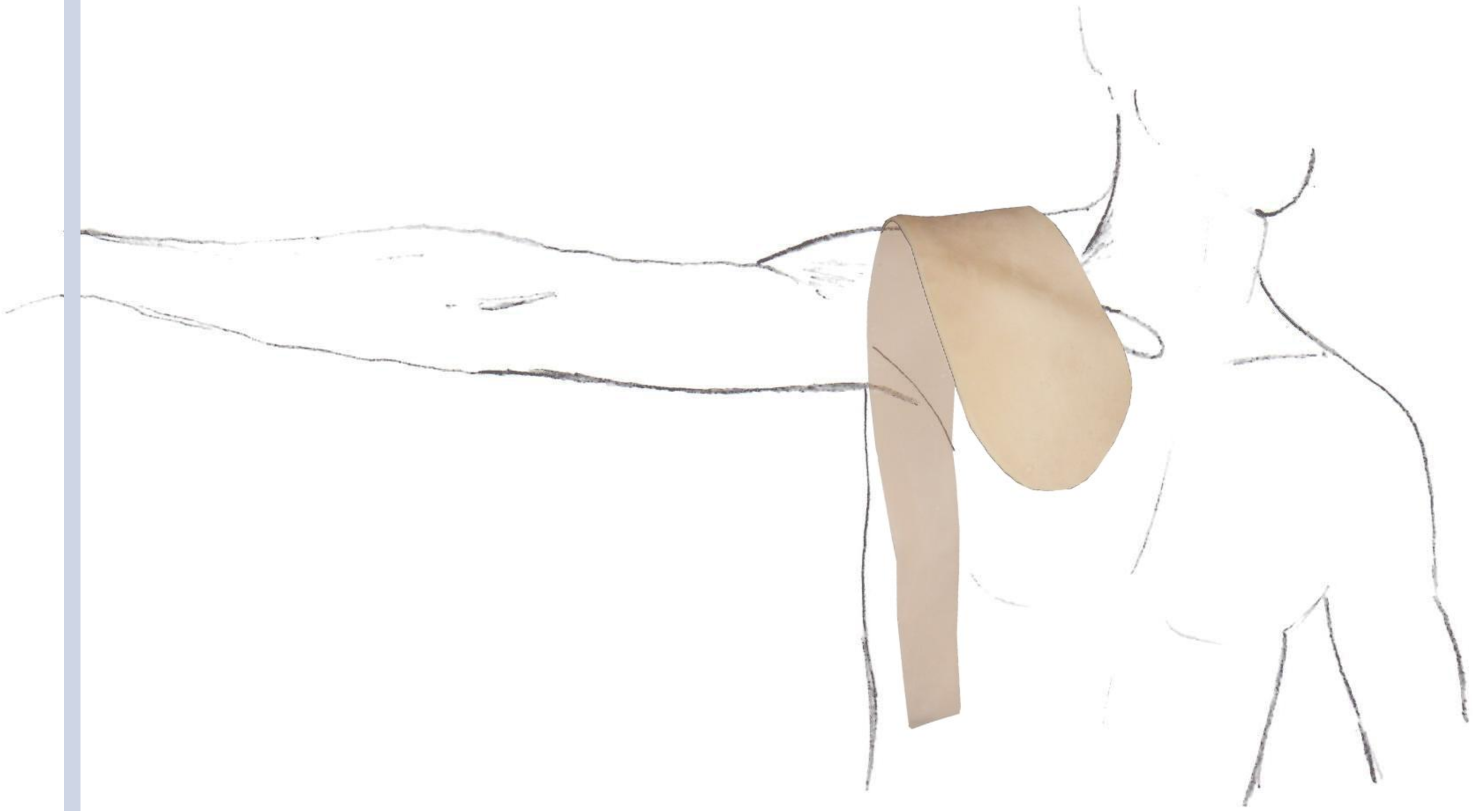


Figure 37; Prototype sketch

The conclusion of the second prototype test is that the material is not suitable for the cause. The material turned out to be too flexible after hardening. This means that it could not be tested if the mould was able to keep the shoulder in a backwards position. In the conclusion there will be a recommendation for future use.

6. Conclusion

To summarize this Bachelor Assignment, first a general research was done on the clavicle. After looking at incidence and current methods of repairing, it was concluded that there was a need for an external solution. In the design part the following questions were answered:

Design part:

5) *Come up with new design solutions for the chosen group.*
    - Make a problem analysis and define objectives.
    - Define main and sub functions.
    - Make a schedule of requirements.
    - Brainstorm and sketching.
    - Look at different materials and methods.
    - Set apart at least one design idea.
    - Finish with a prototype or model.

6) *What is the conclusion?*
    - Check for feedback on the model with experts.
    - Conclusions and recommendations.

From the functions followed the morphological schedules and the sketches. After reviewing the ideas with a specialist, some ideas had to be discarded. Two designs could be tested, albeit for a different function. The final design had to ensure that the injured side shoulder was put in a better position than is the case current arm slings.

To evaluate the two tested options a schedule was made:

	Option 1, taping	Option 2; OrthoThermoplast
Sub functions		
The design must provide the energy for moving the bone fragments.	+	-
The design must pull the shoulder backwards.	+	-
The design must exercise two forces on the body.	+	-
Requirements		
Be a non-invasive solution; do not penetrate the skin in any way.	+	+
Be adjustable to different people (m/f), between 1.60 and 2.00 m in height, and weighing between 50 and 100 kg.	+	+
Comfortably wearable.	-	-
Suitable for at least 4 weeks use while remaining the same amount of functionality.	-	-
The device can not cause any discomfort on other parts of the body, for example back pain etc.	-	-
Installable by one person.	-	-
Cannot weigh more than 0.5 kg.	+	+
Cannot be in direct contact with the fracture site.	+	+
Wishes		
Be appliable by the user self.	-	-
Cannot be more expensive than current solutions.	+	-
Be hand washable.	-	+

Figure 38; Evaluation schedule

As can be seen in figure 38, the tape option worked very well although there are a lot of restrains in the everyday use. The tape is not very comfortable and the strength does not last long enough. The basic function of pulling the shoulder back to improve the alignment of the bone fragments is fulfilled.

The mould option with the OrthoThermoplast could not be tested properly. It is possible to make a very precise mould of a patient around the fractured clavicle. This would also be very suitable for adjustments. However in this assignment there was no suitable material found for the design. The OrthoThermoplast used was too thin and caused the mould to be too flexible.

Recommendations

For the future a recommendation is to look at the possibility of using a so called cast tape made of gypsum. The big problem with the second prototype using a mould was that the material did not have the right properties to be tested for the cause. The option to improve the position of the shoulder during the healing of a fractured clavicle should definitely be researched further.

As a second recommendation it is advised to turn at the internal fixation of a broken clavicle, because as this report shows there seems to be not a lot possible to improve the external solution. It can be expected that the experts interviewed were a bit weary to see changes in their own workspace. Therefore they will say that they are satisfied with current methods. If something revolutionary is designed as an internal solution this might change their view.

Appendices

A) Sources

[1]http://www.chirurgenarnhem.nl/media/File/Folders%20Maatschap%20Chirurgen%20Orthopeden/Folder_Claviculafractuur_een_gebroken_sleutelbeen_160608.pdf

[2]http://emedicine.medscape.com/article/1260953-overview

[3]http://www.msdlatinamerica.com/ebooks/DisordersShoulderDiagnosisManagement/sid695958.html

[4]Elaine N. Marieb, Katja Hoehn, 'Human Anatomy & physiology', 2010

[5]http://www.orthopaedia.com/x/kYAS

[6] Charles F. Preston, M.D., and Kenneth A. Egol, M.D., 'Midshaft Clavicle Fractures in Adults', Bulletin of the NYU Hospital for Joint Diseases 2009.

[7]C.M. Robinson, 'Fractures of the clavicle in de the adult', Royal Infirmary of Edinburg, The journal of bone & joint surgery 1998.

[8] Dr van Walsum, traumatologist MST, Enschede, 2010.

[9] http://www.omnimed.ch

[10] Rockwood clavicle pin; 'Acute Midshaft Clavicular Fracture' Jeray J Am Acad Orthop Surg. 2007.

[11] www.synthes.com

[12]http://www.sonomaorthopedics.com/index.php?page=case-studies

[13] Praktijk voor sport- en topsport fysiotherapie Rene Polman, Enschede

[14]www.shoulderdoc.co.uk.

[15]Yian EH, Ramappa AJ, Arneberg O, Gerber C. The Constant score in normal shoulders.

[16] ESSEX; European Society for Shoulder and Elbow Surgery ; http://www.secec.org

[17]http://www.dash.iwh.on.ca

[18] Andersen K, Jensen PO, Lauritzen J. Treatment of clavicular fractures. Figure-of-eight bandage versus a simple sling. Acta Orthop Scand. 1987 Feb; 58(1):71-4.

[19] Shen WJ, Liu TJ, Shen YS. Plate fixation of fresh displaced midshaft clavicle fractures. Injury.
1999 Sep;30(7):497-500.

[20] Hudak PL, Amadio PC, Bombardier C. Development of an upper extremity outcome measure: the DASH (disabilities of the arm, shoulder and hand) [corrected]. The Upper - Extremity Collaborative Group (UECG). Am J Ind Med. 1996;29(6):602-8.

General use:

Gray's Anatomy of the Human Body; www.education.yahoo.com
www.medterms.com

B) Survey Traumatologist Dr. van Walsum, Friday 26th March.

Short introduction of me and my assignment
'Interest in operative management of clavicle is growing'
'experts, traumatologists, physiotherapists'

Short introduction of Dr. van Walsum

Dr. Van Walsum is een van de traumatologen op het MST. Ze werken met een team van 14 chirurgen, waarvan er 5 gespecialiseerd zijn in traumatologie. Hij ziet wekelijks mensen met gebroken sleutelbenen binnenkomen op de afdeling chirurgie.

Bent u geïnteresseerd in nieuwe ontwikkelingen op dit gebied?
Are you interested in new developments in this area?
Ja, vooral in nieuwe methoden van opereren.

Onderzocht:
'Collarbones are likely to fracture; approximately 4 to 5% of all fractures in adults concern the collarbone.' (Arnhem, chirurgie)
'Up to 12% New York'

Is dat hier ook zo? (verhouding met andere breuken?)
Dat kan hij zo niet zeggen, ze zien ze zeker wel wekelijks.

Hoe komen sleutelbeenpatiënten bij u (de traumatoloog) terecht?
(komen ze überhaupt wel direct op de goede plek terecht?)

In eerste instantie komen mensen binnen op de spoedeisende hulp, hier wordt beoordeeld of ze doorverwezen worden. In ernstige gevallen zoals auto-ongelukken bijvoorbeeld wordt de traumatoloog er bij voorbaat al bij geroepen.

Aantal redenen om hier terecht te komen:

- enkelvoudig letsel, foto maken geeft operatie indicatie.
- politrauma, patiënt komt binnen met zoveel stuk, dat alles vastzetten de beste stabilisatie geeft.
- Beroepsmatig, patiënt heeft esthetische dan wel professionele redenen om geopereerd te worden (modellen, wielrenners).
- Wanneer uit foto's blijkt dat de breuk het bot meer dan 25 mm verkort.
- Wanneer uit foto's blijkt dat er tussen de beide botdelen een schachtbreedte verschil in allignment zit, want dan groeit het bot hoogstwaarschijnlijk niet meer aan elkaar.
- Als er sprake is van een open fractuur.

Het MST opereert vaker op breuken dan andere ziekenhuizen in Nederland volgens Dr. Van Walsum. Waarom? Omdat ze strengere indicaties gebruiken voor operatie.

Wordt er dan gebruik gemaakt van een classificatie / systeem om de breuk in te delen?
(Almann / Neer?)

Nee, er wordt per patiënt gekeken naar een mogelijke behandeling. Natuurlijk wordt er wel vermeld (geclassificeerd) waar en wat voor breuk het is.

Classificatie laten zien (zie Figure 6), is die handig?

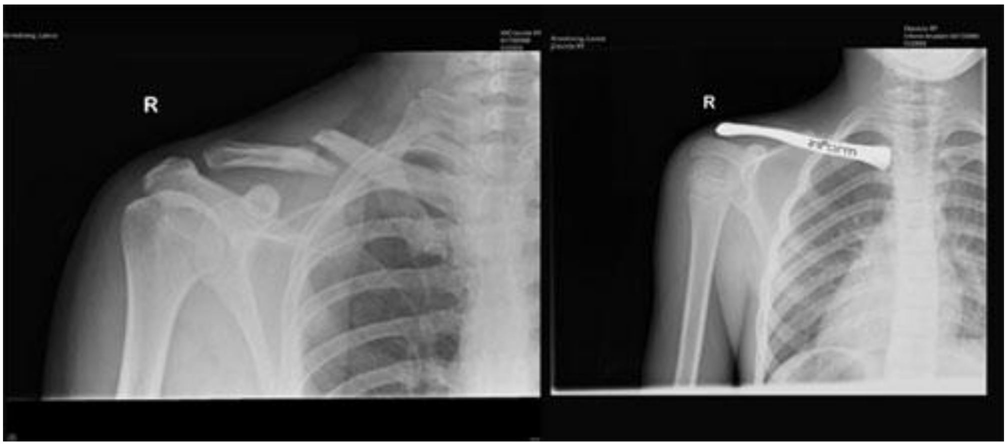
Best handig, maar dit gebeurt in principe ook wel automatisch al.

Hoe beslist u welke oplossing het beste is per patiënt?

Per geval verschillend. Bovenstaande zaken bijvoorbeeld. Verder gebruikt van Walsum alleen platen. Hij is geen voorstander van pinnen. De winst van een pen ten opzichte van een plaat is nog nooit bewezen, dus dan is het de voorkeur van de arts zelf die de doorslag geeft. De platen zijn in zoveel verschillende maten dat er altijd wel 1 past.
De gebruikte pennen en platen worden alleen verwijderd als er een indicatie is voor pijn of last bij het laten zitten ervan.

Possible methods found on the internet:

1) Conservative, do nothing, arm in a sling / figure 8.
Ja gebruiken ze natuurlijk, geen figure 8 want die zit erg slecht.
2) Osteosynthesis; A surgical procedure that stabilizes and joins the ends of fractured bones by mechanical devices such as metal plates, pins, rods, wires or screws.
Ja, vooral platen dus, hangt wel samen met de voorkeur van de arts in kwestie.
3) Intramedullary fixation
Pinnen bijvoorbeeld, bij uitzondering dus wel.
4) Total replacement? (1 April prank Lance Armstrong)
Nee, zou wel interessant zijn, maar extreem ingrijpend.
5) Claviculectomy
Bij hoge uitzondering, bijvoorbeeld op doorverwijzing van een oncoloog.
6) Kirschner wire (might migrate?)
Gebruiken ze ook bij uitzondering, vooral voor de uiteinden van de clavicle. Plaatjes zijn daar moeilijk te bevestigen.
7) Other?
Soms wordt er ook een hoekplaat gebruikt voor lateral clavicle fractures, where additional stability for the acromium is required.



Fake clavicle implant?
Wat wordt er hier in het MST wel gebruikt als oplossing?
Bij welke indicatie geschikt?
Sterke / zwakke punten?

Sonoma repositie ding kennen ze niet, wel hip.

Acumed platen werden wel gebruikt. Platen van Synthes wel. (www.synthes.com)
Platen werken prima, zijn meerdere maten van. Grootste vooruitgang sinds lange tijd was de entree van verschillend gevormde plaatjes. Zo direct geen grote nadelen meer te bedenken dus. Ook niet wat de operatie betreft, gaat tegenwoordig allemaal heel snel.

Hoe is de bereikbaarheid van het sleutelbeen? Rekening houden met (?) voor een operatie?

Geen tijd om deze vraag te stellen helaas.

Wat zou er beter kunnen qua behandeling? Bijvoorbeeld qua opereren, qua ongemak voor de patiënten, qua littekens of qua herstel en effectiviteit van de behandeling?

Was maar 5 jaar eerder gekomen met verschillend gevormde plaatjes☺
Wat nu het grootste probleem is; je wil zo minimaal invasief mogelijk opereren. Dit voornamelijk vanwege grote littekens. Probleem hierbij is dat de breuk meestal niet uitgelijnd is. Hierdoor kun je niet van buiten opereren met een pin ofzo. Niet opereren blijft het best, maar als het dan toch moet, dan liefst zo minimaal invasief mogelijk.

Hoort u ook hoe het verder gaat met patiënten na behandeling?
Ziet u veel patiënten terug? Alsnog met klachten?

Nee, doorgaans komen ze terug voor controle en dat is het dan. Eventueel dus nog voor verwijdering plaatje. Heel soms komen er mensen die zonder operatie niet herstellen om alsnog geopereerd te worden.

De fysiotherapeut zegt wel mensen te zien met klachten te wijten aan een eerder gebroken sleutelbeen. Wat is hiervan de oorzaak denkt u?

Geen idee, wij horen nooit dat mensen klachten hebben na niet-opereren. Interessant, wil wel meer horen. Wij gebruiken op zich een goede indicatie voor operatie denken we, dus als zou blijken dat veel mensen toch last hebben, is dat interessant en zou het te overwegen zijn om onze indicatie aan te passen. De oorzaak is dan waarschijnlijk toch de verkorting of verdrukken van onderliggend weefsel.

Kan ik een keer kijken?

Ja, mail mij en dan kun je meekijken met Thomas Winkelhorst.

Einde.

Woordenlijst:

- Politrauma: Bij een politrauma is er sprake is van meerdere, vaak verschillende soorten verwondingen.
- Invasief: involving entry into the living body (as by incision or by insertion of an instrument)

Bron: http://www.merriam-webster.com/

C) Survey physiotherapist Rene Polman, Friday 26th March.

Korte introductie mijzelf / opdracht
Korte introductie Rene Polman

Er wordt beweerd dat mensen met een gebroken sleutelbeen, conservatief behandeld, hier later last van kunnen krijgen. Ik zoek hier bewijs voor. Kunt u mij wat vertellen over uw eigen ervaringen op dit gebied?

Schouderklachten komen veel binnen.

Komen er veel mensen met klachten die volgens u te wijten zijn aan een eerder gebroken (en niet behandeld) sleutelbeen?

Ja. Beknelde zenuwen, boven de 60 graden arm omhoog zijn er vaak klachten, kleine klachten zijn er vaak aan te wijten vermoedt hij.
Kijken of ie inderdaad ooit gebroken is, en dan is er weinig aan te doen, 'range of motion' kan nauwelijks nog vergoot worden na zo'n lange tijd.

Wat zijn dit voor klachten?

Stabiliteitsproblemen in de vorm van slijmbeursontsteking, irritatie, zenuwbeknelling, vermindere kracht in de arm etc.

Hoe weet u zeker of dat echt de oorzaak is?

Je weet het nooit helemaal zeker, maar je kunt goed vergelijken met de andere schouder. TOS syndrome wel, dat valt direct te wijten aan een sleutelbeenbreuk.

Wat is een mogelijke behandeling?

Rekken, schouder naar achter drukken, liggend, handdoek onder rug. Pectoralis minor.
Anders is het pech. Eventueel houding corrigeren.

Zou het beter zijn om meer mensen te opereren misschien om dit te voorkomen?

We zien veel gebroken sleutelbenen die te passief behandeld worden. Kracht, oefenen, stabiliteit, zou het wel moeten doen. Schouderklachten die mogelijk eruit voorkomen kunnen wij achteraf nauwelijks meer behandelen. Of eerder opereren zou helpen, geen idee.

Met mitella zien wij mensen geregeld (1 per 3 maand) voor oefeningen. Rene taped hem (de schouder) als ondersteuning liever in ipv mitella gebruik, want dat is te passief.
Rene is voorstander van iets permanenters ipv tape, maar dat werkt wel goed.
Mensen met bv tinteling in een arm, die mensen zeggen niks tegen coaches enzo. Die komen misschien niet eens bij de huisarts! Wij zien ze pas vele jaren later terug.
Tip: Let op frozen shoulder, endo rotatie naar exorotatie, abductie vd schouder, ipv sling. Kijk ook goed naar de rug. Oorzaak gevolg, houding is belangrijk. Veel schouder houding komt voort uit de rug.

D) Survey Traumatologist Dr. Winkelhorst, Wednesday 29th October.

Short introduction of me and my assignment

How easily are the fragments of a clavicle fracture moved and put together?

Niet makkelijk. Het kost erg veel kracht om tijdens een operatie de twee botdelen weer juist te positioneren. Dit wordt o.a. met klemmen direct op de botdelen gedaan.

Can this be done from the outside?

Nee, dat lijkt me niet mogelijk. Door de huid heen? Je hebt dan helemaal geen grip op de botdelen en je kunt nooit de benodigde kracht leveren. Daarnaast is het van binnen een enorme chaos, en kun je dus nooit van buiten zien hoe de botdelen precies zitten. Je loopt van buitenaf een groot risico op het beschadigen van allerlei spieren etcetera.

How perfect does the fracture need to be to be able to align it properly?

Dat valt op zich mee, de breuk wordt altijd gefixeerd op een bepaalde manier wanneer de botdelen recht worden gezet. Het is niet mogelijk om de botdelen goed uit te lijnen van buitenaf.

What if there are more than two fragments?

Dat is eigenlijk altijd zo. Het bot breekt bijna nooit perfect, er is meestal sprake van een gedraaide breuk of een breuk die gedeeltelijk over de lengte van het bot loopt. Je zult dus ook goed rekening moeten houden met zwevende deeltjes tijdens het opereren.

Do the bone fragments fit together at all after a fracture?

Nee niet perfect dus. Door middel van een plaatje wordt dit wel sterk verbeterd.

How is it possible to check if the bone fragments are in correct position again?

Dat is op foto's moeilijk te zien, doordat er zoveel om het bot heen ligt aan material. Wanneer er geopereerd wordt, kijkt de chirurg ter plekke of de positie volstaat. Van buitenaf kun je nooit zien of de positie goed is, maar dit is dan ook niet nodig in de meeste gevallen.

Can this be evaluated externally and is it measurable?

Niet meetbaar dus, wel eventueel met een MRI scan, maar dat is niet nodig. Van buitenaf is het niet te controleren hoe het er van binnen uit ziet.