

Innovative Surgical Concept for Septic Sternoclavicular Arthritis: Case Presentation of a Simultaneous Joint Resection and Stabilization with Gracilis Tendon Graft Including Literature Review

Innovatives OP-Konzept bei septischer Arthritis des Sternoklavikulargelenks: Falldarstellung einer simultanen Gelenkresektion und Stabilisierung mit Gracilissehnengraft inklusive Literaturübersicht

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Key words

SCJ, sternoclavicular joint infection, septic arthritis, SC joint reconstruction, SC joint graft augmentation

Schlüsselwörter

SCG, Sternoklavikulargelenk, septische Arthritis, SCG-Instabilität, SCG-Sehnenaugmentation

published online

Bibliography

Z Orthop Unfall 2020

DOI 10.1055/a-1219-8342

ISSN 1864-6697

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ABSTRACT

Introduction Septic arthritis of the sternoclavicular joint (SCJ) is a rarity in everyday surgical practice with 0.5–1% of all joint infections. Although there are several risk factors for the occurrence of this disease, also healthy people can sometimes be affected. The clinical appearance is very variable and ranges from unspecific symptoms such as local indolent swelling, redness or restricted movement of the affected shoulder girdle to serious consequences (mediastinitis, sepsis, jugular

vein thrombosis). Together with the low incidence and the unfamiliarity of the disease among practicing doctors in other specialties, this often results in a delay in the diagnosis, which in addition to a significant reduction in the quality of life can also have devastating consequences for the patient.

Patient and Method According to a stage-dependent procedure, the therapy strategies range from antibiotic administration only to radical resection of the SC joint and other affected structures of the chest wall in severe cases with the following necessity for flap reconstruction. The aspect of possible post-interventional instability after resection of the SCJ receives little or no attention in the current literature. In the present case report of a 51-year-old, otherwise healthy gentleman with isolated monoarthritis of the right SCJ with *Escherichia coli* (*E. coli*) shortly after two prostatitis episodes, the possibility of a new surgical approach with a one-stage eradication and simultaneous stabilization of the SCJ is presented. Therefore, a joint resection including extensive debridement is performed while leaving the posterior joint capsule and inserting an antibiotic carrier. In the same procedure, the SCJ is then stabilized with an autologous gracilis tendon graft by using the “figure of eight” technique, which has become well established particularly for anterior instabilities of the SCJ in recent years.

Results and Conclusion One year after operative therapy, the patient presented symptom-free with an excellent clinical result (SSV 90%, CS89 points, CSM 94 points, TF 11 points, DASH 2.5 points). It is concluded that in selected cases with an infection restricted to the SCJ without major abscessing in the surrounding soft tissues, the demonstrated procedure leads to good and excellent clinical results with stability of the joint. If the focus of infection and germ are known, stabilization using an autologous graft can be carried out under antibiotic shielding. To the best of the authors' knowledge, this surgical procedure has not yet been described in the current literature. Depending on the extent of the resection, an accompanying stabilization of the SCJ should be considered to achieve stable conditions and an optimal clinical outcome.

ZUSAMMENFASSUNG

Einleitung Septische Arthritiden des Sternoklavikulargelenks (SCG) stellen mit 0,5–1% aller Gelenkinfektionen eine Rarität im chirurgischen Alltag dar. Obwohl eine Vielzahl an Risikofaktoren für das Auftreten dieser Erkrankung existiert, können gelegentlich gesunde Menschen daran erkranken. Das klinische Erscheinungsbild präsentiert sich mitunter sehr variabel und reicht von unspezifischen Symptomen bis hin zu schwerwiegenden Folgeerscheinungen (Mediastinitis, Sepsis, Jugularvenenthrombose). Zusammen mit der niedrigen Inzidenz und der Unbekanntheit der Erkrankung bei praktizierenden Ärzten anderer Fachrichtungen resultiert dies nicht selten in einer Verzögerung der Diagnosestellung, was neben einer deutlichen Einschränkung der Lebensqualität u.U. auch verheerende Folgen für den Patienten nach sich ziehen kann.

Patient und Methode Gemäß eines stadienabhängigen Vorgehens reichen die Therapiestrategien von der reinen antibiotischen Abschirmung bis hin zu einer radikal-chirurgischen Resektion des Gelenks und anderer betroffener Strukturen der Thoraxwand in schwerwiegenden Fällen mit möglicher Notwendigkeit einer plastischen Deckung. Der Aspekt einer möglichen postinterventionellen Instabilität nach Resektion des SCG findet dabei in der aktuellen Literatur wenig bis keine Beachtung. Im vorliegenden Fallbeispiel eines 51-jährigen, ansonsten gesunden Patienten mit isolierter Monoarthritis des rechten SCG mit *Escherichia coli* (*E. coli*) kurze Zeit nach

2-maliger Prostatitis soll die Möglichkeit einer neuen operativen Herangehensweise mit einzeitiger Infektsanierung und gleichzeitiger Stabilisierung des SCG vorgestellt werden. Hierbei wird zunächst eine Gelenkresektion inkl. eines ausführlichen Débridements durchgeführt, wobei die hintere Gelenkkapsel belassen und ein Antibiotikaträger eingelegt wird. Anschließend erfolgt in derselben Prozedur die Stabilisierung des SCG mittels eines autologen Gracilissehnengrafts in der insbesondere für anteriore Instabilitäten etablierten „figure-of-eight“-Technik.

Ergebnisse und Schlussfolgerung Ein Jahr nach operativer Therapie präsentiert sich der Patient im Follow-up beschwerdefrei mit einem exzellenten klinischen Resultat (SSV 90%, CS89 Punkte, CSM 94 Punkte, TF 11 Punkte, DASH 2,5 Punkte). Es wird daraus geschlussfolgert, dass das demonstrierte Vorgehen in ausgewählten Fällen mit einer auf das SCG beschränkten Infektion zu guten klinischen Ergebnissen mit stabilen Gelenkverhältnissen führt und bei bekanntem Keim einzeitig unter antibiotischer Abschirmung nach Fokussanierung eine Stabilisierung mithilfe eines autologen Sehngrafts erfolgen kann. Nach Kenntnis der Autoren wurde dieses chirurgische Vorgehen bis dato in der Literatur noch nicht beschrieben. Abhängig vom notwendigen Resektionsausmaß sollte eine damit einhergehende Stabilisierung des SCG in Betracht gezogen werden, um stabile Verhältnisse und ein optimales Patientenoutcome zu erzielen.

Introduction

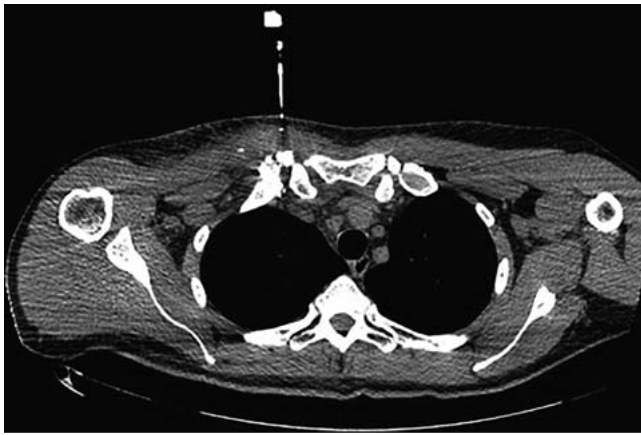
Septic arthritis of the sternoclavicular joint (SCJ) is rare in day-to-day surgical practice, representing 0.5–1% of all joint infections in humans. Arlet and Ficat presented the first scientific pathology report in 1958 with their publication of two cases which were successfully treated and cured by radical resection [1]. The disorder presents unilaterally in 95% of cases, although there are also case reports of bilateral infections [2, 3]. Microbiological examinations most commonly isolate staphylococcus aureus as the causal organism. It is the haematogenous spread of pathogens that usually leads to abscess formation in the SCJ. Although the disease can also affect healthy individuals, distinct risk factors are reported in the literature for the development of septic arthritis of the SCJ. Apart from male sex, a positive history of intravenous drug abuse, previous central venous catheter insertion (above all in the subclavian vein), immunosuppression (chemotherapy, maintenance glucocorticoid therapy, HIV, etc.) and other foci of infection, risk factors also include chronic underlying conditions such as diabetes mellitus, chronic renal failure and rheumatoid arthritis [4–6]. The clinical presentation can be most varied, ranging from non-specific symptoms such as local non-painful swelling or non-specific ipsilateral chest pain to erythema, tenderness, dysphagia or limitation of motion of the affected shoulder girdle, and even to severe sequelae of mediastinitis, generalised sepsis or occasionally even thrombosis of the jugular vein [6–10]. The combination of low incidence and unawareness of the disorder amongst practitioners of other specialties not uncommonly results in delay in

diagnosis, which can sometimes lead to serious repercussions for the patient, in addition to a considerably reduced quality of life.

Based on the following case study of a 51-year-old male in whom prostatitis had been diagnosed and treated twice in short succession, the option of one-stage management of the infection with simultaneous stabilisation of the SCJ using an autologous tendon graft for isolated right-sided septic monoarthritis due to *Escherichia coli* (*E. coli*) will be presented.

Case History and Clinical Examination

The patient initially presented in the central admissions unit with a referral from the medical emergency services end of december. He complained of suffering from a swelling in the region of the right clavicle in the absence of erythema or fever since november. He also reported suffering since then from intermittent limitation of motion of the right shoulder which, being right-handed, had caused him significant problems in everyday life. In the night before admission he had also experienced exacerbation of nocturnal pain at rest with an NRS of 8/10, resulting in the immediate presentation at the hospital. Clinical examination revealed a tender swelling over the right superior thoracic aperture, measuring approx. 4 × 4 cm and associated with initial articular stability of the SCJ and ACJ, pain radiating to the anterior shoulder and as far as the right elbow, together with ubiquitous limitation of motion of abduction/anteversion of 80°/70°. The laboratory results revealed a CRP level of 1.5 mg/dl with a normal white blood count and no other abnormalities.



► **Fig. 1** CT-assisted aspiration of the right SCJ was initially performed for pathogen identification.

Regarding his recent past history, the patient reported that he had experienced fever, chills and pollakiuria for the first time in the middle of October. His urologist had started antibiotic treatment with ciprofloxacin, which the patient had stopped five days later due to severe headache. Over the further clinical course, he developed an anal fissure a few days later which healed with the help of appropriate hygienic measures. Furthermore, he reported recurrent prostatitis from the middle of November which was treated antibiotically, initially with penicillin and later, once again, with ciprofloxacin for a total of ten days, and for which he had been on sick leave for four weeks. When the swelling reported above developed, neither urologist nor general practitioner were able to explain the symptom, so they prescribed symptomatic analgesic therapy.

Pre-existing conditions and regular medication were denied. His previous history included arthroscopy of the right shoulder joint in 2016 with subacromial decompression and bursectomy for impingement syndrome. The patient was admitted as an inpatient on the day of presentation for further diagnostics examinations.

Radiological Investigations

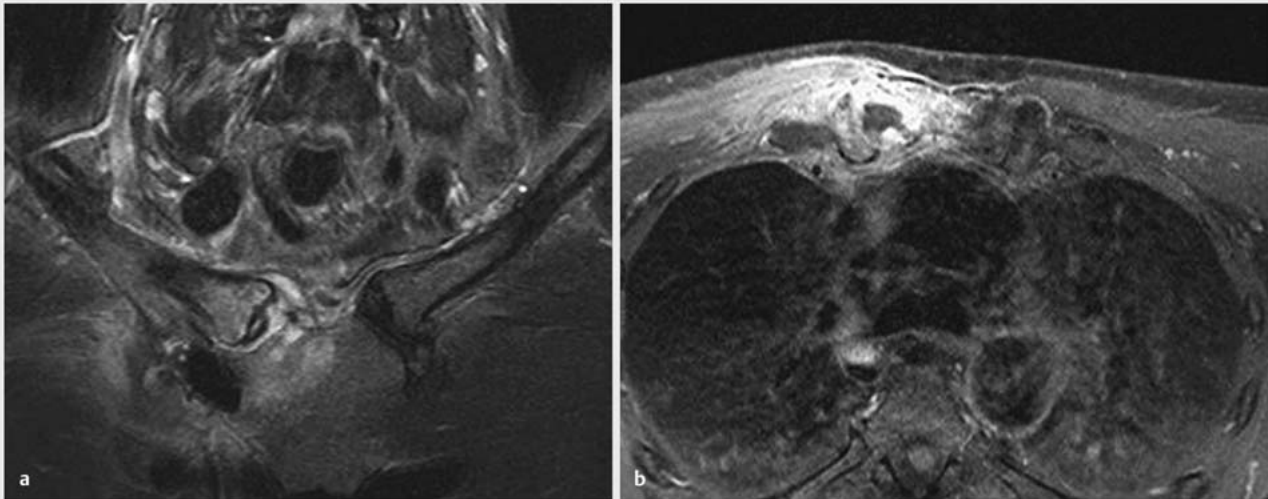
Plane radiographs of the right shoulder joint and clavicle in two projections did not produce any indicative pathological findings. The MRI scans obtained the following day revealed a high-grade fluid collection anterior to the costal cartilage of the right first rib, which was suggestive of an abscess involving the capsule of the SCJ, as well as joint infusion and oedema-like swelling of the contiguous structures. In order to obtain the required bacterial growth, we first decided to perform CT-assisted aspiration, from which 1.5 ml turbid effusion was obtained (► **Fig. 1**). Four days later, microbiological analysis revealed isolation of a multisensitive strain of *E. coli*. With only mild spread of the infection, a conservative treatment modality was pursued and after consultation with the microbiology department the already initiated empiric antibiotic treatment (IV cefazolin and clindamycin) was changed to IV ciprofloxacin in line with the resistogram.

Treatment Course and Therapy

The clinical findings improved during the first inpatient stay, but in retrospect without complete subjective resolution of the pain. Once the laboratory results had returned to normal and antibiotic treatment had been changed to oral administration, the patient was discharged into further outpatient care in the beginning of January 2019. Regular follow-up reviews by the patient's GP revealed renewed exacerbation of the inflammatory parameters despite continued oral antibiotic treatment. The patient continued to suffer from restricted movement, requiring extension of his incapacity-to-work note. He was presented to our consultant during our outpatient clinic three weeks later, when the indication for surgery was finally established. New MRI and CT diagnostic investigations of the superior thoracic aperture were obtained, with both revealing typical, arthritis-specific alterations (► **Fig. 2**). Clinical examination demonstrated instability of the joint. The decision was therefore made to stabilise the SCJ at the same time as bringing the infection under control.

Both the superior thoracic aperture and the right leg for tendon graft harvesting were prepped and draped with the upper body elevated to 30° (► **Fig. 3**). Firstly, the gracilis tendon was harvested with the aid of a tendon stripper via an oblique incision over the pes anserinus using the known standard technique. In the authors' view, this tendon is better suited for stabilisation of the SCJ than the semitendinosus tendon owing to its smaller diameter and flatter form. Stay sutures (FibreWire®, Arthrex GmbH, Munich) were then attached to both ends of the tendon using the baseball stitch technique. Parallel to harvesting the tendon, open resection of the joint capsule, the bony components of the medial clavicle and the sternal articular surface, as well as the damaged articular disc was performed (► **Fig. 4**). The posterior joint capsule was preserved due to its close anatomic proximity to the neurovascular bundle dorsal to the SCJ (brachiocephalic trunk, right subclavian artery and vein, right internal thoracic artery, right phrenic nerve). The capsule was debrided and a Sulmycin sponge inserted. Two K-wires each were then inserted in a V-shaped manner into the medial end of the clavicle and in the region of the sternum to guide holes drilled with a 4.0 mm cannulated drill bit. In modification of the Spencer and Kuhn technique, drilling was directed towards the joint space while ensuring that the posterior cortex was not breached in order to protect the above-mentioned anatomical structures [11]. After introducing the harvested tendon graft with the aid of pre-placed shuttle sutures, reconstruction was achieved using the figure-of-eight technique, by which the tendon limbs were sutured together after reduction of the joint and determining the required tension [12, 13] (► **Fig. 5**). The protruding ends of the tendon were excised, and the soft tissues then closed in layers. Altogether, the skin-incision to skin-closure time was 43 minutes with little blood loss and an uneventful intra-operative course.

The patient was discharged from the ward two days after surgery on 25.01.2019 with instructions to continue oral antibiotic treatment with ciprofloxacin for a total of three weeks. The pathology results confirmed the suspected infection in all submitted materials (disc, joint capsule, cartilage). Aftercare involved a Gilchrist sling without loading for six weeks with restriction of move-



► **Fig. 2** After failed conservative therapy, the up-dated MRI scan (STIR) confirmed erosive changes of the articular surfaces of the right SCJ, intra-articular effusion and subchondral bone marrow oedema secondary to reactive osteomyelitis of the juxta-articular bony components of the medial clavicle and the right side of the manubrium of sternum. **a** Frontal plane. **b** Transverse plane.

ment of abduction/anteversion to 60° for three weeks, then to 90° during weeks 3–6 with restriction of internal rotation to 80°. Release for full range of motion occurred from seventh postoperative week, with increased loading from the third month.

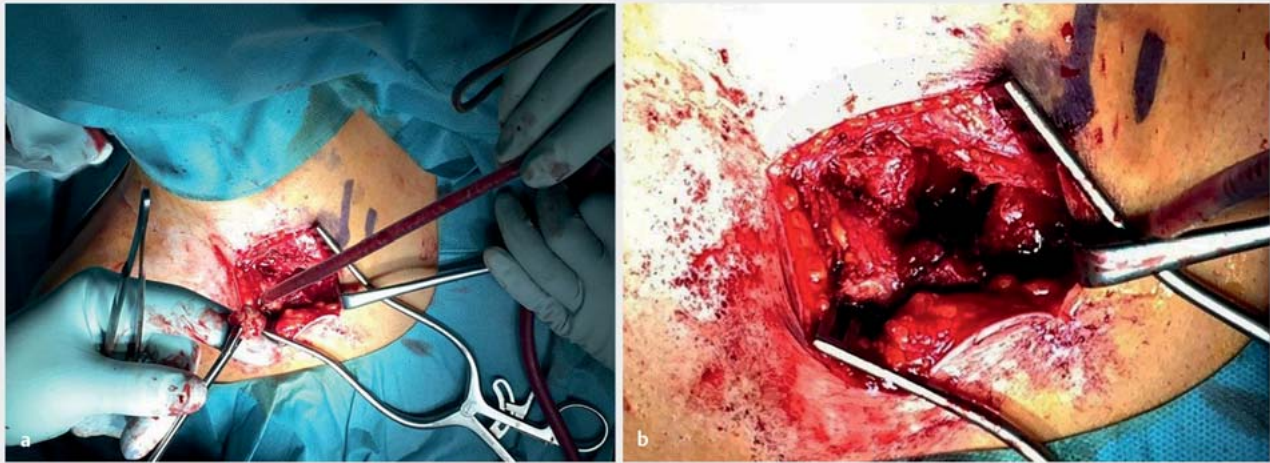
Follow-up

At the first clinical follow-up examination seven weeks after surgery, swelling of the right shoulder girdle had completely settled with no evidence of on-going infection. The joint healed in a stable condition, as confirmed on a CT follow-up scan (► **Fig. 6**). At this time, the patient himself was very pleased with the outcome of surgery; he was already fit for work as a bank clerk six weeks after surgery. After this examination, he was allowed to gradually increase loading.

At the one-year follow-up review, there were neither signs of recurrent infection nor tenderness in the region of the right SCJ. Clinical examination confirmed a stable joint in comparison with the contralateral side. Examination of the strength of both shoulder girdles revealed no abnormalities at all, with equal Janda strength grades of 5/5 on both sides on testing both rotator cuffs. The ranges of motion were demonstrated to be free and equal on both sides, with the exception of end-range restriction of deep internal rotation (right as far as L2, left as far as T10) (► **Fig. 7**). Scapular dyskinesia was not evident, neither clinically nor when applying the SICK Scapula Rating Scale (0/20 points). So far, SCJ-specific scores have not been reported in the literature, but evaluation of shoulder-specific scores produced the following very good outcome: Subjective Shoulder Value (SSV) 90%, Constant Score (CS) 89 points, age-adapted CS98.8 points, Taft Score (TF) 11 points, The Disabilities of the Arm, Shoulder and Hand Score (DASH) 2.5. The patient was satisfied with the cosmetic result and was completely satisfied with function associated with permanent absence



► **Fig. 3** Intraoperative setting: Patient placed in the supine position with the upper body elevated to 30°, sterile draping of the right leg, with tourniquet applied, and superior thoracic aperture for simultaneous operating.



► **Fig. 4** After placing a curved hockey stick incision above the palpable SCJ, resection is undertaken. **a** The damaged articular disc is removed (2×1.5 cm). **b** Situation after complete removal of the bony joint surfaces of the medial clavicle (left) and sternal components (right) as well as soft-tissue debridement.

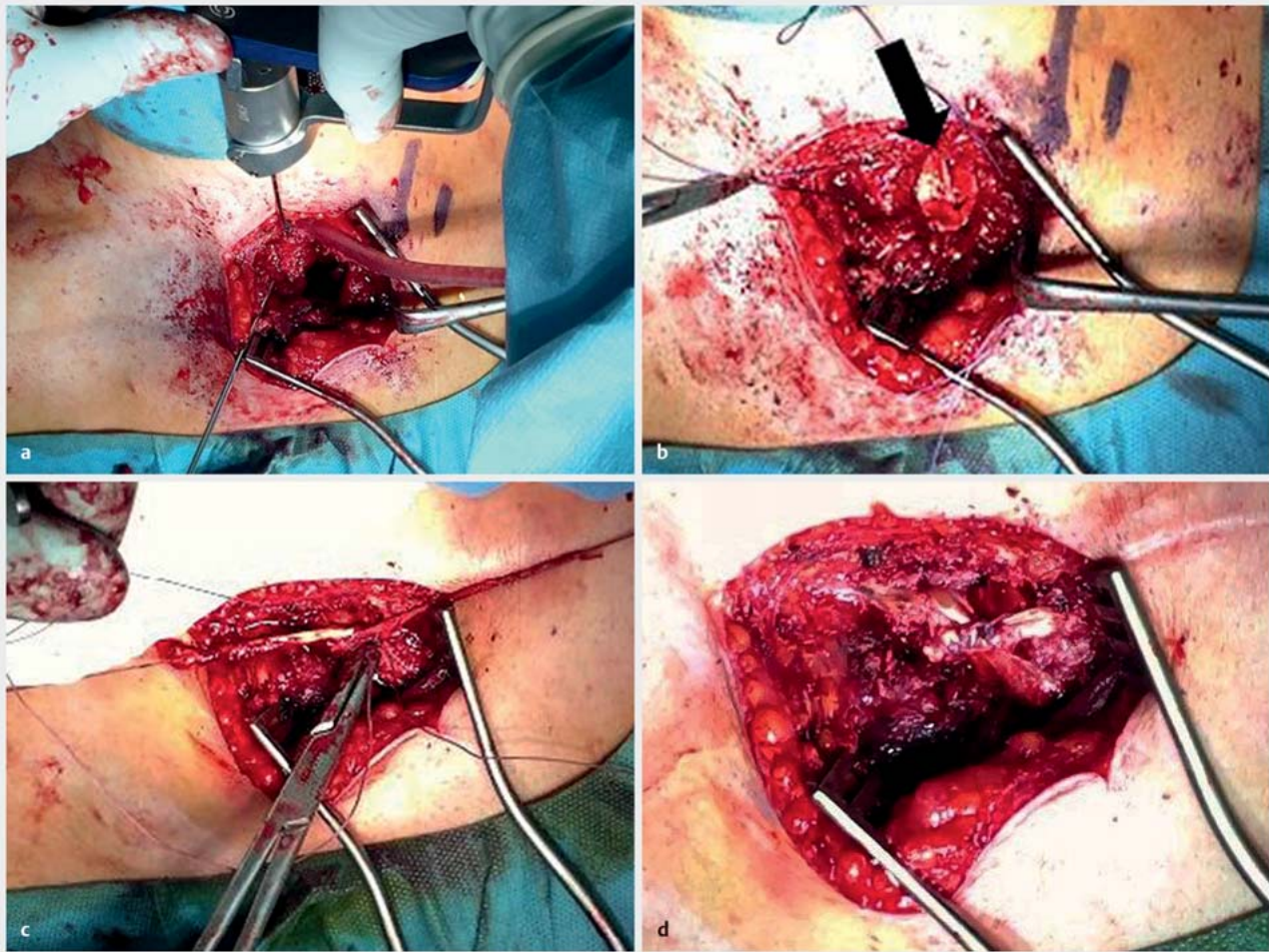
of pain. Work incapacity due to the reported pathology did not recur after surgery once he had taken up work again, and his level of sporting activity once again reached that of prior to surgery.

Discussion and Literature Review

Although septic arthritis of the SCG is a rare disorder, the diagnosis should be established quickly. In terms of anatomy, this joint is the only real connection between the shoulder girdle and the axial skeleton with a considerable range of motion. Only the antero-inferior pole of the medial, saddle-shaped end of the clavicle demonstrates cartilage cover and articulates with the concave surface of the sternal clavicular notch (► **Fig. 8**). The resulting joint incongruence is partially compensated on the one hand by an articular disc which, as such, is bradytrophic tissue and must be removed, in the authors' view, in the event of an infection of the joint. On the other hand, the SCJ is characterised by a tight capsular and ligamentous system which, in the event of increased articular fluid secondary to an infection, can rapidly lead to excess pressure within the joint, with the development of fistulae and purulent discharge into the surrounding tissue, associated with subsequent spread of the infection. In the present case, 39 days had elapsed between the occurrence of the initial symptoms and diagnosis, despite several medical presentations, clearly exceeding the average 14 days cited in the literature [14]. The patient admittedly received antibiotic cover for a while, but nevertheless, other studies report longer treatment periods with increased morbidity and mortality after developing complications such as abscess formation (neck phlegmon, chest wall abscess, mediastinitis, pleural effusion, etc.) or sepsis [7, 14]. Therefore, when septic arthritis of the SCJ is suspected, the aim must be to identify other foci of infection and immediately initiate appropriate diagnostic investigations. Conventional radiographs are unreliable for revealing changes such as osteolytic lesions, joint-space widening and tis-

sue proliferation and are therefore of minor significance here [7, 14]. Computed tomography is an important diagnostic tool, with the aid of which abscess formations and joint effusions can be detected while at the same time excluding mediastinal, pleural or even cervical involvement. Clinically relevant instability of the SCJ can also be demonstrated with the help of 3D-reconstructions. MRI is another component of the diagnostic workup and provides additional information, especially with regard to the extent of infection around juxta-articular bone which is essential for planning the surgical approach. The STIR sequence, in particular, will reveal signal increase from the increased fluid content secondary to inflammation-related increased perfusion [15]. It serves to distinguish from spondylarthritis which is part of the differential. In comparison, a study by Kang et al. discovered capsular distension of more than 5 mm, extracapsular fluid collection and periarticular muscle oedema significantly more often in the presence of septic arthritis [16]. Tietze's syndrome and SAPHO syndrome are relevant differential diagnostic considerations.

Staphylococcus aureus was reported as the most common cause of infection in the majority of the studies [6, 10, 17, 18]. Antibiotic treatment should therefore cover the gram-positive bacterial spectrum (e.g. cefazolin, oxacillin). Early administration of vancomycin should be considered where there is an appropriate risk profile supporting an infection with MRSA [14]. An infection with *Mycobacterium tuberculosis*, on the other hand, plays only a minor role, often involving immunocompromised patients [19]. *E. coli* was isolated in the present case study, which is rather rare, with only a few single-case reports to be found in the literature. Yousef et al., for example, report the case of a 87-year-old patient who was being treated in hospital for sepsis secondary to pyelonephritis, when he secondarily developed septic monoarthritis of the left SCJ which went on to heal completely under antibiotic monotherapy [20]. Given the time link and the appropriate pathogen, we also assume in our case study that there was

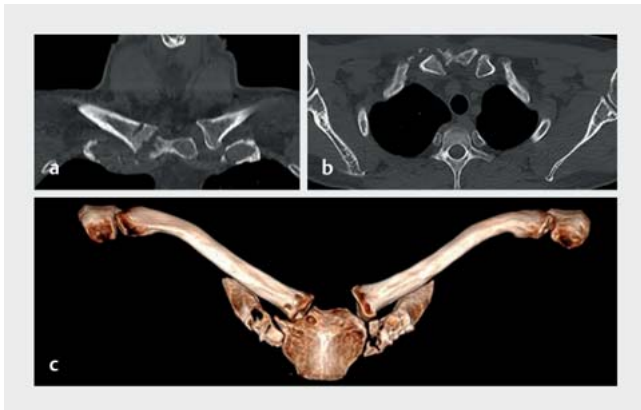


► **Fig. 5** Individual surgical steps for stabilisation of the SCJ using the harvested gracilis tendon in the figure-of-eight technique. **a** V-shaped insertion of two K-wires each into the medial clavicle and the sternum with sufficient distance from the joint, then drilling with a 4.0 mm cannulated bit. **b** Pre-placed shuttle sutures in the clavicle and sternum, the arrow indicates the dorsal position of the dorsal Sulmycin sponge. **c** After defining the tension of the inserted tendon limbs, they are then sutured together. **d** Final result of the figure of eight prior to wound closure in layers.

haematogenous spread from the urogenital tract following a history of previous prostatitis.

More interesting is the question of choosing the right path of surgical management. The literature provides various approaches to this, but a generally accepted treatment algorithm has not yet become established since the studies available so far only comprise mainly retrospective case series. In 2004, Ross et al. published a review containing the so far largest case number totalling in all 180 patients. One-hundred-and-two patients received surgical treatment, 48 of whom underwent limited debridement of the affected bone and soft tissue, while the remaining 54 patients were treated with en-bloc resection of the SCJ with removal of almost one half of the manubrium of sternum as well as the medial third of the clavicle. Thirteen of the 54 patients in the limited debridement group were treatment failures and were consequently operated on at least one occasion. The authors therefore recommend joint resection if any of the following factors are noticed

during the pre-operative diagnostic workup: signs of bony destruction, chest wall phlegmon or abscess, retrosternal abscess, mediastinitis or pleural spread [14]. Abu Arab et al. used five grades of infection based on clinical and radiological criteria and derived from them a graduated algorithm for the therapeutic management of septic arthritis of the SCJ [7]. Using this grading system, Jang et al. treated 22 patients with septic arthritis of the SCJ caused by staphylococcus aureus. Of these, 11 patients with grade I–III infections were treated medically and exclusively with antibiotics, the remaining 11 patients with grade IV–V infections underwent limited surgery (incision, necrosectomy, debridement, irrigation and drainage of the joint). After a median follow-up period of 53 weeks, the infections healed in all patients, for which reason the authors recommend limited surgery in the absence of any major complications [21,22]. Prospective studies which validate this approach, however, are not available. In 2012, Joethy et al. compiled and recommended a staged classification approach



► **Fig. 6** CT follow-up scan six weeks after surgery confirms a stable right SCJ. The drill tunnel defects are well defined in the region of the right manubrium of sternum and the medial clavicle. **a** Frontal view. **b** Transverse view. **c** 3D-reconstruction in comparison with the contralateral side.

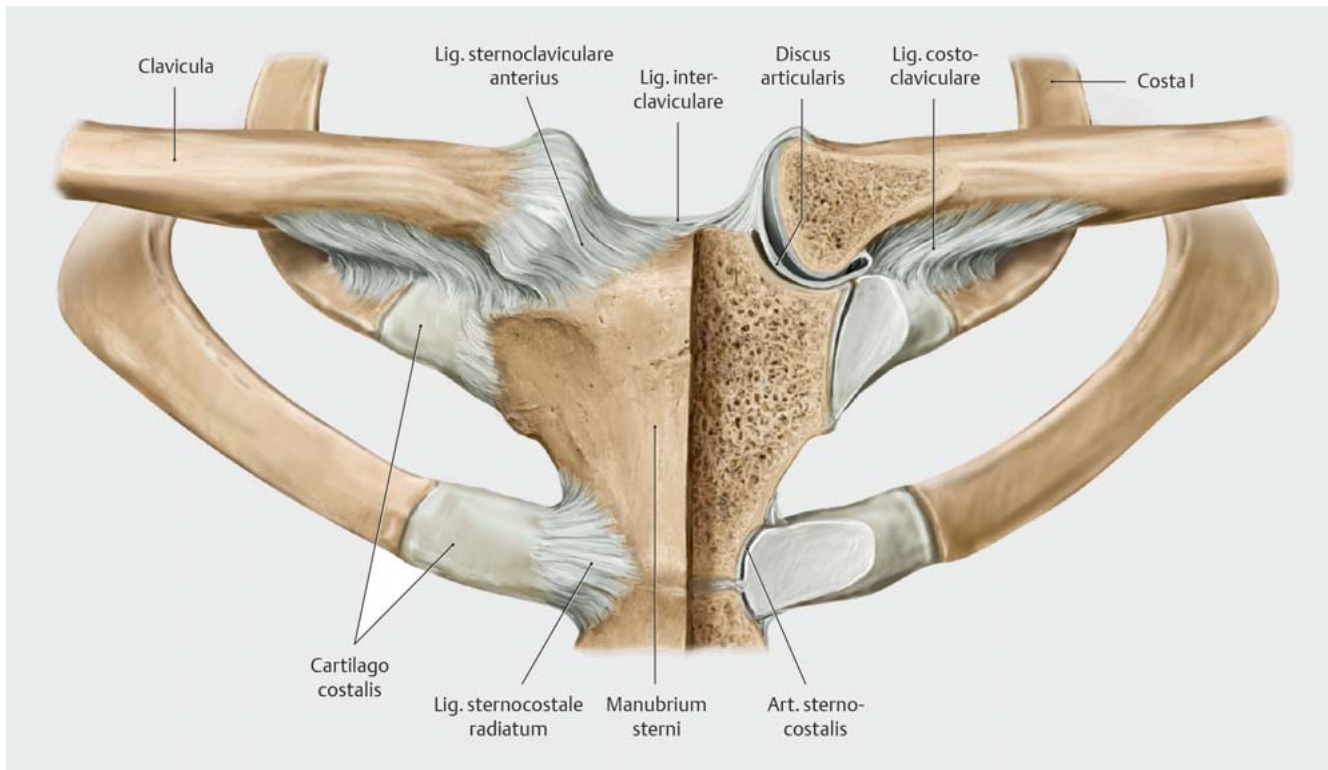
for dealing with post-resectional defects which comprised three groups ranging from secondary wound closure using a VAC dressing to muscle flap plasty (pectoralis major flap, latissimus dorsi flap), depending on the extent of the residual defect following surgical treatment [23].

In the present case, instability of the SCJ was evident at the time of establishing an indication for surgery. The complex capsular and ligamentous system comprises the following components: the anterior and posterior sternoclavicular ligaments, costoclavic-

ular ligament, parts of the interclavicular and intra-articular ligaments, including the articular disc (► **Fig. 8**). The importance of these components with regard to stability for anterior/posterior and superior/inferior translation of the SCJ is impressively demonstrated by von Spencer et al. in their biomechanical study [11]. Several studies are available dealing with the clinical entity of SCJ instability which demonstrate good to very good clinical results associated with a low revision risk following SCJ stabilisation using a figure-of-eight autologous tendon graft reconstruction method [12, 13, 24–26]. In their biomechanical study, Martetschlaeger et al. demonstrated an advantage with regard to fracture risk and construct stability of the straight drill-tunnel technique in comparison with the oblique method used in our case study [27]. The literature available on the issue of instability of the SCJ following joint resection for septic arthritis, on the other hand, is sparse. Chun et al. take up this problem in their publication and demand adequate reconstruction of the SCJ after resection. With the idea of improving postoperative stability of the SCJ in mind, the authors left both the costoclavicular and the posterior sternoclavicular ligaments intact in their case series of ten patients who underwent oblique resection of 1.5–2 cm of the medial clavicle. They also performed intramedullary ligament reconstruction of the anterior sternoclavicular ligament which was left intact at its sternal insertion into the medial end of the clavicle. The follow-up assessment after application of this technique did not detect any postoperative instability of the SCJ [28]. Long-segment resections of the medial clavicle in particular appear to have a destabilising effect, associated with restriction of abduction [6]. In their biomechanical study on a cadaveric model, Katthagen et al. showed that straight resection of 5–10 mm of the medial clavicle



► **Fig. 7** The final functional and cosmetic result was very good one year after surgery with a free range of motion in comparison with the contralateral side.



► **Fig. 8** Anatomy of the SCJ. A tight capsule encloses the joint; the incongruence of the articular surfaces is compensated by the articular disc. The relative position in relation to the neurovascular structures of the upper mediastinum situated immediately behind the joint is vitally important. (Source: Schuenke M, Schulte E, Schumacher U et al. 1.11 Schultergelenke [Shoulder Joints] Überblick und Schlüsselbeingelenke als Ganzes. [Overview and clavicular joints as a whole.] In: Schuenke M, Schulte E, Schumacher U. et al., published by Prometheus LernAtlas-Allgemeine Anatomie und Bewegungssystem [Learning Atlas – General Anatomy and Musculoskeletalsystem]. Fifth completely revised edition. Thieme; 2018. doi:10.1055/b-006-149643).

did not result in destabilisation of the SCJ [29]. Rockwood et al. demonstrated satisfactory results following resection arthroplasty of the SCJ for instability of the joint. They also emphasised the importance of preservation or reconstruction of the costoclavicular ligament to avoid cranial dislocation of the residual medial clavicle by traction of the sternocleidomastoid muscle, with subsequently worse results [30]. This was confirmed further in a cadaveric study by Lee et al. who demonstrated that the costoclavicular ligament has the largest footprint of all the SCJ stabilising structures and is therefore the strongest stabiliser. At the same time, they measured in their 11 examined cadavers an average distance of 10.3 mm of the medial-most fibres of the costoclavicular ligament from the inferior SCJ [24]. In their study, Panzica et al. also stressed the importance of stabilising the medial clavicle to the first rib after resection of the medial clavicle [31].

The approach presented in this article is based on the authors' assumption that a clinically relevant degree of destabilisation can develop, possibly associated with functional impairment and clinical symptoms, as a result of joint resection, the extent of which is ultimately determined by the magnitude of the infection. Adequate treatment, therefore, must consider the aspect of infection eradication while maintaining stability of the SCJ. If the functional results published about case series of exclusive joint resections and debridement for septic arthritis of the SCJ are considered,

then a certain potential for improvement in function of the affected shoulder girdle may be postulated. In their retrospective case series of 13 patients followed-up after en-bloc resection of the SCJ, von Glinski et al. report an average DASH of 18.7, with an average follow-up time of 95 days [7]. The case series by Chun et al. mentioned above reports an average restriction of anteversion of 146° and of external rotation of 48° [4]. As part of a post-operative telephone survey of 11 patients, Kachala et al. report a QuickDASH of 19 ± 6.8 in their study of SC joint resections with primary or delayed wound closure using a VAC dressing [12].

In the present case, simultaneous stabilisation using the technique described above was performed under the assumption of improving the postoperative functional outcome and counteracting any potential sequelae resulting from instability. To the authors' knowledge, there has been no report of such a therapeutic approach in the literature so far. There is the potential risk here of inserting an atrophic tendon in a potentially infectious area, for which reason extensive debridement and perioperative antibiotic cover are recommended. The reported approach is therefore reserved for infection scenarios in which purely joint and bone involvement with no larger soft-tissue abscess formation are present.

It will be the future task of larger case series to demonstrate a benefit with regard to joint stability and functional outcome.

Conclusions for clinical practice

1. Septic arthritis of the sternoclavicular joint is a rare clinical entity with a multiform presentation which can, under certain circumstances, make diagnosis difficult. Should it be suspected, then a surgical consult should be arranged immediately to establish a diagnosis.
2. Although numerous risk factors have been reported, healthy individuals can also be affected.
3. Antibiotic treatment alone would only appear to be promising of success in early stages of the disorder, rendering the importance of surgical intervention undisputed. The exact extent of the infection must be determined before surgery with the aid of appropriate imaging in order to establish a surgical strategy.
4. Depending on the extent of the infection, radical surgical joint resection and debridement of any additionally affected structures using a stage-adapted approach (involved ribs, sternum, abscess drainage for mediastinitis, etc.) are indicated in severe cases. Mere needle aspiration is obsolete, while incision, abscess drainage and irrigation would only appear to be useful in early stages. Temporary application of a VAC dressing to condition the wound and reconstructive measures are available for the management of larger chest wall defects once the infection has been brought under control.
5. With septic arthritis confined exclusively to the SCJ, without involvement of other parts of the chest wall, single-stage surgical treatment with joint resection and simultaneous stabilisation with a gracilis tendon graft resulted in the present case study in a stable joint and very good functional results. Targeted perioperative antibiotic cover is recommended, while other potential foci of infection must also be identified and treated.

Conflict of Interest

Helmut Lill works as an advisor and lecturer for Arthrex as well as lecturer for DePuy Synthes. Marek Hanhoff, Gunnar Jensen und Rony-Orijit Dey Hazra confirm that there are no conflicts of interest to declare.

References

- [1] Arlet J, Ficat P. Osteo-arthritis of the sterno-clavicular joint. *Ann Rheum Dis* 1958; 17: 97–100. doi:10.1136/ard.17.1.97
- [2] Masmoudi K, Elleuch E, Akrouf R et al. Bilateral septic arthritis of the sternoclavicular joint complicating infective endocarditis: a case report. *J Med Case Rep* 2018; 12: 205. doi:10.1186/s13256-018-1709-9
- [3] Pradhan C, Watson NFS, Jagasia N et al. Bilateral sternoclavicular joint septic arthritis secondary to indwelling central venous catheter: a case report. *J Med Case Rep* 2008; 2: 131. doi:10.1186/1752-1947-2-131
- [4] Bar-Natan M, Salai M, Sidi Y et al. Sternoclavicular infectious arthritis in previously healthy adults. *Semin Arthritis Rheum* 2002; 32: 189–195. doi:10.1053/sarh.2002.37284
- [5] Gallucci F, Esposito P, Carnovale A et al. Primary sternoclavicular septic arthritis in patients without predisposing risk factors. *Adv Med Sci* 2007; 52: 125–128
- [6] von Glinski A, Yilmaz E, Rausch V et al. Surgical management of sternoclavicular joint septic arthritis. *J Clin Orthop Trauma* 2019; 10: 406–413. doi:10.1016/j.jcot.2018.05.001
- [7] Abu Arab W, Khadragui I, Echavé V et al. Surgical management of sternoclavicular joint infection. *Eur J Cardiothorac Surg* 2011; 40: 630–634. doi:10.1016/j.ejcts.2010.12.037
- [8] Er C, Tey VHT, Kuthiah N et al. A case of Lemierre-like Syndrome: Internal jugular vein thrombosis secondary to *Staphylococcus aureus* sternoclavicular joint septic arthritis. *Oxf Med Case Reports* 2019; 2019: omz059. doi:10.1093/omcr/omz059
- [9] McAninch SA, Smithson C, Juergens AL et al. Sternoclavicular joint infection presenting as nonspecific chest pain. *J Emerg Med* 2018; 54: 229–231. doi:10.1016/j.jemermed.2017.11.026
- [10] Rodchuae M, Ruangpin C, Katchamart W. Clinical manifestations, treatment outcomes, and risk factors for sternoclavicular septic arthritis. *Rheumatol Int* 2017; 37: 819–824. doi:10.1007/s00296-017-3673-x
- [11] Spencer EE, Kuhn JE. Biomechanical analysis of reconstructions for sternoclavicular joint instability. *J Bone Joint Surg Am* 2004; 86: 98–105. doi:10.2106/00004623-200401000-00015
- [12] Martetschläger F, Braun S, Lorenz S et al. Novel technique for sternoclavicular joint reconstruction using a gracilis tendon autograft. *Knee Surg Sports Traumatol Arthrosc* 2016; 24: 2225–2230. doi:10.1007/s00167-015-3570-3
- [13] Martetschläger F, Warth RJ, Millett PJ. Instability and degenerative arthritis of the sternoclavicular joint: a current concepts review. *Am J Sports Med* 2014; 42: 999–1007. doi:10.1177/0363546513498990
- [14] Kuhtin O, Schmidt-Rohlfing B, Dittrich M et al. Behandlungsstrategie der septischen Arthritiden des Sternoklavikulargelenks. *Zentralbl Chir* 2015; 140 (Suppl. 1): S16–S21. doi:10.1055/s-0034-1382922
- [15] Ross JJ, Shamsuddin H. Sternoclavicular septic arthritis: review of 180 cases. *Medicine (Baltimore)* 2004; 83: 139–148. doi:10.1097/01.md.0000126761.83417.29
- [16] Kang BS, Shim HS, Kwon WJ et al. MRI findings for unilateral sternoclavicular arthritis: differentiation between infectious arthritis and spondyloarthritis. *Skeletal Radiol* 2019; 48: 259–266. doi:10.1007/s00256-018-3023-4
- [17] Murga A, Copeland H, Hargrove R et al. Treatment for sternoclavicular joint infections: a multi-institutional study. *J Thorac Dis* 2017; 9: 1503–1508. doi:10.21037/jtd.2017.05.76
- [18] Nusselt T, Klinger H-M, Freche S et al. Surgical management of sternoclavicular septic arthritis. *Arch Orthop Trauma Surg* 2011; 131: 319–323. doi:10.1007/s00402-010-1178-0
- [19] Sahu S. Sternoclavicular tuberculosis. *Med J Armed Forces India* 2008; 64: 373–374. doi:10.1016/S0377-1237(08)80031-7
- [20] Youssef D, Bhargava A. *Escherichia coli* bacteremia with secondary seeding in the sternoclavicular joint: a case report and literature review. *Germs* 2019; 9: 43–46. doi:10.18683/germs.2019.1156
- [21] Jackson RS, Carter YM, Marshall MB. Surgical management of the infected sternoclavicular joint. *Operative Techniques in Thoracic and Cardiovascular Surgery* 2013; 18: 42–52. doi:10.1053/j.optechstcvs.2013.02.001
- [22] Jang Y-R, Kim T, Kim M-C et al. Sternoclavicular septic arthritis caused by *Staphylococcus aureus*: excellent results from medical treatment and limited surgery. *Infect Dis (Lond)* 2019; 51: 694–700. doi:10.1080/23744235.2019.1639810
- [23] Joethy J, Lim CH, Koong HN et al. Sternoclavicular joint infection: classification of resection defects and reconstructive algorithm. *Arch Plast Surg* 2012; 39: 643–648. doi:10.5999/aps.2012.39.6.643
- [24] Lee JT, Campbell KJ, Michalski MP et al. Surgical anatomy of the sternoclavicular joint: a qualitative and quantitative anatomical study. *J Bone Joint Surg Am* 2014; 96: e166. doi:10.2106/JBJS.M.01451
- [25] Willinger L, Schanda J, Herbst E et al. Outcomes and complications following graft reconstruction for anterior sternoclavicular joint instability. *Knee Surg Sports Traumatol Arthrosc* 2016; 24: 3863–3869. doi:10.1007/s00167-015-3770-x

- [26] Martetschläger F, Imhoff AB. Operative Stabilisierung der akuten/chronischen Sternoklavikulargelenkinstabilität mit autologem Graziliseh-nengraft. *Oper Orthop Traumatol* 2014; 26: 218–227. doi:10.1007/s00064-013-0275-y
- [27] Martetschläger F, Reifenschneider F, Fischer N et al. Sternoclavicular joint reconstruction fracture risk is reduced with straight drill tunnels and optimized with tendon graft suture augmentation. *Orthop J Sports Med* 2019; 7: 2325967119838265. doi:10.1177/2325967119838265
- [28] Chun JM, Kim JS, Jung HJ et al. Resection arthroplasty for septic arthritis of the sternoclavicular joint. *J Shoulder Elbow Surg* 2012; 21: 361–366. doi:10.1016/j.jse.2011.05.020
- [29] Katthagen JC, Marchetti DC, Dahl KD et al. Biomechanical comparison of surgical techniques for resection arthroplasty of the sternoclavicular joint. *Am J Sports Med* 2016; 44: 1832–1836. doi:10.1177/0363546516639302
- [30] Rockwood CA, Groh GI, Wirth MA et al. Resection arthroplasty of the sternoclavicular joint. *J Bone Joint Surg Am* 1997; 79: 387–393. doi:10.2106/0004623-199703000-00011
- [31] Panzica M, Zeichen J, Hankemeier S et al. Long-term outcome after joint reconstruction or medial resection arthroplasty for anterior SCJ instability. *Arch Orthop Trauma Surg* 2010; 130: 657–665. doi:10.1007/s00402-009-0911-z
- [32] Kachala SS, D'Souza DM, Teixeira-Johnson L et al. Surgical management of sternoclavicular joint infections. *Ann Thorac Surg* 2016; 101: 2155–2160. doi:10.1016/j.athoracsur.2016.01.054