Medium-term results after total clavicle resection in cases of osteitis: a consecutive case series of five patients

Ralf Oheim · Arndt Peter Schulz · Rita Schoop ·
Cornelius H. Grimme · Justus Gille ·
Ulf-Joachim Gerlach

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Abstract

Purpose Claviculectomy is a rare and poorly described event in the surgical therapy of diseases of the clavicle. We present a case series and functional results of patients who underwent total claviculectomy.

Methods From 1995 to 2006 a total of 26 patients diagnosed with osteitis of the clavicle underwent surgery in our unit. Of these, five patients (all female) needed a total resection of the clavicle in order to ensure permanent healing from infection. The data collection was prospective. The data gathered preoperatively and at follow-up included clinical examinations, laboratory findings, radiographs and the Constant shoulder scores. The mean follow-up period was 7.5 months.

Results The surgical concept described was able to eliminate infection in all cases studied within an average hospital stay of 13.4 days (8–18 days). Only one patient showed complications; suffering from chronic pain syndrome requiring surgical revision. After total resection of the clavicle four of five patients showed very good functional results. The average Constant score showed a significant increase from 82 before surgery to 95 at follow-up.

Conclusions The surgical technique described for total claviculectomy, along with the insertion of local antibiotic beads, was able to eliminate infection in every case. Good functional results and a low complication rates were observed. For good functional results and the permanent elimination of infection, adjacent joints have to be addressed, the periosteal

tube should be preserved and early functional treatment is essential.

Introduction

Claviculectomy was first mentioned in 1912 and later described in detail by Gurd [1]. Since then, a limited number of case series corresponding to this salvage procedure have been published. In the aforementioned case series tumours, infections, pseudarthroses and chronic pain after trauma or surgery have been described as indications for claviculectomy [2–5]. All of these case series comprised mostly mixed patient populations.

We describe the medium-term results of total claviculectomy in a consecutive case series of five patients with osteitis/osteomyelitis. In these cases, claviculectomy represents a part of the overall therapeutic concept.

In comparison to injuries of the clavicle and its adjacent joints, osteitis of the clavicle can be regarded as a rarity. The incidence rate of osteitis of the clavicle in all cases of osteitis is approximately 7% [6]. The endogenous (haematogenous) bacterial type is considerably less common than the exogenous (post-traumatic/postoperative) type. For this reason, the abacterial type, primarily chronic osteitis, has to be distinguished from the bacterial type [7]. Surgical procedures to the clavicle and adjacent joints are common causes of exogenous osteitis [2]. References to the therapy of clavicular osteitis are limited and only a few case reports plus observations on small patient populations are available.

Patients

From December 1995 to February 2006 a total of 26 patients diagnosed with osteitis of the clavicle underwent

R. Oheim (✉) · A. P. Schulz · R. Schoop · C. H. Grimme ·
J. Gille · U.-J. Gerlach
Septic Bone and Joint Surgery, BG Trauma Hospital Hamburg,
Bergedorfer Straße 10,
21033 Hamburg, Germany
e-mail: r.oheim@buk-hamburg.de

surgery in our unit [8]. Due to severe infection, five patients needed a total clavicle resection in order to ensure healing from infection.

These patients were all female with an average weight of 65.6 kg (52–85 kg) and average height of 170.6 cm (168–175 cm). The average body mass index (BMI) was 22.5 kg/m² (17.6–27.8 kg/m²). At the time of the index operation the average age was 23 years (15–41 years). Of the five cases, four were affected on the right side and one on the left side.

The medical history of the infection stretched over an average of 110 months (six weeks to 312 months) and all patients had already been pretreated with an average of 4.6 operations (2–10). A relevant secondary diagnosis was found in one patient with obesity, who was taking the oral anticoagulant coumarin due to a right-sided subclavian vein thrombosis.

The infection in four patients was of haematogenous origin, where one patient had contracted osteitis after she had undergone surgery for sternoclavicular dislocation using a polydioxanone cord (PDS, Ethicon, Hamburg, Germany) and a tifix® locked plate (Litos, Hamburg, Germany). The time between the surgery and the infection was six weeks and was therefore classified as chronic (over

four weeks) osteitis. Concerning the adjacent joints of these four patients, the sternoclavicular and acromioclavicular joints of three patients were affected, whereas one patient had osteitis in the sternoclavicular joint alone.

In all cases, the preoperative assessment comprised a clinical examination, evaluation of the Constant shoulder score [9] and plain radiography. Further imaging was additionally undertaken in four of the five total claviclectomy cases. In two cases additional computed tomography (CT) scans and in another two cases skeletal scintigraphies were performed (Table 1).

Surgical technique

Following our general concept, the surgical procedure consisted of stages of therapy [8, 10]. The main priority in this type of therapy is infection control (through radical debridement/removal of necrotic/infected tissue and dead bone) and treatment of the damage to soft tissue parts. Infected osteosynthesis materials are completely removed. As tissue samples are required for microbiological testing and histopathological assessment, a smear test and bone biopsy are performed intraoperatively. In the case of

Table 1 Individual data, clinical aspects and diagnostic and follow-up data of the five total claviclectomy patients

Patient	1	2	3	4	5
Age (years)	23	32	15	41	23
Sex	Female	Female	Female	Female	Female
Side	Left	Right	Right	Right	Right
Height (cm)	170	175	168	168	172
Weight (kg)	65	85	55	71	52
BMI (kg/m ²)	22.5	27.8	19.5	25.2	17.6
Previous operations	10	5	2	3	3
Redness	No	Yes	No	Yes	No
Fistula	Yes	No	No	No	No
Scintigraphy	No	No	Yes	No	Yes
CT	Yes	Yes	No	No	No
MRI	No	No	No	No	No
Leukocytes (5–9×10 ⁹ /l)	7.2	8.6	7	8.7	7.1
CRP (0–0.5 mg/dl)	1.4	3.2	1.47	2.1	1.2
Origin	Postoperative	Haematological	Haematological	Haematological	Haematological
Germ	<i>Staph. epidermidis</i>	None	None	None	None
Surgery (min)	47	42	76	88	87
Hospitalisation (days)	16	18	8	11	14
Revision	Yes	No	No	No	No
Follow-up (months)	5	15	6	17	4
Constant score preop.	78	69	85	86	91
Constant score postop.	87	93	99	99	99

MRI magnetic resonance imaging, *Staph. Staphylococcus*, *op.* operative

instability resulting from a bone defect after eliminating infection, we rely on the secondary recovery of bone continuity (via an autologous spongiosa graft if necessary) [11]. In the event of poor primary results or uncontrollable reinfection, we advise total claviclectomy. The periosteal tube should be preserved and finally sealed, if possible. In doing so, the deltoid muscle and pectoralis major fascia will be bonded together, which, in our view, is essential to achieve a good functional result (Figs. 1, 2, 3 and 4). In order to minimise reinfection, the adjacent joints (acromioclavicular and sternoclavicular joints) and the first rib need to be surgically addressed if infected. In addition, for the same reason, the antibiotic beads should be removed after three to six months. To avoid the need for a second operation, nowadays we prefer to use antibiotic-soaked collagen sponges for local antibiotics.

After clavicle resection and wound healing it is essential to perform early physical treatment in order to obtain good functional results. After the smear test is taken, systemic antibiotics is started intraoperatively and continued orally for five days. In the case of recurrence of infection, we recommend early revision surgery.

The microbiological analysis of the smear test results was based on a 14-day incubation period, as previously demonstrated by Ince et al. [12]. Following the method of Jundt and Jani [13], during histological assessment of the bone biopsy direct attention was paid to the characterisation of plasma cells, neutrophil granulocytes, lymphocytes and macrophages, as well as a marrow cavity oedema, which varied in the degree of development, and marrow cavity fibrosis, in order to make a diagnosis.

In addition to the subjective assessment of the patients, the postoperative results were also assessed via the Constant shoulder score [9]. Particular attention was paid to the clinical signs of infection both locally, such as redness, swelling and hyperthermia, and heterotopically, such as lymphangitis or lymphadenitis. At this time in the clinical follow-up examination a plain radiograph was taken in all cases.

Data collection was performed using an Excel spreadsheet (Microsoft Excel, Version Office XP, Microsoft, Richmond, VA, USA). The statistical review was performed using SPSS (SPSS Inc., Version 16.0.1, Chicago, IL, USA).

Results

Preoperatively, three patients showed clinical signs of an infection including redness and swelling ($n=2$) and a fistula ($n=1$). Where clinical signs of inflammation were absent (in two cases), the suspected diagnosis was made solely by means of clinical history and by using extended imaging. From a plain radiological and preoperative point of view, all patients showed typical signs of osteitis, such as lysis, sequestra or periosteal reactions (Fig. 1).

Preoperatively, one patient had a low value of less than 70 of 100 possible points in the Constant shoulder score, one patient had a moderate value in the range of 70–79, two patients scored good initial values in the range of 80–89 and another patient obtained very good initial values of 90–100.

The preoperative laboratory control showed increased levels of C-reactive protein (CRP) in three patients; leukocytosis was not verifiable in any of the patients. Therefore, despite the presence of severe osteitis of the clavicle, the patients only had slightly increased CRP levels in their blood, and none had increased leukocyte levels.

The average duration of the index operation was 68 min (42–88 min). In the case of postoperative osteitis of the clavicle multiple surgical procedures, including debridement and sequestrectomy, had been carried out beforehand. In such cases permanent healing of the infection will only succeed after a total clavicle resection. Thus, in each of our cases, the infection was treated by total clavicle resection.

Histological examination confirmed the presence of osteitis of the clavicle in all cases. Postoperative osteitis evidence of germs (*Staphylococcus epidermidis*) was only verified in one patient.

Postoperatively complications that needed revision occurred in one patient. In this case, chronic pain arose from the region of the clavicle where parts of the clavicle had been preserved. The average hospital stay was 13.4 days (8–18 days). At the time of the follow-up examination, which was after 7.5 months (4–17 months) on average, all wounds were closed without irritation. Furthermore, during the follow-up examination, plain radiographs did not show any signs of osteitis in any of the patients.

Fig. 1 **a** X-ray of chronic haematological infection of right clavicle. **b** Postoperative X-ray after complete resection of right clavicle with implanted antibiotic beads (Mini-Septopal®, Biomet, Berlin, Germany)

Fig. 2 **a** Intraoperative view of chronic infected right clavicle. **b** Total resection of right clavicle. **c** After claviclectomy antibiotic beads (Mini-Septopal®, Biomet, Berlin, Germany) are implanted into the preserved periosteal tube. **(d)** Closure of the preserved periosteal tube which is important for a good functional result since the m. deltoideus and m. pectoralis insert into the periosteum of the clavicle

Regarding the postoperative results, all patients reported that they were either very satisfied (Constant shoulder score >90, $n=4$) or satisfied (Constant shoulder score >80, $n=1$). All of them said that they would opt for the index operation again if they found themselves in the same situation. In one case, chronic pain in the shoulder area continued after ten different initial reconstructive and resective operations. Overall, the Constant shoulder score values significantly improved from the preoperative to the postoperative stage, from 82 to 95 (Fig. 5).

Discussion

Publications on the therapy of bacterial osteitis of the clavicle and total clavicle resection are limited, and only a

few case reports and observations on small patient populations are available [6]. This study of a consecutive case series of five patients, describes the results of surgical therapeutic regimens from a medium-term perspective.

The endogenous (haematogenous) bacterial type of osteitis is considerably less common than the exogenous (post-traumatic/postoperative) type [7]. Our patient population mostly showed cases of haematogenous osteitis. In general, the therapy of exogenous osteitis is surgical [14], whereas haematogenous osteitis used mainly to be treated by non-operative therapy. Surgical therapy is undoubtedly needed in every situation where abscesses or sequestra occur, and also when non-operative therapy is unsuccessful [15].

The post-traumatic and postoperative infection rate is increased by 30% in cases where there are open bone fractures of the lower limb [10]. In comparison, the infection rate of the upper limb is not so high and the clavicle is only affected in up to 7% of all osteitis cases [6]. Due to the tendency to operate on fractures of the clavicle and ligament lesions of the adjacent sternoclavicular and acromioclavicular joints, previously a domain of non-operative therapy, osteitis of the clavicle will presumably account for an increasing number of problems in orthopaedic and trauma surgery [16]. From a differential diagnostic point of view, attention will need to be paid to aseptic and, primarily, chronic osteitis as their aetiology remains vague [7].

In this study, some of the cases did not show a preoperative increase in inflammatory marker values (CRP, leucocytosis). This is in accordance with the literature, which describes normal inflammatory marker values in the

Fig. 3 Postoperative cosmetic result after right total claviclectomy

Fig. 4 Functional result after right total claviclectomy with full retroversion (**a**), full rotation (**b, c**) and full elevation (**d**)

event of chronic osteitis [15]. Furthermore, the markers mentioned are admittedly sensitive regarding the presence of an infection, although with a low specificity [17]. Overall, chemical laboratory tests merely play a minor part when diagnosing osteitis.

Cases of conventional diagnostic radiology scleroses, loss of bone substance (lusis, inactivity osteoporosis), irregular bone structures (periosteal reactions) and loose implants were classified as changes that can give rise to osteitis (Fig. 1). In our study, all patients showed such changes preoperatively. The high number of positive radio-

diagnoses was a result of the fact that all cases of osteitis were of the chronic type. The results of this study confirmed the fact that plain radiological changes can only be expected after the disease progresses, which would be after several weeks. Thus, sensitivity is low in cases of an acute incidence of the disease [18]. In such an instance of extended diagnosis, which was carried out in two cases in the form of CT imaging, the exact bone structure can be assessed. With regard to the detection of osteitis, scintigraphy shows a high sensitivity but has unsatisfactory specificity [19]. Therefore, a negative scintigraphy probably excludes an infection. However, from a differential diagnostic point of view, positive scintigraphy does not add to any further diagnosis either. This particularly applies to post-traumatic or postoperative osteitis as a differentiation between instability and osteitis cannot be confidently made by means of skeletal scintigraphy. It seems that a combination of various techniques (i.e. ^{99m}Tc -MDP and ^{111}In) may increase diagnostic accuracy [15].

Overall, osteitis remains a clinical diagnosis that can be additionally clarified both chemically in the laboratory and via diagnostic imaging. In contrast to chronic osteitis, the guiding clinical symptoms of acute osteitis are the classic signs of an infection (redness, calor, dolor and loss of function) [14]. These were prominent in four patients whose adjacent joints were included in the infection, most often the sternoclavicular joint.

Fig. 5 Box-and-whisker diagram showing significant improvement in pre- vs postoperative Constant score results. Scores are presented as medians; the ends of the boxes define the 25th and 75th percentiles

In all cases in our study the therapy was designed as a step-by-step plan that first dealt with eradication of the infection, followed by closure of the soft tissue defects and finally reconstruction of the osseous defect [10]. A prerequisite for infection control would be the radical removal of all infected dead bone, soft tissue and foreign material and the resection of infected adjacent joints. If the periosteal tube is preserved and the pectoral girdle is substantial (Fig. 2), an osseous reconstruction of the clavicle is not required to achieve good functional results. This is in accordance with Wessel and Schaap, who reported good shoulder mobility and brachial strength in six cases of claviclectomy during follow-up examinations [20]. Furthermore, regeneration of bone from the periosteal tube has been described and was observed in our series in two patients [21].

In our study the average Constant shoulder score value significantly improved from 82 (preoperative) to 95 (postoperative) (Fig. 5). Therefore, in our view, early functional treatment is essential. In the event of total clavicle resection, functional treatment can unconditionally take place immediately after wound healing (Figs. 3 and 4).

An important part of our treatment concept is local and systemic antibiotics. Since gentamicin polymethyl methacrylate (PMMA) beads lose their antibiotic activity after several years and increase the risk of antibiotic-resistant strains of bacteria developing [22], we try to remove all PMMA beads after three to six months. These days, biodegradable antibiotic delivery systems such as antibiotic-soaked collagen sponges are a good alternative since their use means that a second operation to remove the beads is no longer necessary. In general, we prefer a short period of systemic antibiotics of only five to seven days in total. Intravenous antibiotics is given from surgery to first microbiology findings (two to three days) and then orally for another two to four days. Where persistent signs of an infection occur after this period, we believe that surgical revision is needed in most cases.

Microbiological evidence (*Staphylococcus epidermidis*) was only verified in one case in this study, via an intraoperative smear test. In relevant references, *Staphylococcus epidermidis* is often mentioned in connection with bone and joint infections [23]. The microbiology evidence was discovered in the course of a culture incubation where it can, however, provide false-negative results [24]. Further studies will show whether or not this diagnostic gap can be closed using 16S rRNA gene sequence analysis [12].

In all cases, the histopathological assessment of intraoperative biopsies verified osteitis with evidence of inflammatory cells, bone sequestra and partial necrosis. The discrepancy between histological evidence of osteitis

and lack of microbiological evidence has already been described by White et al. [25], who only found bacterial evidence in 40–60% of all cases of histologically verified osteitis.

Conclusion

The surgical procedure of a total clavicle resection along with the local insertion of antibiotic beads resulted in healing of the infection in all cases studied. Thus, total clavicle resection without successive reconstruction can lead to good functional results with a low complication rate. The adjacent joints were often included in the infection and must be surgically addressed.

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