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Short- and long-term quality of life in patients after surgically treated Spondylodiscitis

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Die Daten, auf denen die vorliegende Arbeit basiert, wurden teilweise publiziert:

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AIDS	Acquired immunodeficiency syndrome
ACCI	Age-adjusted Charlson Comorbidity Index
ESR	Erythrocyte Sedimentation Rate
CI	Confidence interval
CRP	C-reactive Protein
CT	Computed Tomography
MCS	Mental Component Summary
MRI	Magnetic Resonance Imaging
MRSA	Methicillin Resistant Staphylococcus Aureus
ODI	Oswestry Disability Index
Op	Operation
OR	Odds Ratio
PCS	Physical Component Summary
QoL	Quality of life
SF-MPQ	Short form-McGill Questionnaire
SF-36	Short Form Health 36
SF-WAI	Short Form Work Ability Index
WBC	White Blood Cell

1 Introduction

1.1   Spondylodiscitis

1.1.1   Definition

Spondylodiscitis represents a severe spinal infection, affecting intervertebral discs (discitis) and the adjacent parts of the vertebral bodies (spondylitis), often resulting in the destruction of the diseased segment (Pola et al. 2017). Based on its etiology, the disease is categorized as pyogenic, granulomatous or parasitic (Hadjipavlou et al. 2000).

1.1.2   Epidemiology

The incidence rate for unspecific spondylodiscitis varies from 4 to 24 per million per annum, depending on multiple factors, such as collective patient criteria (Digby and Kersley 1979; Joughin et al. 1991; Colmenero et al. 1997; Chelsom and Solberg 1998; Krogsgaard et al. 1998; Beronius et al. 2001; Hopkinson et al. 2001; Grammatico et al. 2008). Today, the recorded incidence rate varies from 0.2 to 2.4 per 100,000 per annum (Cottle and Riordan 2008; Skaf et al. 2010; Cheung and Luk 2012) and accounts for 3 - 5% of all osteomyelitis cases (Sobottke et al. 2008a). Men are 1.5 to 2 times more likely to be diagnosed for unknown reasons (Sapico and Montgomerie 1979; Grammatico et al. 2008; Mylona et al. 2009). Although the disease can occur at any age, it peaks in individuals aged between 50 and 70 years. Merely 10% of patients are under 50 (Digby and Kersley 1979; Sapico and Montgomerie 1979; Malawski and Lukawski 1991; Krogsgaard et al. 1998; Gerighausen 2012). However, tuberculous spondylodiscitis occurs more frequently in younger patients (Gerighausen 2012). Spine infection occurs most commonly in the lumbar region (58%), followed by the thoracic region (30%), and finally the cervical region (11%) (Mylona et al. 2009).

In the twentieth century, over 50% of spondylodiscitis were caused by Mycobacterium tuberculosis (Jensen et al. 1997; Yee et al. 2010; Cheung and Luk 2012; Rutges et al. 2016). Today, the nature of the disease is mostly pyogenic (Jensen et al. 1997; Yee et al. 2010; Cheung and Luk 2012; Rutges et al. 2016). Studies show that there has not only has there been a rise in pyogenic spondylodiscitis, but also a rise in the overall incidence rate (Cervan et al. 2012; Cheung and Luk 2012; Guerado and Cerván 2012; Rutges et al. 2016). A Danish report recorded a rise in spondylodiscitis cases from 2.2 per 100,000 persons per annum in 1995 to 5,8 per 100,000

persons per annum in 2008 (Kehrer et al. 2014; Pola et al. 2017) and in Japan there has been an increase from 5.3 per 100,000 in 2007 to 7.4 per 100,000 in 2010 (Akiyama et al. 2013). This trend may be due to several reasons. Firstly, diagnostical quality has improved dramatically as a result of increased accuracy and a more widespread access to magnetic resonance imaging (MRI) (Carragee 1997b). Secondly, risk factors for spinal infections including immunosuppression, intravenous drug use, higher age (due to increasing life expectancy) and invasive spinal procedures (source of iatrogenic infection) are continuously rising (Carragee 1997a, Musher et al. 1976, Deyo et al. 2004, Pola et al. 2017). Despite still being rare, spondylodiscitis is the most common spinal infection and has a mortality of approximately 5 to 10% (Rutges et al. 2016; Dragsted et al. 2017).

1.1.3 Etiology and Pathogenesis

Spondylodiscitis most often originates from a septic dissemination from endogenous distant foci (Mylona et al. 2009; Pola et al. 2017). Spondylodiscitis can also have iatrogenic etiology (for example from discography, lumbar disc procedures, epidural procedures, etc.), contributing to up to 30% of all cases (Jiménez-Mejías et al. 1999; Legrand et al. 2001). Spread per continuitatem is uncommon but can result after a ruptured esophagus or a retropharyngeal abscess, for example (Gouliouris et al. 2010).

Hematogenous infections are repeatedly overlooked because these infections are frequently clinically asymptomatic and often occur long before initial spondylodiscitis symptoms appear. Thus, a concrete correlation between spondylodiscitis and its hematogenous focus is difficult to identify, and a distant focus is found in only 50% of all cases (Michiels and Jäger 2017). Hematogenous spread can be arterial, venous or lymphatic (Sobottke et al. 2008a). According to Mylona et al., bacteria may arise from the urogenital tract (17%), followed by the heart (12%), skin, subcutaneous tissue, fascia, muscle (11%) and digestive tract (5%) (Mylona et al. 2009).

Among pyogenic spondylodiscitis cases, Staphylococcus aureus accounts for half of cases in Europe (Carragee 1997a; Hadjipavlou et al. 2000; McHenry et al. 2002). Hospital microorganisms such as Methicillin Resistant Staphylococcus Aureus (MRSA) have been increasingly reported over the last two decades (Torda et al. 1995; Hadjipavlou et al. 2000; Al-Nammari et al. 2007). Other important germs include Staphylococcus epidermidis, Streptococci (particularly Streptococcus viridans in urogenital infections) and gram-negative bacteria like Escherichia coli or Pseudomonas aeroginosa (predominantly found in intravenous drug user population) (Perronne et al. 1994; Torda et al. 1995; Colmenero et al. 1997; Turunc et al. 2007). Fungal (for example Candida or Aspergillus) and parasitic forms (for example Echinococcus)

represent less than 2% of all cases (Hadjipavlou et al. 2000; McHenry et al. 2002; Pigrau et al. 2005; Fantoni et al. 2012).

Tuberculosis is globally the most common cause of spinal infection and holds accountable for approximately 9% to 46% of all cases (Perronne et al. 1994; Colmenero et al. 1997; Tuli 2007; Turunc et al. 2007). Although currently less frequent than a century ago, tubercular spondylodiscitis is on the rise again due to increased travel and migration (Tuli 2002; Keil et al. 2005). The percentage of reported polymicrobial cases ranges below 10% (Mylona et al. 2009).

Immunosuppression (human immunodeficiency virus, chemotherapy etc.) or chronic disease favor the occurrence of spondylodiscitis (Ahlhelm et al. 2006; Huttner and Opravil 2006). Diabetes mellitus presents the most widely known risk factor among chronic illnesses. Nevertheless, advanced age, intravenous drug use, malignancy, rheumatological diseases, renal failure, obesity, chronic hepatitis, endocarditis, chronic steroid intake, urogenital infections and previous spinal surgeries are also considered to be important risk factors (Nolla et al. 2002; Schinkel et al. 2003; Butler et al. 2006; Sobottke et al. 2008b; Sobottke et al. 2008a; Sobottke et al. 2010).

To understand the pathological process of spondylodiscitis, it is important to consider the differences in spinal vascular supply in adults and children. In children, the vascularized venous plexus and arteries supply the spinal column and build extensive anastomoses between segmental veins, the portal system, equatorial and circumferential metaphyseal arteries (Skaf et al. 2010). This prevents a relevant embolization and thereby an extensive infarct, limiting the infection to the spinal disc (Gouliouris et al. 2010). With age, these intraosseous anastomoses diminish and end-veins and arteries are formed, risking larger infarcts and spread of infection (Wiley and Trueta 1959; Ratcliffe 1982; Ratcliffe 1985). Therefore, the course of spondylodiscitis in children is generally benign (Brown et al. 2001; Garron et al. 2002; Kayser et al. 2005).

1.1.4 Clinical presentation

Symptoms of spondylodiscitis are often unspecific, atypical, or not present. This leads to a delay in determining the correct diagnosis (Skaf et al. 2010; Cheung and Luk 2012; Rutges et al. 2016). The most common symptom found is back pain (90%), accompanied by paravertebral muscle tenderness and immobility. Fever is found in 52% of cases (Mylona et al. 2009). Radiating unspecific pain to the thorax, abdomen, leg, inguinal or pelvic region occurs in 50% to 93% of patients, often leading to an incorrect diagnosis or even unnecessary surgery (Malik and McCormick 1988; Jensen et al. 1998; Skaf et al. 2010). Complications in advanced stages of the

disease include abscesses (psoas, paravertebral, epidural and intraspinal), neurological dysfunctions, gibbus formation and death (Pigrau et al. 2005; Mylona et al. 2009). Important differential diagnoses include inflammatory (pyelonephritis, appendicitis etc.), neoplastic (malignant spine tumors etc.) or degenerative (erosive osteochondrosis, disc herniation etc.) processes (Sapico and Montgomerie 1979; Skaf et al. 2010).

1.1.5 Diagnosis

Diagnostic tools consist of anamnesis, physical examination, laboratory tests and modern radiological imaging (Rodiek 2001; Ahlhelm et al. 2006; Renker et al. 2009; Yoon et al. 2010). Identifying spondylodiscitis often proves to be a challenge due to its rare and unspecific nature. Studies show that the mean time period after recorded first symptoms to disease identification lies between two to six months (Zarghooni et al. 2012).

Past medical history taking should include symptom onset and duration, previous procedures (for example invasive surgical, spinal or oral intervention), chronic diseases and presence of risk factors, medication taken and accompanying symptoms such as neurological deficits, fever, weight loss and fatigue (Gerighausen 2012). The physical examination should focus on spinal tenderness, a complete neurological checkup and detection of potential sources of infection such as open skin wounds. Further symptoms to consider are pain in the leg, loss of motoric or sensory functions and urinary incontinence as they appear in up to a third of patients (Mylona et al. 2009; Gouliouris et al. 2010).

C-reactive Protein (CRP) is believed to be the most useful and accurate laboratory value to reflect infection. It is generally elevated and should be used to monitor disease progression (Rath et al. 1996; Chelsom and Solberg 1998; Beronius et al. 2001; Schimmer et al. 2002; Dufour et al. 2005; Euba et al. 2008). Furthermore, an elevation of the erythrocyte sedimentation rate (ESR) is also seen in almost all cases but is less specific (Gouliouris et al. 2010; Skaf et al. 2010). The white blood cell (WBC) count is thought to be the least precise laboratory finding and is elevated in only 35% of patients (Skaf et al. 2010). Pyogenic spondylodiscitis is usually accompanied with a rise in neutrophilic leukocytes compared with tubercular or brucellar spondylodiscitis (Colmenero et al. 1997; Sakkas et al. 2009). Approximately two-thirds of patients with spondylodiscitis may be anemic (Beronius et al. 2001; Hopkinson et al. 2001) and around 50% have a raised alkaline phosphatase serum value (Colmenero et al. 1997; Beronius et al. 2001).

Additionally, microbiological investigations and identification of causative pathogens remain important factors in the treatment of disease because of the wide variety of potentially responsible pathogens and increasing antibiotic resistance (Lillie et al. 2008). Three blood

culture pairs (aerobic, anaerobic) should be taken from every patient prior to initiation of antimicrobial therapy, even in the absence of elevated body temperature (Nolla et al. 2002; Sobottke et al. 2008a). Cultures are positive in around 50% of cases and prove to be helpful when selecting appropriate and effective antimicrobial therapy (Skaf et al. 2010). Accurate results are lower in postoperative infections, where a biopsy may be needed to confirm the diagnosis (Dufour et al. 2005).

Open biopsy techniques have shown the highest diagnostical accuracy (90%), (Nickerson and Sinha 2016; Michiels and Jäger 2017) followed by needle biopsy under CT (Computed Tomography)-guidance (70 to 100%) (An et al. 2006; Skaf et al. 2010).

Radiological imaging is also vital to achieving the correct diagnosis and deciding an appropriate therapy approach. The MRI is the ideal method for the radiological depiction and diagnosis of spondylodiscitis with a total accuracy of 94% (Modic et al. 1985; Sharif 1992; Maiuri et al. 1997; Ledermann et al. 2003). It offers an excellent anatomical resolution and provides a good depiction of soft tissue (Modic et al. 1985). Additionally, the MRI displays an image of the spine in three levels, picturing the inflammation and its extent in early stages of infection (Rodiek 2001; Huttner and Opravil 2006; Yoon et al. 2010; Gerighausen 2012). Gadolinium enhancement of surrounding tissue improves the accuracy of MRI (Post et al. 1990; Dagirmanjian et al. 1996). Figure 1 presents an example of an MRI picture of the lumbar spine showing spondylodiscitis at L5/S1 level. It shows increased signal intensity between L5 and S1 vertebrae after administered gadolinium contrast with paraspinous abscess formation, consistent with spondylodiscitis.

Figure 1: MRI of the lumbar spine showing spondylodiscitis at L5/S1 level (CC BY 3.0 picture from Choudhury et.al, Choudhury et al. 2009 in "Streptococcus viridans osteomyelitis and endocarditis following dental treatment: A case report", Source: https://www.researchgate.net/figure/MRI-Lumbar-Spine-showing-spondylodiscitis-at-L5-S1-level_fig1_38094370, Picture modified)

Conventional radiography occasionally reveals erosions of the end-plate and adjacent bone, narrowing of the disc space, loss of vertebral and disc height and structural deformities and destructions (Jevtic 2004; Skaf et al. 2010). These pathological changes occur only with a progression of the disease (only 2 to 8 weeks after onset of symptoms), making conventional methods unsuitable for early diagnosis (Waldvogel and Papageorgiou 1980). On the other hand, CT proves to be effective in portraying bone abnormalities and destructions in the early stages of the disease (Jevtic 2004), but will fail to demonstrate disc changes. It is less effective than MRI in imaging neural tissue and abscesses and is currently mostly used for the radiological

guidance of spinal biopsy, percutaneous punctures and abscess drainage (Kornblum et al. 1998; Chew and Kline 2001; Enoch et al. 2007; Gerighausen 2012). Figure 2 shows an example of spondylodiscitis in a CT-image, depicting C5/C6 vertebral body destruction.

Figure 2: CT of the cervical spine showing spondylodiscitis at the level of C5/C6 causing neurological symptoms (CC BY-SA 3.0 picture from Heilman's own work 2011 "An infected disc causing neurological symptoms", Source: https://commons.wikimedia.org/wiki/File:Pinfecteddisc.png, Picture modified)

Radionuclide bone imaging (bone scintigraphy) with Technetium-99m–methylene diphosphonate yields a sensitivity of 90%, but a poorer specificity of 78%, resulting in false-positive results (Modic et al. 1985; Gemmel et al. 2006). The scintigraphy results should be considered together with clinical, laboratory and imaging findings. This method of imaging can

additionally represent an alternative for patients with contraindications for MRI testing (artificial pacemakers, etc.). Furthermore, Fluorine-18 fluorodeoxyglucose positron emission tomography (FDG-PET) is an extremely sensitive technique for diagnosing spinal infections (Schmitz et al. 2001; Skaf et al. 2010). It can successfully differentiate between infectious and degenerative changes and has shown to be more effective in differentiating between tuberculous and pyogenic spondylodiscitis, compared to MRI (Stumpe et al. 2002; Lee et al. 2009). The tuberculin skin test and interferon-gamma release assays can expose a Tuberculosis infection if such a disease is suspected (Trecarichi et al. 2012; Mavrogenis et al. 2017). Histology, molecular diagnosis, and serology also contribute to ascertaining the diagnosis of spondylodiscitis (Kemp et al. 1973; Digby and Kersley 1979; Kornblum et al. 1998; Harris and Hartley 2003).

1.1.6   Therapy

The aims of treatment should be to cure the underlying infection, reduce pain, prevent or treat motor and sensory deficits and recreate spinal stability (Skaf et al. 2010). While some therapeutical recommendations exist, there is no systematized treatment of spondylodiscitis and therapy is largely determined by physician liking and experience (Sobottke et al. 2008a; Gasbarrini et al. 2011; Rutges et al. 2016). Surgical treatment can be instituted in addition to conservative treatment (Sobottke et al. 2008a; Bettini et al. 2009; Skaf et al. 2010; Guerado and Cerván 2012).

Conservative treatment can be considered when clinical indications are relatively mild or when the risk of operation appears too great (Klöckner et al. 2001; Schinkel et al. 2003; Sobottke et al. 2008a). Conservative therapy consists of spinal immobilization, orthosis, effective antimicrobial and pain therapy and careful clinical observation (Quiñones-Hinojosa and Rosenberg 2004; Sobottke et al. 2008a). The optimal antimicrobial route and duration is still not standardized and remains under discussion (Jensen et al. 1998; Butler et al. 2006; Linhardt et al. 2007). Grados et al. suggest that appropriate antibiotics should be given over a course of 12 weeks, as recommended for chronic bone infections (Grados et al. 2007). This recommendation varies depending on the patient's overall wellbeing and laboratory findings (for example CRP results) (Legrand et al. 2001; McHenry et al. 2002). Antimicrobial treatment should not start until the pathogen is identified, unless otherwise required (for example in sepsis patients) (Grados et al. 2007; Zarghooni et al. 2012). In such a case, wide-spectrum antibiotics should be administered (Ozuna and Delamarter 1996). Most patients can be managed successfully with non-operative treatment alone (Schinkel et al. 2003; Sobottke et al. 2008a; Mavrogenis et al. 2017). However, patients treated conservatively are often bed-bound, which raises the risk of

venous thromboembolism and pneumonia, potentially prolonging recovery-time and increasing mortality-rate (Zarghooni et al. 2012). Therefore, elderly patients and patients with poor general well-being may still be candidates for surgical treatment (Sobottke et al. 2010).

Surgical treatment is advised for patients with motor or sensor deficits, loss of spinal stability, high age, conservative treatment failure and the presence of an epidural abscess (Ozuna und Delamarter 1996; Butler et al. 2006; Darouiche 2006; Guerado und Cerván 2012; Gupta et al. 2014). A great variety of surgical techniques exist and a choice is made depending on surgeon preference and patient characteristics (Gouliouris et al. 2010).

The main goals of surgical management include spinal decompression, debridement, stabilization, and identification of the responsible pathogen (Sobottke et al. 2008a). Although guidelines vary, anterior debridement and stabilization appears to be the predominantly recommended approach (Sobottke et al. 2008a; Gouliouris et al. 2010). This procedure usually involves interbody implants arranged with internal fixation (Kuklo et al. 2006; Gonzalvo et al. 2011; Zarghooni et al. 2012; Shiban et al. 2014). In recent literature however, posterior and combined approaches have also been described (Ozturk et al. 2007; Včelák et al. 2014; Rutges et al. 2016). Less invasive techniques may yield at least comparable results to open surgery (Hadjipavlou et al. 2000; Lee et al. 2014; Včelák et al. 2014; Rutges et al. 2016; Keric et al. 2017). These surgical techniques are becoming more common as a consequence of reduced injury and destabilization of adjacent anatomical structures (Stokes et al. 2000). Nevertheless, open surgery still remains the conventional surgical approach for many clinicians (Ito et al. 2007; Rutges et al. 2016).

1.2   Research Question

In summary, the incidence of spondylodiscitis is rising because of an increase in the susceptible population. Spondylodiscitis is associated with a sizeable mortality rate and potential long-term disabilities. Quality of life after treatment has hitherto predicted to be reduced when compared to the general population. The aim of this dissertation was to examine the short and long-term outcomes of patients who underwent surgery for spondylodiscitis and to assess which prognostic factors affect these results.

2   Patients and methods

2.1   Study design and study population

This single-center retrospective cohort analysis was undertaken at the university medical center Göttingen, Germany. The study was approved by the ethical commission of Universitätsmedizin Göttingen (application number: 3/12/17) and archived in accordance with local and institutional laws and data protection regulations. The research was completed in agreement with the ethical principles provided in the Declaration of Helsinki and its later alterations.

This analysis was based on a retrospective chart review. Patient medical records were gathered with the help of a digital clinic dataset. It contained 218 patients who underwent surgical treatment for pyogenic spondylodiscitis from 2008 to 2017 in the Department of Neurosurgery. Patients had an average of 4.8 ± 2.4 years follow-up duration after initial surgery. Treatment was based on interdisciplinary consensus. The diagnosis of spondylodiscitis was based on patient history, physical examination, laboratory, and imaging findings. Bloodwork included CRP and full blood count. Identification of the causative pathogen was done by blood culture or biopsy where applicable.

All of the patients in this study obtained early intravenous antibiotic treatment and underwent spinal surgery. 115 patients (52.75%) received a standard free-hand operation, and 103 (47.25%) patients received a robot-facilitated operation.

Four questionnaires addressing quality of life, general well-being, work ability and back pain were distributed by regular mail to the patients. Patients could participate in the study if all requirements were met: a diagnosis of spondylodiscitis established on clinical, imaging, and serological results, surgical therapy of spondylodiscitis between January 2008 and July 2017, patient aged 18 years or older, ability to consent, knowledge of the German language and no death or severe cognitive impairment.

Patients were excluded when spondylodiscitis was treated conservatively. Patients with little to no understanding of the German language, no written consent, patient death or unavailability, severe cognitive impairment and/or unresponsiveness (for example patients under intubation or intensive medical care) did not receive questionnaires. Only the first episode of spondylodiscitis in a given patient was included in the study.

2.2   Study procedure

Patients received questionnaires by mail in June 2018. The letter also included information related to the study and a declaration of consent. Next, the patients were informed telephonically of the project and were kindly asked to take part in the study. The sent documents were to be filled out by the patient and returned. This procedure of sending the questionnaires by mail was repeated a second time in February 2019 after initially low feedback rates (14% response-rate). In addition to sending the questionnaires a second time, patients' general physicians were contacted and asked for further assistance regarding contact to the patient and knowledge of eventual death or migration.

2.3   Data collection

The World Health Organization (WHO) defines quality of life (QOL) as

> *an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards, and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment* (WHO | WHOQOL: Measuring Quality of Life).

Four questionnaires were chosen in order to grasp an insight into the patients' quality of life; the Oswestry Disability Index (ODI), the Short Form Health 36 (SF-36), the Short Form McGill Questionnaire (SF-MPQ) and the Short Form Work Ability Index (SF-WAI). Each of these questionnaires analyzes different aspects of life, which play a role to higher quality of life. All patient surveys were conducted in German.

2.3.1   Oswestry Disability Index (ODI)

The Oswestry Disability Index (also known as the Oswestry Low Back Pain Disability Questionnaire) is a widely used questionnaire that has been proved to be a reliable and valid tool for the measurement of permanent disability due to pain (Ebrahim 1989; Grönblad et al. 1993). The test comprises of ten items that ask the patients to reflect on their everyday functionality and to assess to what extent these activities are limited by their back pain. Each item is scored from 0 (no limitation) to 5 (maximal limitation). Scores are added and transformed to generate a disability score (0 to 100%). The items include (Fairbank and Pynsent 2000): Pain

intensity, Personal care (e.g., washing and dressing), Lifting, Walking, Sitting, Standing, Sleeping, Sex life (if applicable), Social life and Traveling.

2.3.2 Short Form Health 36 (SF-36)

The Short Form Health 36 survey is one of the most popular instruments for evaluating health-related quality of life (Lins and Carvalho 2016). The survey has been used to describe the personal health status of individuals and yields a collective outcome, differing to tests that focus on a certain age, gender, or race (Ware 2000). This aspect proves to be useful when determining the quality of life of a general population.

The SF-36 contains 36 questions and measures the following specific dimensions of health: Physical functioning (PF), Role limitations due to physical health (RP), Role limitations due to emotional problems (RE), Energy/fatigue or vitality (VIT), General mental health (MH), Social functioning (SF), Bodily pain (BP) and General health (GH).

For each element, results are coded and added to create a total outcome from 0 (worst possible health condition) to 100 (best possible health condition). The eight dimensions are additionally frequently summarized to generate two values: a Physical Component Summary (PCS) and a Mental Component Summary (MCS) (Stewart 2007). This survey concentrates less on the identification and quantification of bodily functions and more on the subjective view of the patient on his/her personal engagement in each of the eight dimensions. Scale scoring instructions were found on the RAND corporation website (https://www.rand.org/health-care/surveys_tools/mos/36-item-short-form/scoring.html).

2.3.3 Short Form McGill Questionnaire (SF-MPQ)

The SF-MPQ is a valuable tool for the assessment of the qualities of pain (Melzack 1987). The questionnaire evaluates the quality and intensity of pain, expressed in sensory pain index (11 items, 0 to 3 points each), affective pain index (4 items, 0 to 3 points each), current pain intensity on a visual analogue scale (0 to 10) and overall patient pain appraisal (on a scale from 0 to 5). For each aspect, scores are added to create a total result from 0 (none/ no pain) to 100 (worst possible pain perception) (Melzack und Torgerson 1971; Melzack 1975; Ngamkham et al. 2012). The survey provides physicians with useful information about the patient's perception of their present pain state (Strand et al. 2008).

2.3.4 Short Form Work Ability Index (SF-WAI)

The Short Form Work Ability Index is a well-founded tool to assess the work ability of a patient, in respect to his/her working demands, health status, and working capabilities (El Fassi et al. 2013). Currently, it is the most commonly utilized instrument for determining work ability (van den Berg et al. 2009). The survey includes seven scales regarding current work ability compared with lifetime best, the number of present diseases, the hinderance at work caused by these diseases, the nonattendance from work due to these diseases and lastly the patients' own prediction of work ability (Martus et al. 2010). Scores can be added to a total WAI outcome varying from 7 (unable to work) to 49 (full work ability), allowing a summarization of work ability: excellent (WAI 44 - 49), good (WAI 37 - 43), moderate (WAI 28 - 36) and poor (WAI ≤ 27) (Roelen et al. 2014).

2.3.5 Age-adjusted Charlson Comorbidity Index (ACCI)

The Charlson Comorbidity Index is a measurement tool used to evaluate the degree of comorbidity (Charlson et al. 1994). The Charlson Comorbidity Index was first introduced in 1984 and comprises nineteen weighted and summed comorbidity items (heart attack, heart failure, peripheral vascular disease, dementia, apoplexy, hemiplegia, chronic lung disease, liver disease, moderate or severe kidney disease, diabetes with/without with end organ damage, connective tissue disease, peptic ulcer, leukemia, lymphoma, tumor without metastasis, tumor with metastasis and acquired immunodeficiency syndrome (AIDS) (Yang et al. 2018). This index is most commonly applied to estimate therapy outcome and patient mortality (Charlson et al. 1987; Jiménez Caballero et al. 2013; Mayr et al. 2014; Yang et al. 2018). Age has also been determined to be an important predictor of survival and has been incorporated into the comorbidity index to form the age-adjusted Charlson Comorbidity Index (ACCI) (Charlson et al. 1994). This index was used in this study to assess and summarize patient comorbidities.

2.3.6 Additional Data

The following patient features were found and collected: demographics (name, date of birth, age, sex), past medical history and comorbidities (including smoking and immunosuppression), clinical data (surgical indications, preoperative pain, preoperative motor deficits, preoperative incontinence, epidural and/or intraspinal abscess, multi-resistant germs, method of diagnosis ascertainment, hemoculture and microorganism findings, date of discharge, date of last clinical follow-up), laboratory results (CRP and white blood count by admission, after 3 - 7 days, by discharge and last CRP available), antibiotic treatment (antibiotic choice, route, and duration),

surgery (date of surgery, surgery duration, radiation time, operated levels, surgical techniques), general postoperative complications and surgical postoperative complications (including new deficits, durotomy, screw misplacement/loosening, psoas abscess, wound infections with microorganism findings), necessity of revision surgery, i.e. wound revision or implant revision and outcome parameters (length of stay, 30-day mortality, one-year mortality, death, relapse infection, new pain relapse, new neurological deficit, progressive bone destruction, epidural abscess recurrence, residual disability, wound revision, revision surgery for construct failure, CRP, and WBC count at relapse infection).

2.4   Statistical Analysis

Statistical analysis took place in cooperation with the Department of Medical Statistics of the Universitätsmedizin Göttingen. Explorative comparisons between groups were performed using applicable parametric and non-parametric statistical analysis (independent-sample t-tests for continuous variables and Fisher's exact testing for categorical values). One-sided Fisher's exact test were used when predictor factors influenced a direction in only one way. Result differences were determined significant at a probability of 95% ($p < 0.05$). Continuous variables were described as mean ± standard deviation and frequency data was portrayed as counts and percentages. The correlation between the assessed variables in the survey and clinical data was investigating using linear and multiple regression.

Dimensional socio-demographic variables (e.g. comorbidity-count) were summed up by mean, median, standard deviation, minimum and maximum when applicable. Qualitative socio-demographic variables (e.g. sex) were summed up by counts and percentages.

Statistical evaluation and diagrams were generated with the help of Microsoft Excel (2013, Microsoft Inc, Seattle, Washington, USA) and Statistica (v13.3.1, Statistica Inc, Hamburg, Germany).

3 Results

3.1 Retrospective Analysis

3.1.1 Patient gender and age distribution

A total of 218 patients were surgically treated at Universitätsmedizin Göttingen Klinik für Neurochirurgie (Department of Neurosurgery) from January 2008 to July 2017 for spondylodiscitis. The mean duration of follow-up among patients was 4.8 ± 2.4 years after initial surgery (min: 0.04, max: 10.92). 134 patients were male (61.47%), and 84 patients were female (38.3%), generating a ratio of 1.6:1.

The average age by admission was 69.41 ± 11.90 years (min: 30, max: 91). Furthermore, age distribution presented a notable maximum in the 71 - 80 years of age category (38.99%).
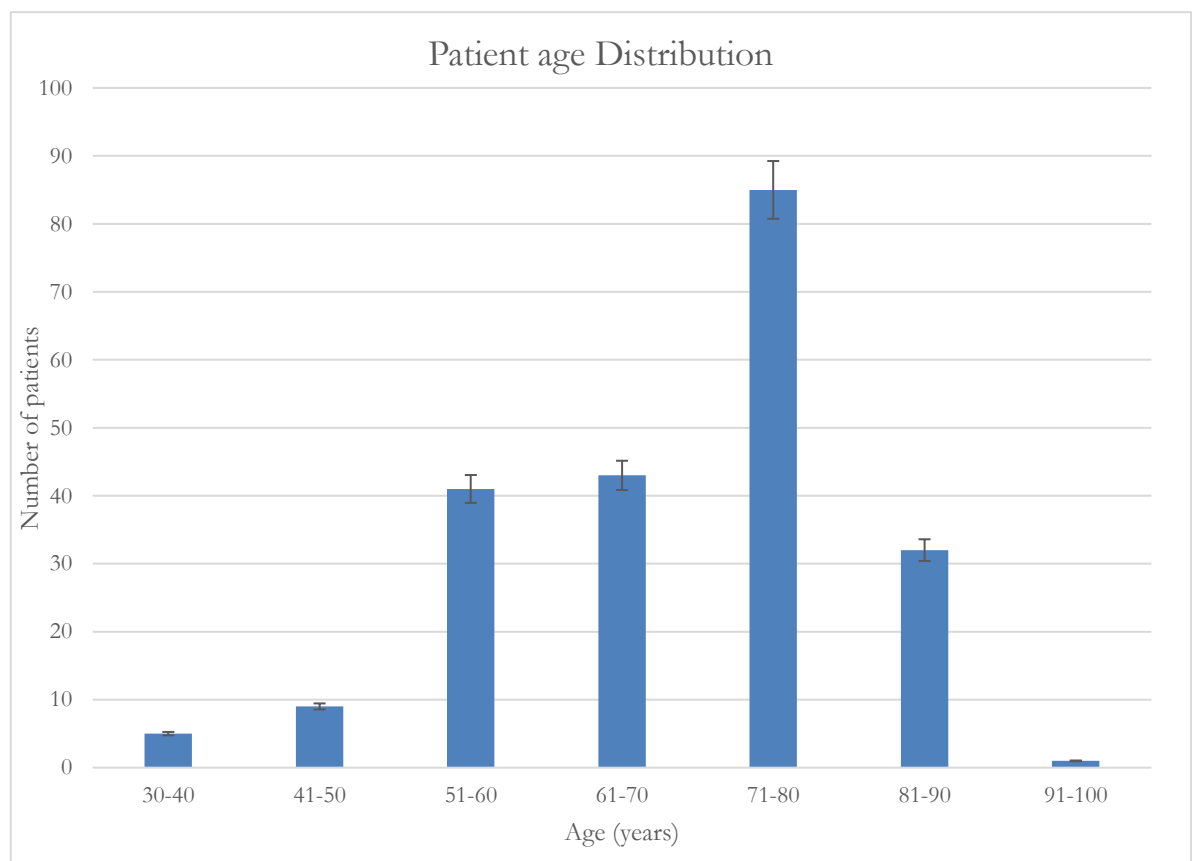
Figure 3: Patient age Distribution

3.1.2 Patient comorbidities

The mean Age-adjusted Charlson Comorbidity Index (ACCI) was calculated to be 6.56 ± 4.48 (min: 0, max: 23). Additionally, 14 patients (6.42%) had Osteoporosis, 30 patients (13.76%) were

obese, 24 (11.01%) smoked and 5 (2.29%) were active injecting drug users. 29 patients (13.30%) had a MRSA-associated infection. MRSA was most common in wound smears, followed by blood cultures and the nasopharynx region. The most common underlying medical condition was diabetes mellitus (79 patients, 36.24%), followed by a moderate or severe kidney disease (68 patients, 31.20%) and cerebrovascular disease (51 patients, 23.39%). Table 1 shows the number of patients with these comorbidities.

Table 1: Patient comorbidities/risk factors

Comorbidity/risk factor	Number of patients	Overall frequency %
None	38	17.43
Diabetes mellitus	79	36.24
Moderate or severe kidney disease	68	31.20
Cerebrovascular disease	51	23.39
Heart failure	47	21.56
Chronic lung disease	43	19.72
Malignant Tumor	38	17.43
Diabetes with end organ damage	33	15.14
Obesity	30	13.76
MRSA infection	29	13.30
Heart attack	24	11.01
Smoking	24	11.01
Non-malignant tumor	22	10.09
Peripheral vascular disease	20	9.17
Chronic liver disease	19	8.72
Peptic ulcer	15	6.88
Hemiplegia	14	6.42
Osteoporosis	14	6.42
Dementia	11	5.05
Moderate or severe liver disease	11	5.05
Tumor with Metastasis	9	4.13
Intravenous drug abuse	5	2.29
Leukemia/Lymphoma	1	0.46
AIDS	0	0
Connective tissue disease	0	0

3.1.3 Clinical presentation

By admission, almost all patients (200 patients, 91.74%) experienced spinal pain with or without radiation into the respective dermatome. 91 patients (41.74%) had motor deficits and 31 patients (14.22%) were incontinent. Overall, 111 patients (50.92%) had neurological deficits (including

motor and sensory deficits, polyneuropathy, incontinence, voiding disorder, paresis, paraplegia etc.). Imaging showed an epidural abscess in 68 patients (31.19%) and an intraspinal abscess in 11 patients (5.05%).

3.1.4   Diagnosis

In all cases, the diagnosis of spondylodiscitis was determined with the assistance of clinical, serological, and imaging findings. Blood cultures were taken in 82 patients (37.61%). Two patients underwent a biopsy. Altogether, pathogens were identified in 119 (54.59%) of cases. The most common bacterial pathogens were Staphylococcus aureus (59 patients, 27.06%), Staphylococcus epidermidis (23 patients, 10.55%), Escherichia coli (11 patients, 5.05%) and Enterococcus faecalis (10 patients, 4.59%). Mixed infections were observed in sixteen cases (7.34%). Out of the 59 Staphylococcus aureus infections, 29 (49.15%) were MRSA associated. Figure 4 below shows a detailed summary of the frequency of the responsible microorganisms.
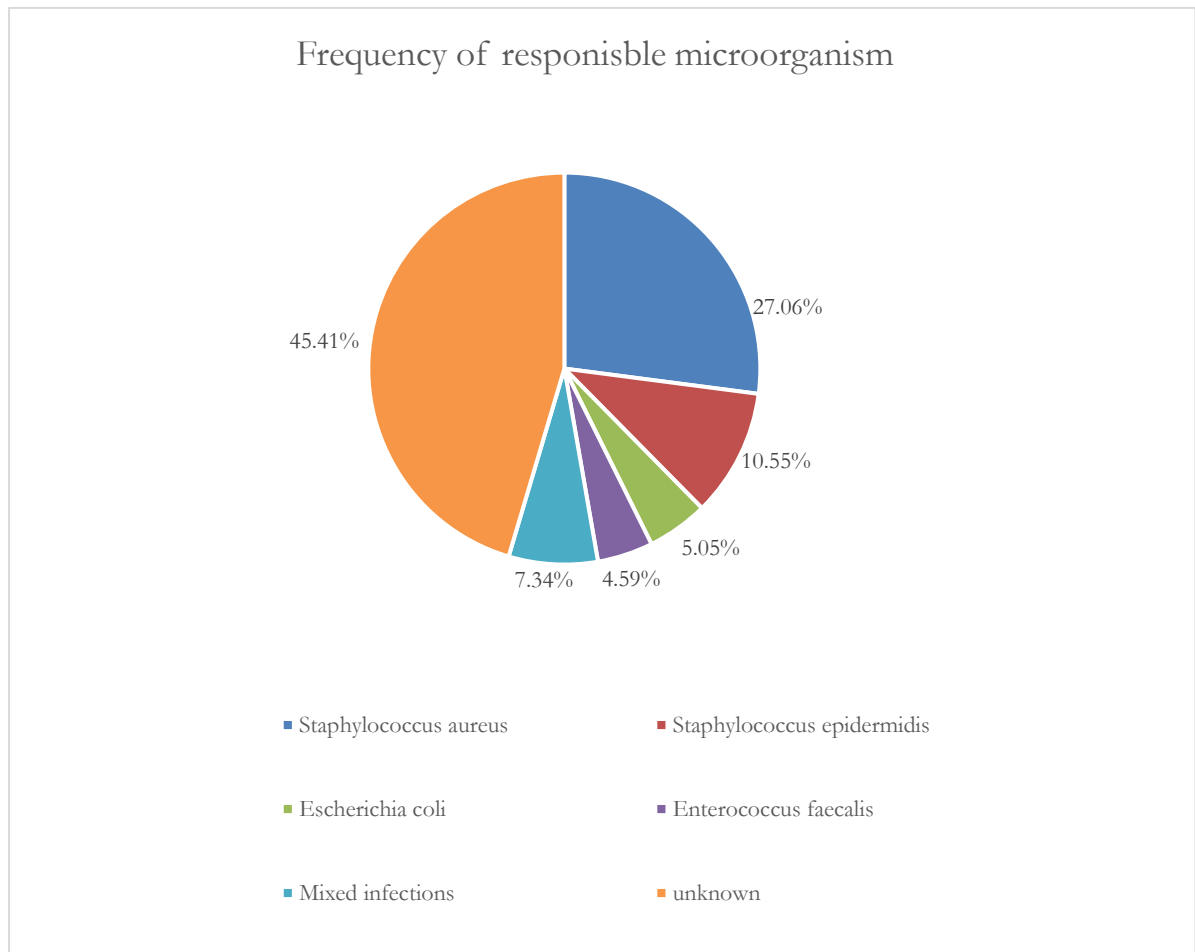
Figure 4: Frequency of responsible microorganism

On admission, CRP was elevated in 195 patients (89.45%) over the normal value of 5 mg/L. In 14 patients the CRP was not measured. 65 patients (29.82%) had a WBC count of over 11 x 10^9/L. Furthermore, CRP and WBC were measured 3 to 7 days after surgery and at discharge. Figure 5 shows the average inflammation-specific laboratory parameters at various clinic times.
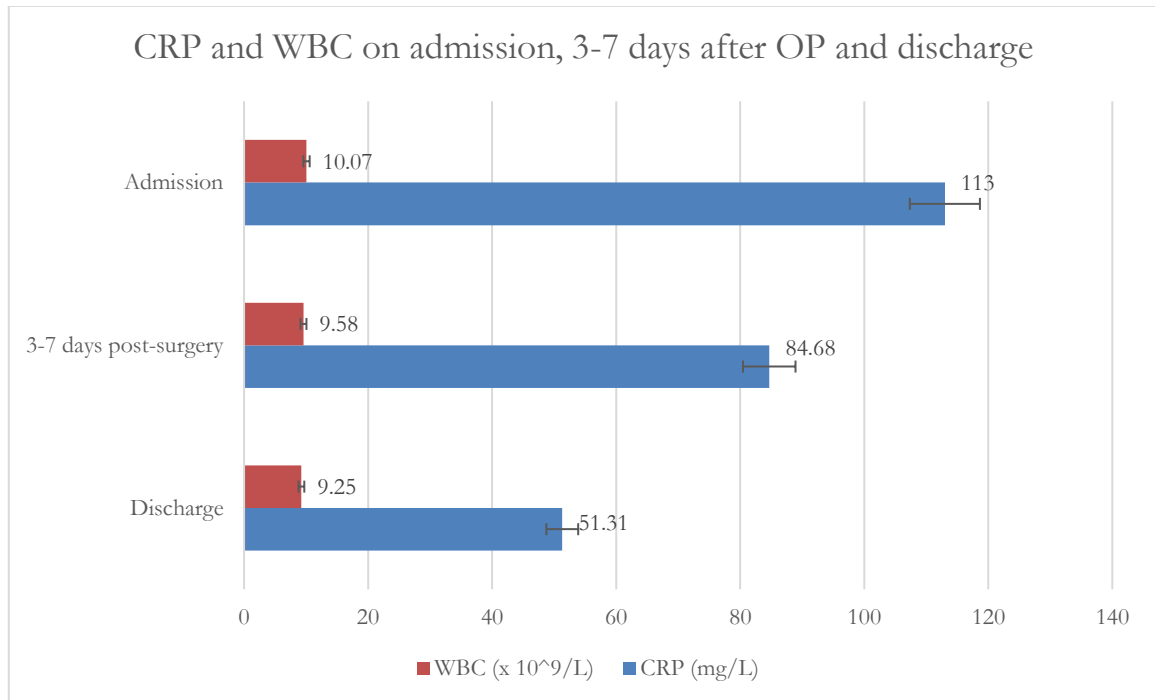
Figure 5: Mean CRP and WBC count on admission, 3 - 7 days after surgery and at discharge

The average CRP was significantly higher (p = 0.0005) on admission (112.99 ± 98.48, median 89) than at discharge (51.31 ± 47.42, median 34.6). The mean WBC count on admission was not significantly higher than at discharge (10.07 ± 4.66, median 9.2 vs. 9.25 ± 12.31, median 6.52, p = 0.47).

3.1.5 Location of infection

A total of 575 spinal segments were affected by spondylodiscitis in the selected patient group. The most common location of infection was the lumbar region with a sum of 305 (53.04%) affected segments. 254 (44.17%) infected segments were diagnosed in the thoracic region and 16 (2.78%) spinal segments were affected in the cervical region. Transition areas (such as the thoracolumbar region) were counted to the region directly above the infected segment (for example the thoracolumbar region was counted as the thoracic region). Figure 6 shows the number of patients and respective infected regions.
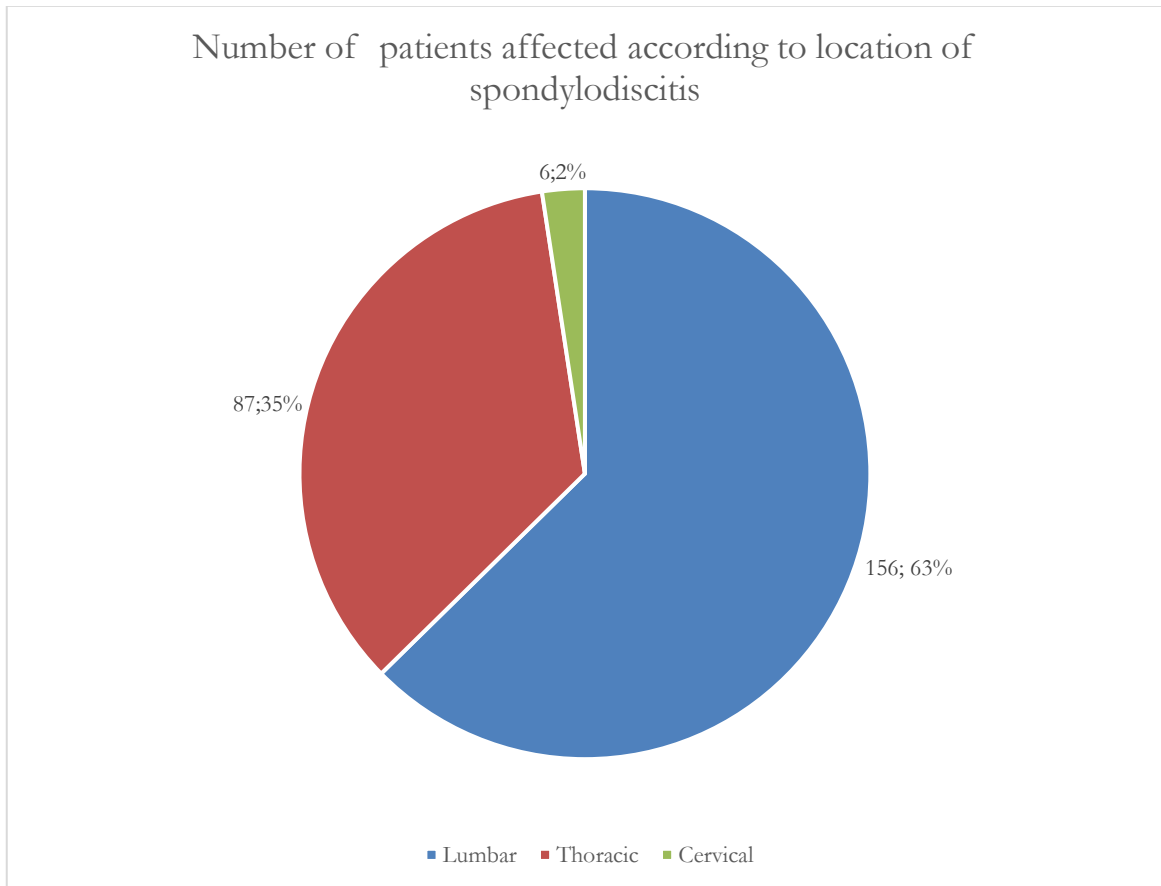
Figure 6: Number of patients affected according to location of spondylodiscitis

Multi-segmental spondylodiscitis was identified in 148 (67.89%) cases (44 cases with two segments, 48 cases with 3 segments, 18 cases with 4 segments, 28 cases with 5 segments, 5 cases with 6 segments, 1 case with 7 segments and 3 cases with 8 segments). 70 cases (32.11%) were mono-segmental. One case was not identified. Figure 7 presents this information.
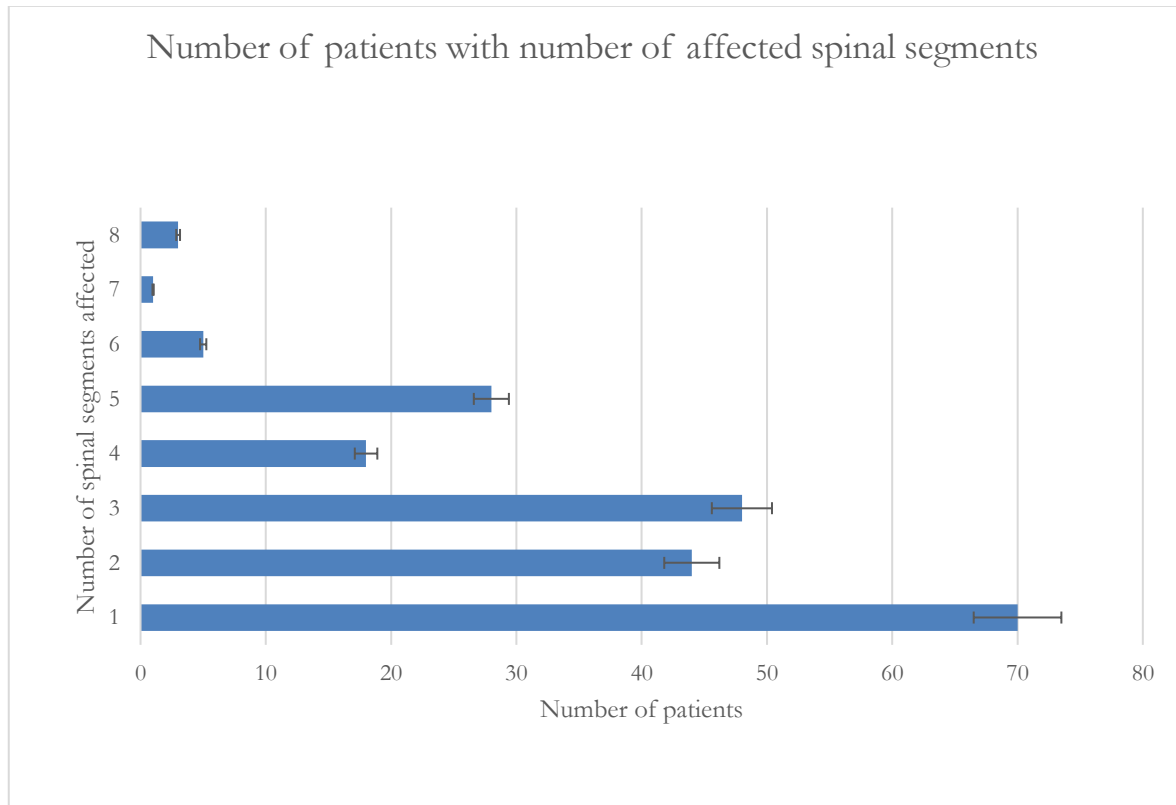
Figure 7: Number of patients with number of spinal segments affected

3.1.6 Therapy

Antibiotic therapy was administered for an average of 10.11 weeks. Surgical indications included failure in conservative therapy, epidural and intraspinal abscesses, neurological deficits, instability, or deformity and/or patient preference. All 218 patients were treated surgically. Different operative approaches were considered. These methods included posterior fusion, corpectomy, interbody cages and spinal canal decompression. In some patients, pedicle screw fixation was performed using robot-assistance. Figure 8 shows the different aspects of surgery and respective frequencies.
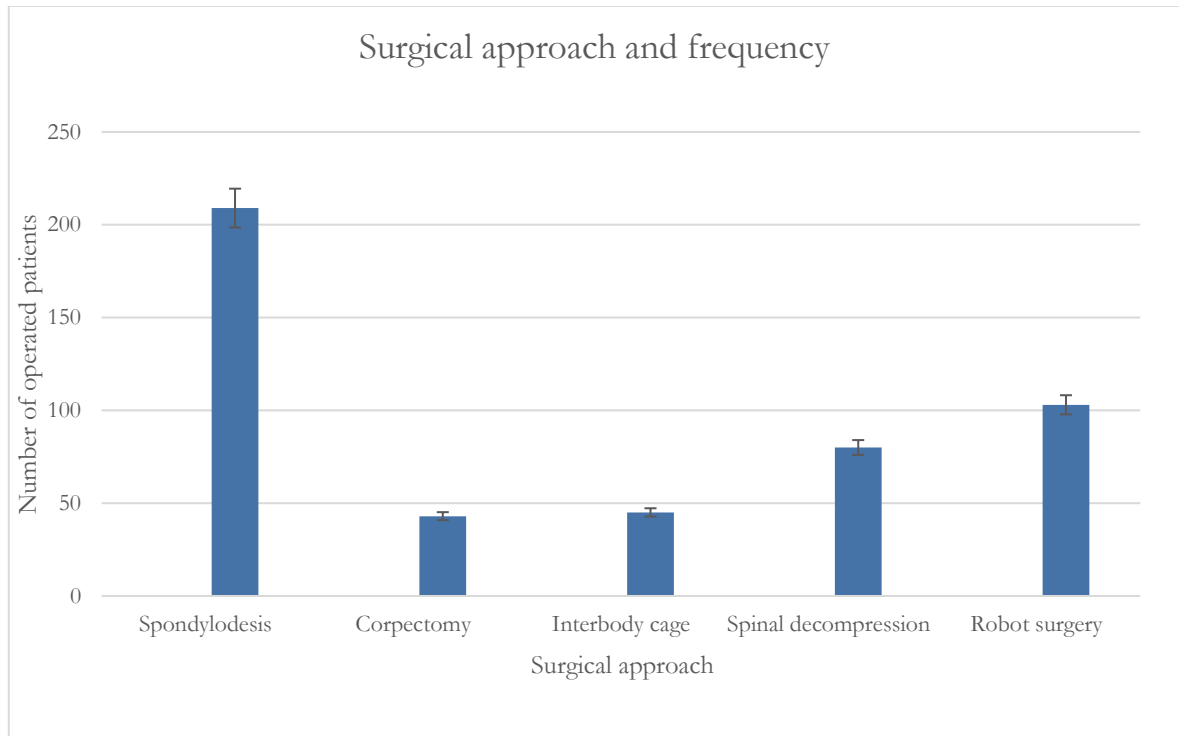
Figure 8: Surgical approach and frequency

Average duration of surgery was 200.4 ± 89.5 minutes (min: 65, max: 469). In 41 cases, duration of surgery duration was not available. Table 2 displays the duration of operations and their frequencies.

Table 2: Surgery duration

Surgery duration (hours)	Frequency	Overall frequency (%)
< 1	0	0
1 - 2	34	19.21
2 - 3	58	32.77
3 - 4	31	17.51
4 - 5	27	15.25
5 - 6	16	9.04
6 - 7	7	3.95
7 - 8	4	2.26

Operations performed with robot-assistance (mean: 182.88 ± 85.52 minutes, min: 65, max: 458) were significantly shorter than conventionally performed surgeries (mean: 221.71 ± 90.29 minutes, min: 78, max: 469) (p = 0.0038).

Moreover, both the conventional free-hand pedicle screw implantation and robot-assisted surgery required X-ray radiation for the intraoperative fluoroscopy. Mean radiation time was measured to be 141.9 ± 94.2 seconds (min: 1.03, max: 500). In 61 cases radiation duration was not available. Radiation duration times in robot-assisted surgeries (mean: 127.71 ± 87.08 seconds, min: 1.03, max: 364) were significantly shorter than in free-hand surgeries (mean: 161.02 ± 100.69 seconds, min: 5, max: 500) ($p = 0.028$).

3.1.7 Postoperative complications

General post-surgical complications included hospital acquired cardiac, pulmonal, renal, gastral, neurological, and urological diseases. 55 patients (25.23%) suffered from general postoperative complications. The most common complications were pulmonary failure and/or dyspnea (10 patients, 4.59%), pleural effusions (10 patients, 4.59%) and a postoperative state of confusion/somnolence/hallucination (9 patients, 4.13%). Table 3 shows a summary of these conditions. 5 patients (2.29%) died within thirty days after the surgical procedure.

Table 3: General complications

Complication	Number of patients
Respiratory failure and/or Dyspnea	10
Pleural effusion	10
Postoperative state of confusion/somnolence/hallucination	9
Urinary retention	6
Sepsis	6
Electrolyte disorder	5
Decubitus Ulcer	5
Atrial fibrillation	5
Pneumonia	4
Anemia	4
Renal failure	3
Myocardial infarct	3
Hyper/hypotensive Crisis	3
Gastropathy	3
Epileptic seizure	3
Urinary tract infection	2
Pulmonary Embolism	2
Pneumothorax	2
Depression	2
Clostridium difficile infection	2
Myocardial failure	1
Meningitis	1
Leg Thrombosis	1
Ileus	1
Erysipelas	1

Postoperative wound healing abnormalities/infections, screw misplacements/loosening, new motor and sensory deficits, durotomy and psoas abscesses were considered direct surgical complications. Overall, 98 patients (44.95%) suffered from these surgical complications. Table 4 shows the frequency of these conditions. 38 from the 40 patients (95%) with wound infection

and 26 from the 29 patients (89.67%) with screw misplacements/loosening required surgical revision.

Table 4: Direct surgical complications

Complication	Number of patients	Overall frequency (%)
Wound infection	40	18.35
Screw misplacement/loosening	29	13.30
New motor and/or sensory deficit	17	7.80
Durotomy	7	3.21
Psoas Abscess	5	2.29

The most common wound infection microorganisms were Staphylococcus epidermidis (8 patients, 20%) and Enterococcus faecium (8 patients, 20%). Other pathogens were Staphylococcus aureus (6 (15%) patients, out of which 5 (12.5%) were MRSA), Corynebacterium species (3, 7.5%), Pseudomonas aeruginosa (2, 5%), Klebsiella pneumoniae (2, 5%), Candida albicans (2, 5%), Staphylococcus haemolyticus (1, 2.5%), Klebsiella oxytoca (1, 2.5%), Candida glabrata (1, 2.5%) and Enterobacter asburiae (1, 2.5%). 10 infections (25%) were caused by more than one pathogen. In 12 cases (30%) no causative microorganism could be found. 4 patients (10%) received no blood cultures or would smears.

No significant variances among patients with wound infections and patients without wound infections were calculated regarding gender, Charlson Comorbidity Index, diabetes mellitus, smoking, obesity, drug abuse, osteoporosis, preoperative CRP count, epidural abscess, neurological deficits, duration of surgery, number of levels operated, method of surgery, general postoperative complications, postoperative misplaced or loosened screw or a revision surgery. Patients with higher age, elevated preoperative WBC levels and a MRSA-associated infection ($p = 0.048$, $p = 0.028$, $p = 0.0006$ respectively) however had a significantly higher chance of developing a wound infection, prolonging hospital stay ($p < 0.001$). Table 5 below shows the statistically relevant factors associated with wound infection.

Table 5: Factors associated with wound revision

Wound infection				
Risk factor	**Total (n = 218)**	**Wound infection developed (n = 40)**	**No wound infection developed (n = 178)**	**p-Value**
Background				
Age at surgery (mean (range))	69.41 (30 - 91)	72.73 (48 - 88)	68.55 (30 - 91)	0.0484
MRSA-associated infection (n (%))	29 (13.30)	12 (41.38)	14 (48.28)	0.0006
Presenting features				
WBC count on admission (mean x 10^9/L (range))	10.07 (0.8 - 35.8)	11.49 (5.1 - 35.8)	9.71 (0.8 - 22.90)	0.0297
Post-surgical features				
Length of hospital stay (mean (range))	29.86 (4 - 162)	53.24 (14 - 162)	24.42 (4 - 105)	< 0.001

3.1.8 Relapse rate

16 patients (7.34%) developed an infection relapse after an average of 28.87 ± 26.85 weeks after initial surgery (min: 1, max: 112). 1 patient was suspected with a disease relapse. Mean CRP value at relapse was 86.45 ± 54.40 mg/L (min: 7.1, max: 183.4). The average WBC count was measured to be 10.65 ± 4.53 x 10^9/L (min: 4.87, max: 21.4). 8 patients (50%) underwent a revisional surgery. No differences were found between patients with disease relapse and patients without disease relapse regarding gender, age, Charlson Comorbidity Index, diabetes mellitus, smoking, obesity, osteoporosis, MRSA-associated infection, preoperative inflammation

markers, epidural abscess, neurological deficits, duration of surgery, number of levels operated, method of surgery, general postoperative complications, postsurgical wound infection or length of hospital stay. Patients with active drug abuse and/or a misplaced or loosened screw however had a significantly higher chance of developing a spondylodiscitis relapse ($p = 0.0042$, $p = 0.0036$ respectively). Table 6 presents a summary of the statistically relevant analysis performed.

Table 6: Factors predicting relapse infection

Relapse infection				
Risk factor	Total (n = 218)	Relapse infection developed (n = 17)	No relapse infection developed (n = 201)	p-Value
Background				
Active drug abuse (n (%))	5 (2.29)	3 (60)	2 (40)	0.0042
Post-surgical features				
Misplaced or loosened screw (n (%))	29 (13.30)	7 (24.14)	22 (75.86)	0.0036

3.1.9   Length of hospital stay

Hospital stay was defined as time from admission until clinical discharge. The mean hospital stay after surgical treatment of spondylodiscitis was 29.86 ± 21.99 days (min: 4, max: 162). Duration of stay was = < 21 days in 89 (40.83%) and > 21 days in 125 (57.34%) of the patients. In four patients (1.83%) the length of hospital stay was not known. Patients were discharged during the first, second, third, fourth, fifth, sixth, seventh week and afterwards in 1.38%, 13.76%, 26.15%, 14.68%, 15.14%, 6.88%, 6.42% and 15.88% of the cases, respectively. No difference between the two groups was found regarding patient gender, Charlson Comorbidity Index, drug abuse, smoking, osteoporosis, obesity, and preoperative inflammation markers. Patients with higher ages ($p = 0.017$), multidrug-resistant bacteria ($p = 0.022$), neurological deficits on admission ($p = 0.026$), higher number of operated levels ($p = 0.041$), interbody cages ($p = 0.026$), general postoperative complications ($p = 0.077$) and wound infections ($p = < 0.001$) had a longer hospital stay. Patients operated with robot-assistance ($p = 0.018$) had a shorter

hospital stay. Multivariate analysis showed that surgical site infection and general post-surgical complications were independently associated with a hospital stay longer than 3 weeks (Odds ratio (OR) 6.04, CI 95% 2.35 - 15.51, p < 0.001 and OR 2.62, CI 95% 1.24 - 5.56, p = 0.012, respectively). Surgical site infection was the only independent factor associated with a hospital stay longer than 4 weeks (odds ratio 3.24, CI 95% 1.57 - 6.71, p = 0.002). Table 7 shows influencing factors.

Table 7: Factors predicting length of hospital stay

Length of hospital stay				
Risk factor	Total (n = 218)	Length of hospital stay > 21 days (n = 125)	Length of hospital stay = < 21 days (n = 89)	p-Value
Background				
Age at surgery (mean (range))	69.41 (30 - 91)	71.1 (36 - 91)	67.15 (30 - 87)	0.0167
MRSA-associated infection (n (%))	29 (13.30)	23 (79.31)	5 (17.24)	0.0219
Presenting features				
Preoperative neurological deficits (n (%))	111 (50.92)	72 (65.45)	37 (33.64)	0.0264
Surgical features				
Number of levels operated (mean (range))	2.65 (1-8)	2.84 (1 - 8)	2.38 (1 - 7)	0.041
Interbody cage (n (%))	45 (20.64)	33 (73.33)	12 (26.67)	0.0262
Robot Surgery (n (%))	103 (47.25)	50 (48.54)	51 (49.51)	0.018
Post-surgical features				
General post-surgical complications (n (%))	55 (25.23)	40 (72.72)	15 (27.27)	0.0077

Post-surgical wound infection (n (%))	40 (18.35)	37 (92.5)	1 (2.5)	< 0.001

3.1.10 Death

At final follow up, one hundred patients had passed away (45.87%). In-hospital mortality rate was 1.83%. Thirty-day postoperative mortality rate was 2.29% and the overall 1-year crude mortality rate was 6.88%. In 54 cases (54%) time of death was not known. No differences were found between deceased patients and non-deceased patients regarding gender, diabetes mellitus, smoking, osteoporosis, multidrug-resistant bacteria, preoperative WBC, preoperative epidural abscess, residual disabilities, relapse infections or revision surgeries. In the univariate analysis, patients with a higher age (p = 0.0001), a higher Charlson Comorbidity Index (p = < 0.001), obesity (p = 0.0325), active drug abuse (p = 0.0394), preoperative neurological deficits (p = 0.0366), higher preoperative and last measured CRP values (p = 0.02, p = 0.0005 respectively), postoperative general complications (p = 0.0374), longer hospital stays (p = 0.0092), and post-surgical wound infections (p = 0.0032) however had a significantly higher chance of death. Patients operated with robot-assisted (p = 0.0143) had a lower incidence of death. In the multivariate analysis, obesity predicted in-hospital mortality (OR 13.732, CI 5 - 95% 1.12 - 168.65, p = 0.041), last CRP value and preoperative neurological deficits predicted one year death (OR 1.011, CI 5 - 95% 1.003 - 1.018, p = 0.006 and OR 11.56 CI 5 - 95% 1.37 - 97.71, p = 0.025, respectively) and death at follow up could be predicted by length of hospital stay, last CRP value, age at admission and Charlson Comorbidity Index (OR 1.022, CI 5 - 95% 1.003 - 1.041, p = 0.024, OR 1.009, CI 5 - 95% 1.002 - 1.016, p = 0.025, OR 1.038 CI 5 - 95% 1.005 - 1.073, p = 0.024 and OR 1.149, CI 5 - 95% 1.055 - 1.253, p = 0.002, respectively). Table 8 shows these influencing factors.

Table 8: Factors predicting death

Death			
Risk factor	**Total (n = 218)**	**Death (n = 100)**	**Survival (n = 118)**	**p-Value**
Background			
Age at surgery (mean (range))	69.41 (30 - 91)	72.82 (50 - 90)	66.53 (30 - 91)	0.0001
Obesity (n (%))	30 (13.76)	19 (63.33)	11 (36.67)	0.0325
Active drug abuse (n (%))	5 (2.29)	0 (0)	5 (100)	0.0394
Charlson Comorbidity Index (mean (range))	6.56 (0 - 23)	8.31 (2 - 23)	5.08 (0 - 18)	< 0.001
Presenting features			
Preoperative neurological deficits (n (%))	111 (50.92)	58 (52.25)	53 (47.75)	0.0366
CRP value on admission (mean mg/L (range))	112.99 (2 - 467)	129.96 (2 - 467)	97.92 (2 - 370)	0.02
Surgical features			
Robot Surgery (n (%))	103 (47.25)	38 (36.89)	65 (63.17)	0.0143
Post-surgical features			
General post-surgical complications (n (%))	55 (25.23)	32 (58.18)	23 (41.82)	0.0374
Post-surgical wound infection (n (%))	40 (18.35)	27 (67.5)	13 (32.5)	0.0032
Length of hospital stay (mean (range))	29.86 (4 - 162)	34.10 (4 - 162)	26.28 (6 - 148)	0.0092
Last CRP measured (mean mg/L (range))	52.57 (0.7 - 400.7)	69.39 (1.4 - 400.7)	39.02 (0.7 - 291.3)	0.0005

3.1.11 Residual disabilities

Longer-term disabilities occurred in 35 patients (16.06%). Significant ongoing or renewed back pain requiring regular analgesia and/or further surgical revision occurred in 32 patients (14.68%), persisting or renewed motor and/or sensory deficits in 9 patients (4.13%), two (0.92%) developed incontinence, two (0.92%) developed a new spinal bone destruction and five (2.29%) developed an epidural abscess following treatment of the infection. Subsequent analysis revealed that active drug abuse at the time of diagnosis of spondylodiscitis was significantly predictive of an unfavorable outcome (p = 0.0345). Multiple linear regression showed that 50% of the variance was accounted by active drug abuse, misplaced or loosened screw, revision surgery and relapse infection (p = < 0.05). Table 9 below lists risk factors potentially playing a role in developing residual disabilities.

Table 9: Factors predicting residual disabilities

Residual disabilities				
Risk factor	**Total (n = 218)**	**Residual disabilities developed (n = 35)**	**No residual disabilities developed (n = 183)**	**p-Value**
Background				
Active drug abuse (n (%))	5 (2.29)	3 (60)	2 (40)	0.0345
Post-surgical features				
Misplaced or loosened screw (n (%))	29 (13.30)	15 (51.72)	14 (48.28)	< 0.001
Revision surgery (n (%))	40 (18.35)	26 (65)	14 (35)	< 0.001
Relapse infection (n (%))	17 (7.80)	14 (82.35)	3 (17.65)	< 0.001

3.2   Quality of life

The 218 patients (134 male, 84 female) that were admitted to the hospital Universitätsmedizin Göttingen Klinik für Neurochirurgie and thereupon surgically treated for spondylodiscitis in the time frame January 2008 to July 2017 were postally asked to fill out four questionnaires (ODI, SF-36, SF-MPQ and SF-WAI) related to current quality of life and pain and send these completed surveys back to the clinic. At the time of the study, 100 (45.87%) patients had died and 31 (14.22%) could not be contacted, primarily due to migration. A total of 44 (20.18%) patients responded. 43 (19.72%) patients were not interested in participating in the project.

Out of the 44 responders, 16 (37.21%) were female and 28 (63.63%) were male. The average responder age was 72 years (min: 48, max: 89).

3.2.1   ODI

The average percentage of permanent pain-related disability in patients was calculated to be $45.24 \pm 8.21\%$ (min: 0, max: 95.56). 23% of the patients had a minimal disability, 21% a moderate disability, 19% a severe disability, 33% a complete disability and 4% were bed-bound.

Highest disability rates were seen in lifting (54.26%), standing (47.22%) and sex life (47.5%). The lowest pain-related percentage of disability was found in sleeping (24.42%). The mean overall disability rate was calculated to be 38.45%. One patient did not complete this questionnaire. Figure 9 shows a detailed representation of the survey results.
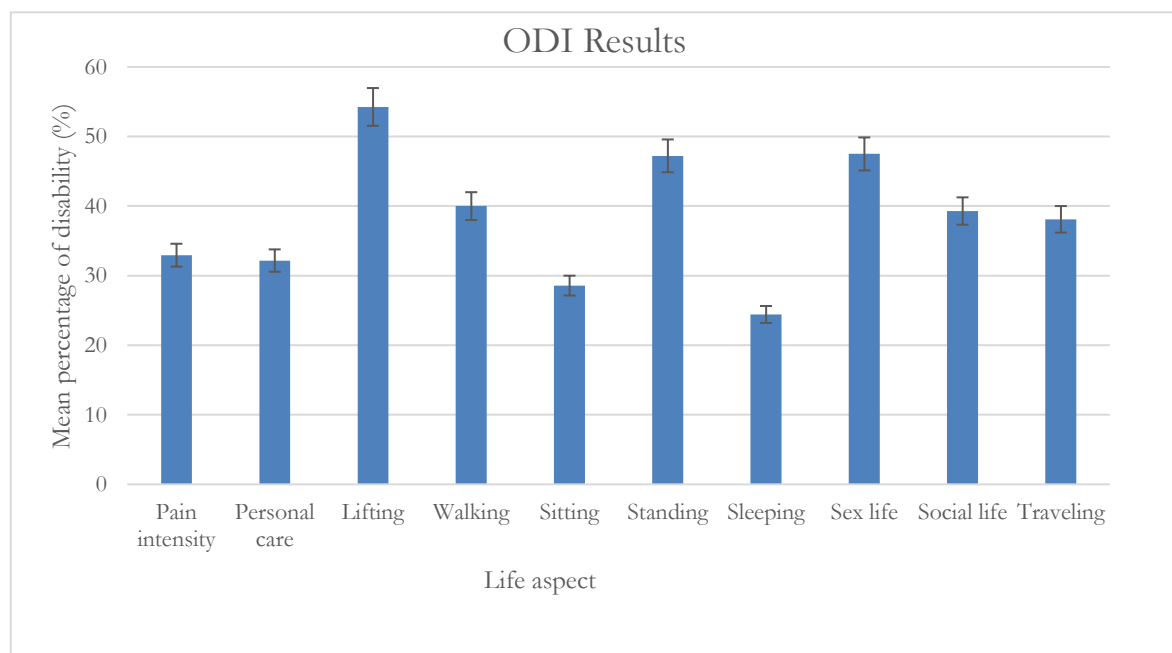
Figure 9: ODI Results

On linear regression analysis, we found that patients with higher age and residual disabilities significantly influenced ODI results (p = 0.03 and p = 0.028 respectively). These results are showed in the figures below (Figures 10.,11.).

Figure 10: ODI and age at surgery
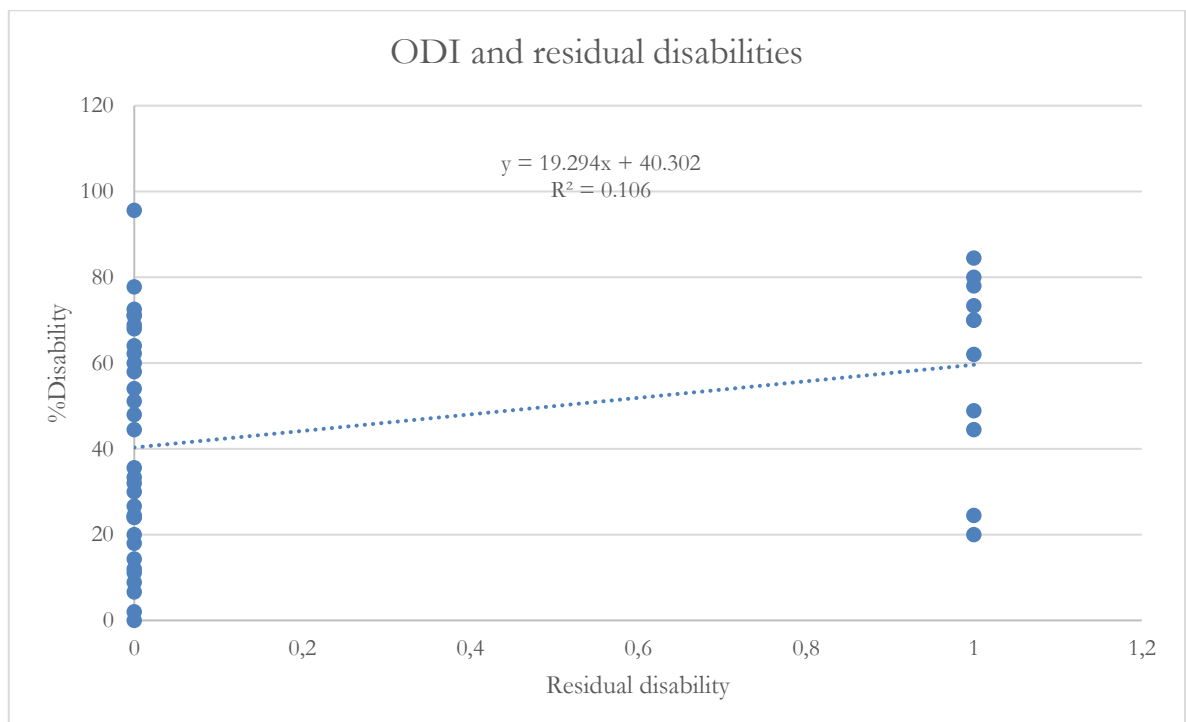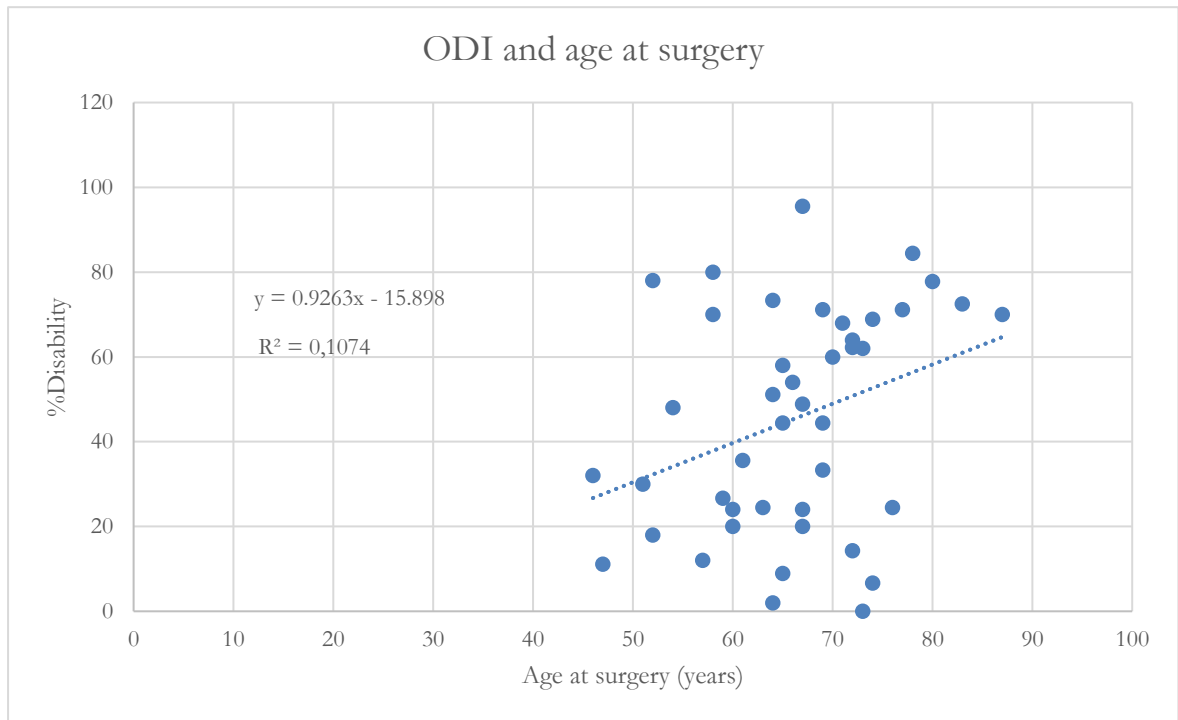
Figure 11: ODI and residual disability

Multiple linear regression showed that 11% of the variance was accounted by age and previously documented residual disabilities of patients (p = 0.033).

3.2.2 SF-36

Patients scored best in GMH (60.53%) followed by SF (52.03%), VT (42.31%), GH (41.32%), BP (38.13%), RE (36.59%), PF (25.57%) and the lowest in RP (14.49%). Figure 12 demonstrates values of all dimensions of SF-36.
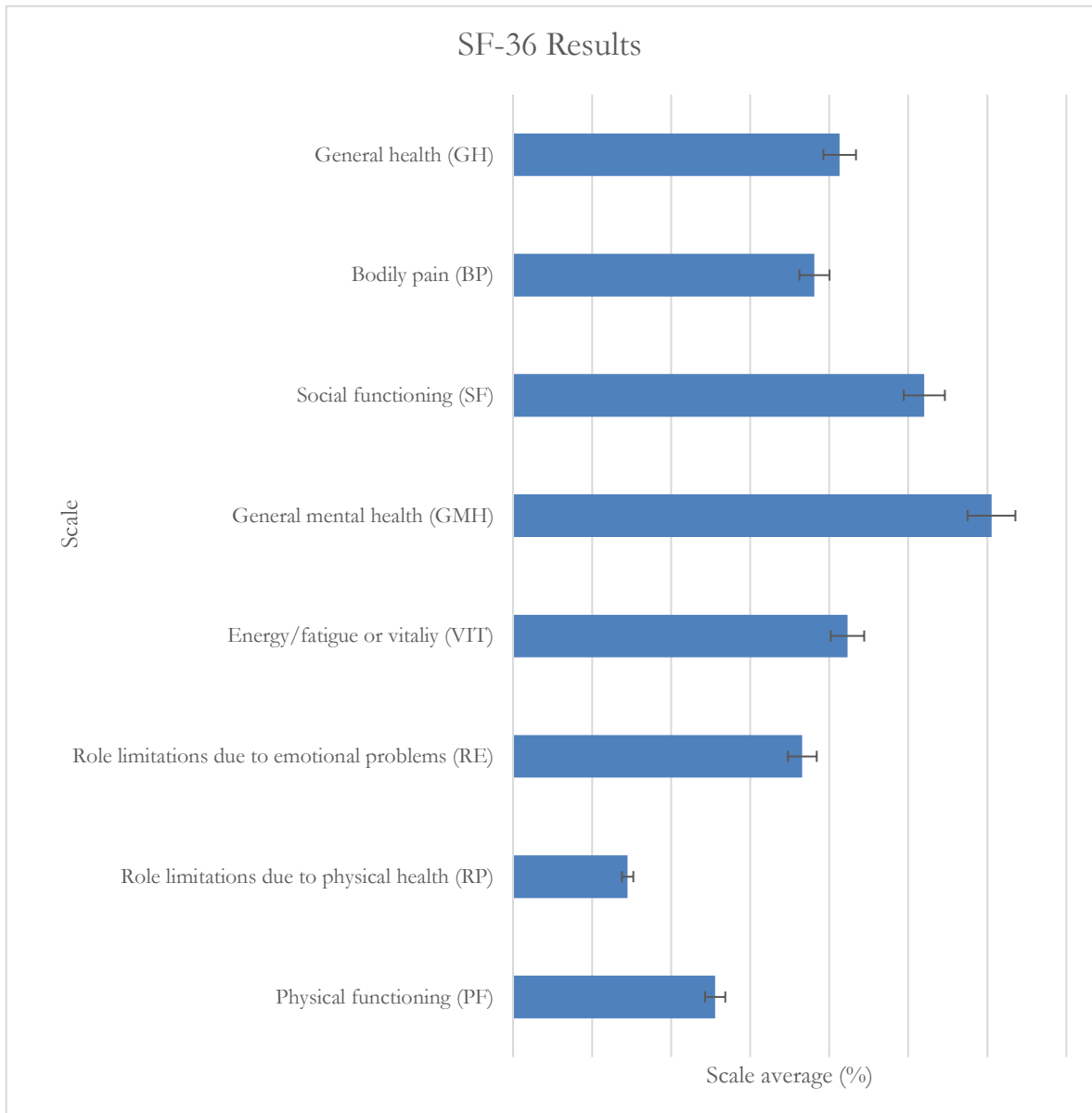
Figure 12: SF-36 Results

These results can be further summarized into the two summary scores PCS and MCS (PCS = PF + RP + BP + GH), (MCS = VIT + SF + RE + MH). Figure 13 displays these scores.
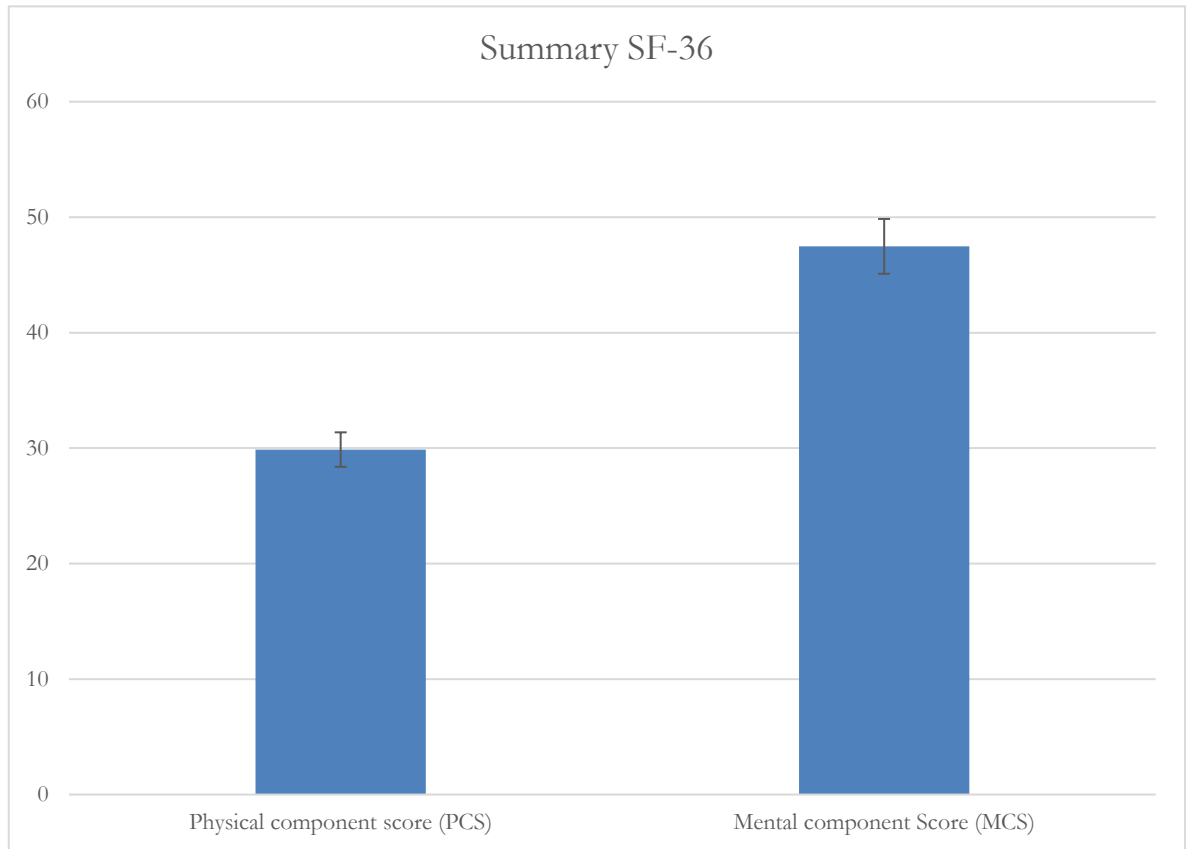
Figure 13: Summary SF-36

Linear regression showed a high correlation between mental score and physical score (Figures 14 and 15).
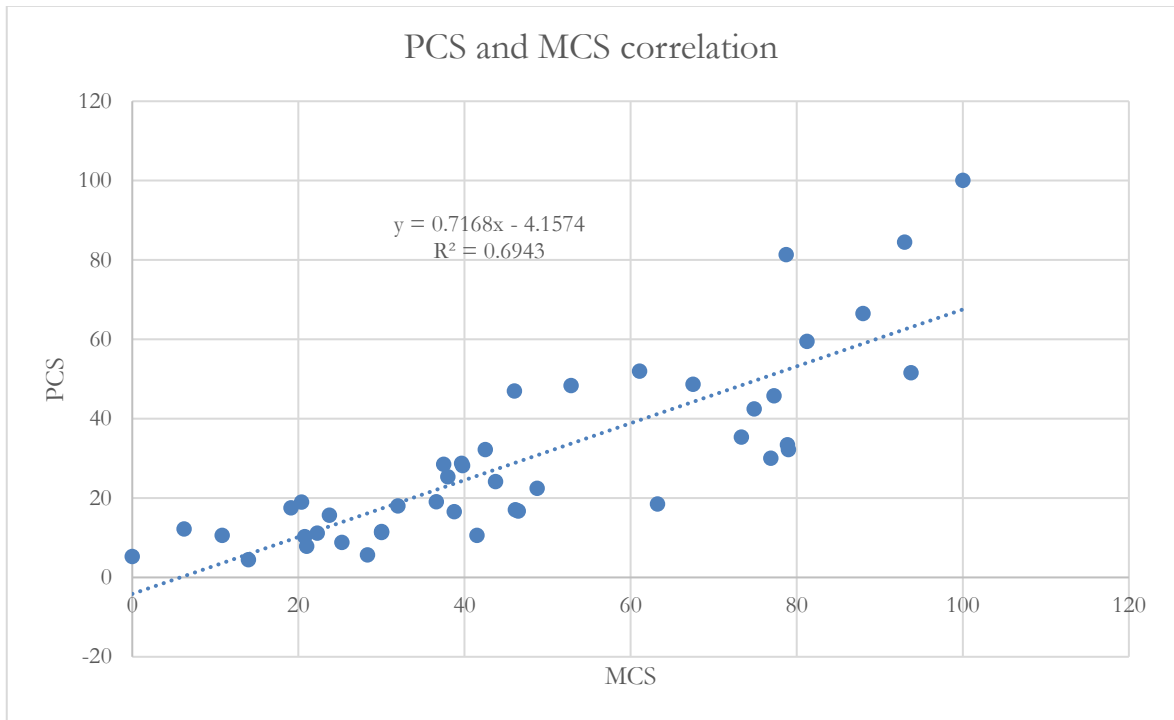
Figure 14: PCS and MCS correlation
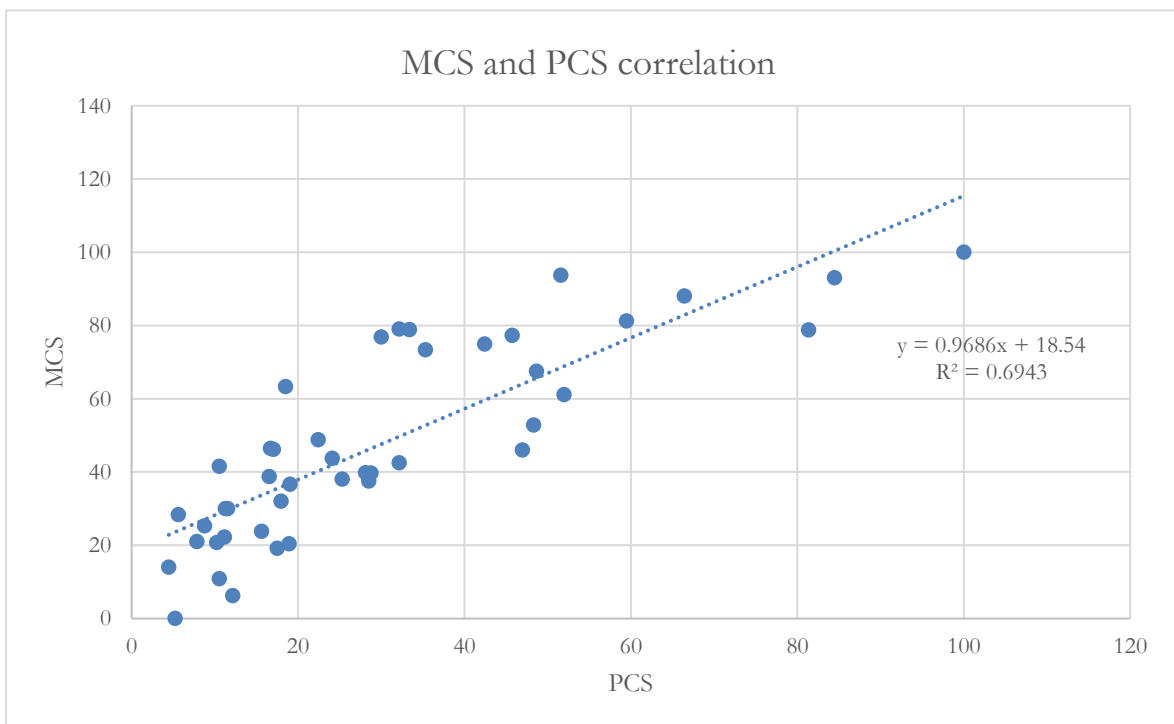
Figure 15: MCS and PCS correlation

Preoperative neurological deficits had a significant impact on PCS (p = 0.049). Figure 16 displays these results.
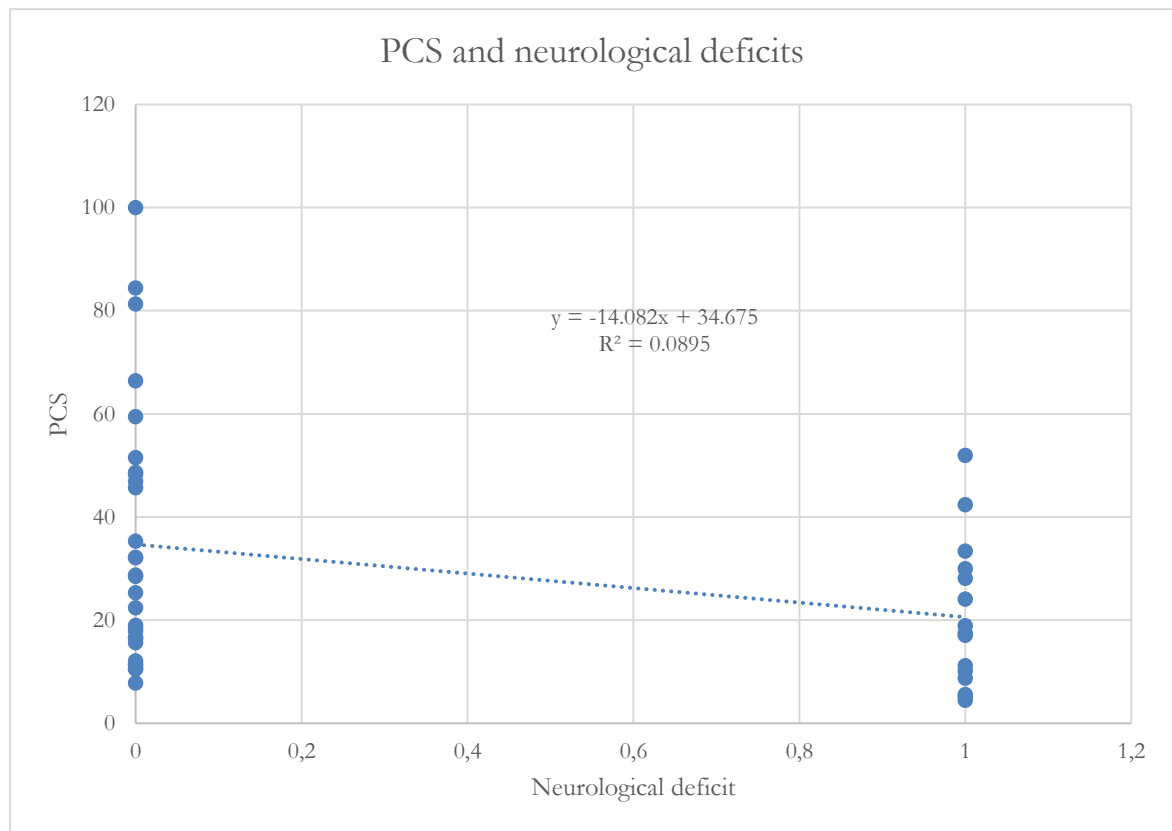
Figure 16: PCS and neurological deficits

3.2.3 SF-MPQ

The average sensory pain index was calculated to be 19.21% (6.34/33). Sixteen patients (36.36%) did not fill out the average affective pain index. Thus, this item result (19.33%, 2.32/12) could not be considered dependable as too much information was missing. The average total pain index (19.24%, 8,66/45) must therefore also be neglected as this score is the sum of the average sensory and affective pain index. Average current pain intensity on a visual analogue scale was 4.57 (45.7%) and overall patient pain appraisal on a scale from zero (pain-free) to five (agonizing pain) averaged to be 45.8% (2.29/5). Overall, three patients did not complete this survey and twelve surveys were only partly filled out. Figure 17 demonstrates values of all aspects of SF-MPQ.
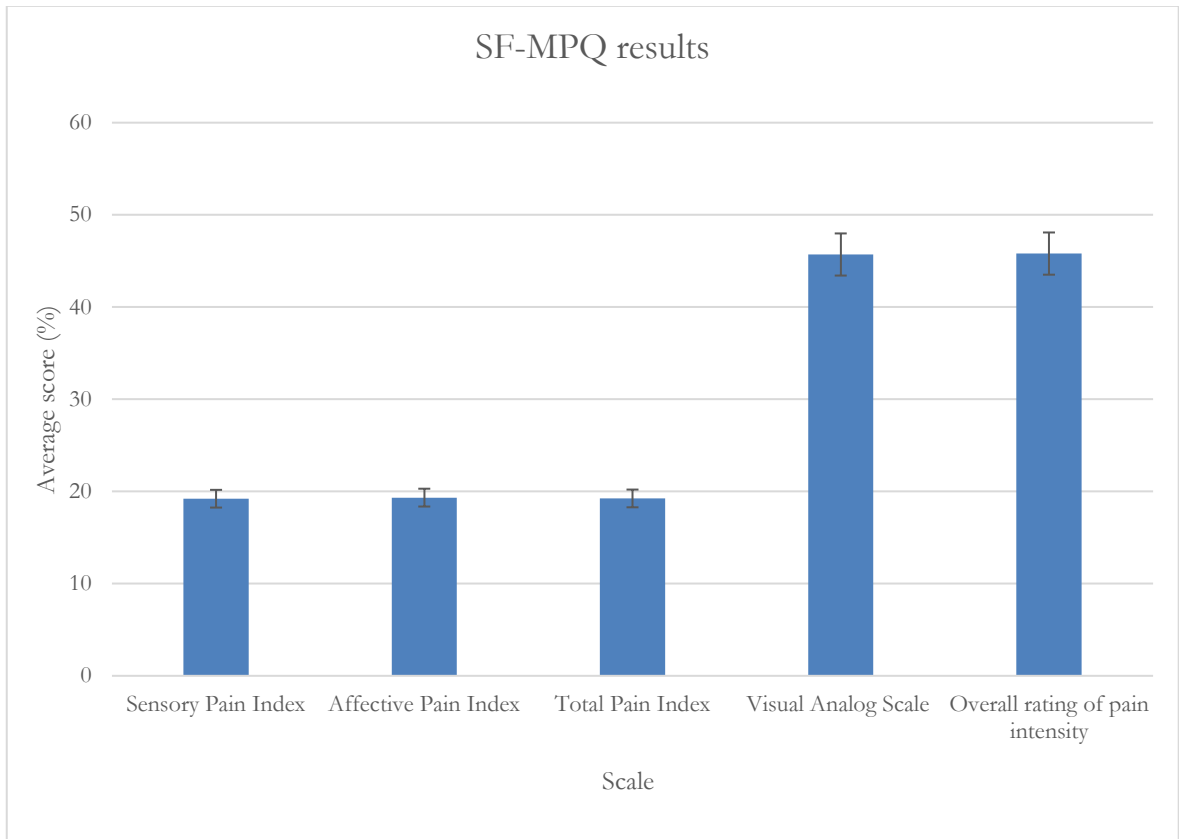
Figure 17: SF-MPQ results

Overall rating of pain intensity was dependent of residual disabilities (p = 0.034), Figure 18.
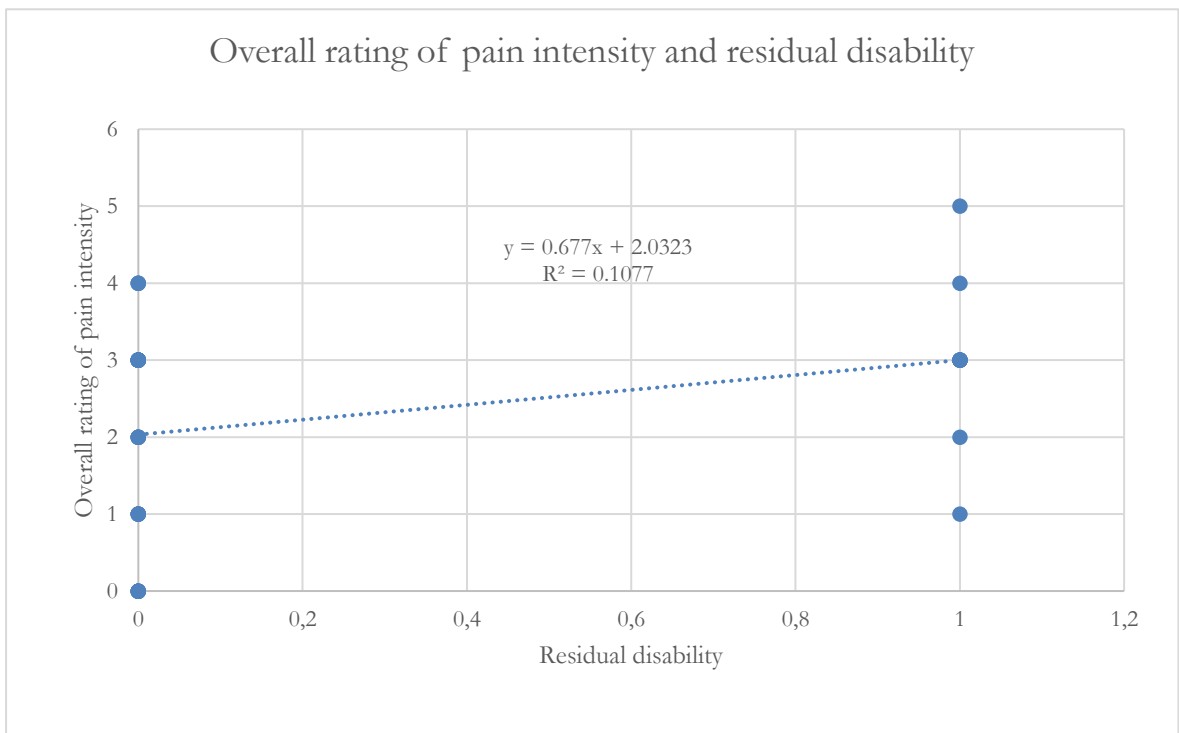
Figure 18: Overall rating of pain intensity and residual disability

3.2.4 SF-WAI

Average work ability score on SF-WAI questionnaire was 17.81. The majority of patients (70.45%) were classified in the category "bad", 11.36% in the category "moderate", 6.81% in the category "good" and 2.27% in the category "very good". 4 patients did not complete this survey.

Table 10: SF-WAI results

Number of total points	Number of patients	Overall frequency (%)
7 - 27 (bad)	31	70.45
28 - 36 (moderate)	5	11.36
37 - 43 (good)	3	6.81
44 - 49 (very good)	1	2.27

Most patients (65%) who answered this survey were ≥ 65 years old. 80.77% of these patients had a critical, 11.65% had a moderate, 3.85% had a good and 3.85% a very good work ability. 35% patients were under sixty-five years of age. 64.29% of these patients had a critical, 21.43% had a moderate and 14.29% had a good work ability.

Age and the Charlson Comorbidity Index of patients correlated significantly with the results of the SF-WAI survey ($p = 0.038$ and $p = 0.029$, respectively). Figures 19 and 20 display results.
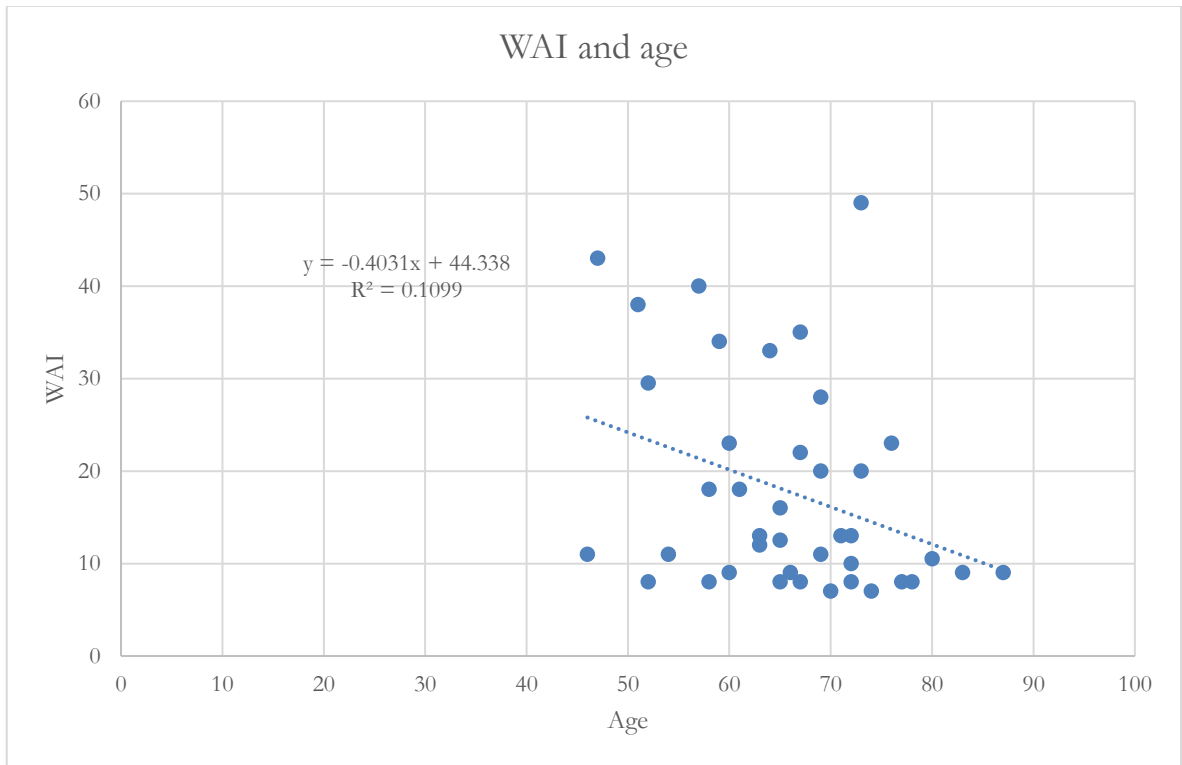
Figure 19: WAI and age
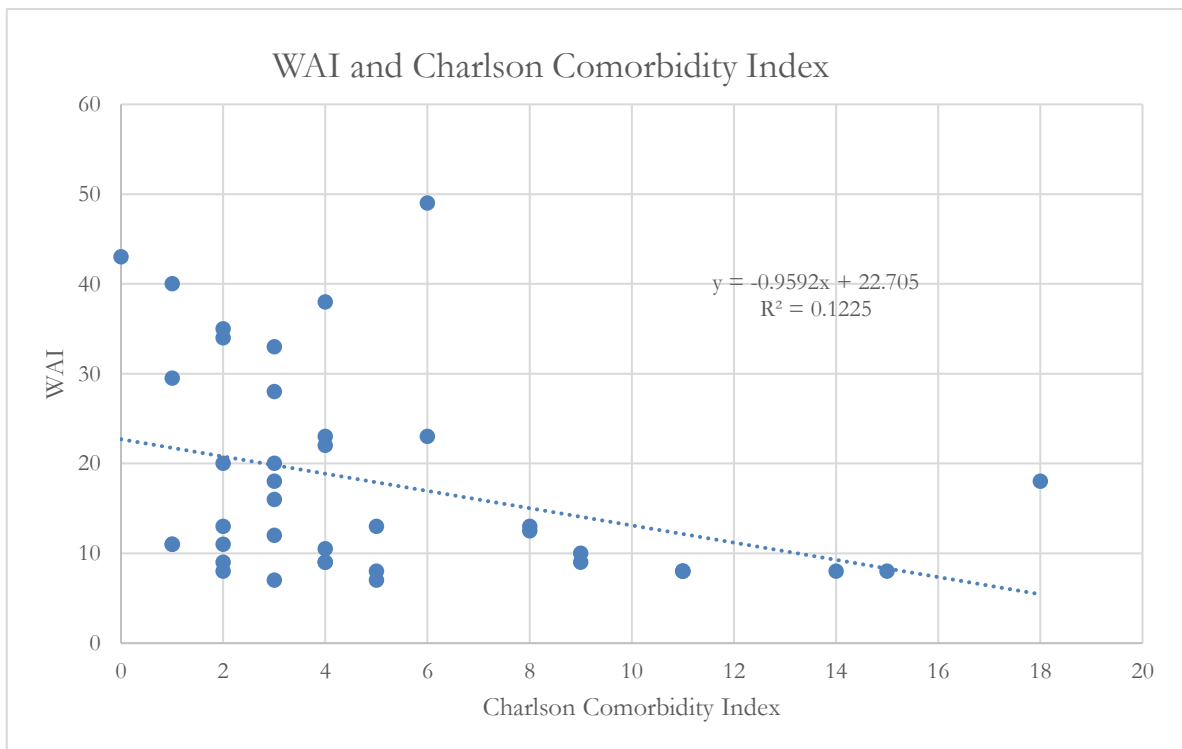
Figure 20: WAI and Charlson Comorbidity Index

Multiple regression analysis showed 12% of the variance was accounted by patient age and Charlson Comorbidity Index (p = 0.027).

A Comparison using Kruskal-Wallis one way analysis of variance suggested a significant difference between dimensions of the quality of life (PF, RF, RE, VT, GMH, SF, BP and GH, $p = < 0.001$). Using the same test, a significant difference between different features of ODI (pain intensity, personal care, lifting, walking, sitting, standing, sleeping, sex life, social life and traveling, $p = < 0.001$) was found. Additionally, there was also a significant difference between sensory pain index, affective pain index, visual analogue scale, and total pain appraisal ($p = < 0.001$).

A significant correlation between poor work ability and severe disability on ODI, $p < 0.001$, as well as a low score on each of the dimensions PF, RP, RE, VT, SF and BP of SF-36, $p < 0.05$ were calculated.

4 Discussion

4.1 Aim of dissertation

This dissertation reported on clinical presentation, diagnosis, management, and outcomes of adults surgically treated for spondylodiscitis in the years 2008 to 2017 at Universitätsmedizin Göttingen Klinik für Neurochirurgie. Trends over the past 2 decades have shown a progressive increase of incidence in spondylodiscitis (Acosta et al. 2006; Kehrer et al. 2014; Sur et al. 2015). This can be explained by rising life expectancy, prevalence of immunosuppressed patients, intravenous drug abuse and increases in spinal surgery (Carragee 1997a, Musher et al. 1976, Deyo et al. 2004, Pola et al. 2017). Spondylodiscitis is correlated with high postoperative mortality and disability rates, suggesting reduced quality of life in affected patients (Zarghooni et al. 2012; Gupta et al. 2014; Rutges et al. 2016; Dragsted et al. 2017; Widdrington et al. 2018; Giordan et al. 2019; Yagdiran et al. 2020). Nevertheless, there still poses a need for more information concerning treatment and perioperative outcomes regarding patients with spondylodiscitis. The aim of this paper was to analyze the short- and long-term outcomes in patients after operatively treated spondylodiscitis and to summarize the dominating prognostic factors.

4.2 Results

Patients who underwent surgery for spondylodiscitis in our cohort suffered from distinct reductions in all domains of quality of life compared to an age-matched population. The analysis confirmed the high total mortality and post-surgical complication rates in patients after surgically treated spondylodiscitis and suggested that physical health posed the highest limitation for affected patients. The results further revealed an insight into patient's work ability and everyday coping capabilities (for example lifting and standing), which were reduced compared to the general population. Bodily pain and fatigue were common even years after initial infection.

In our cohort, active drug abuse and misplaced or loosened screws were identified as risk factors for residual disabilities and relapse infections. The study further indicated that patients operated with robot-assisted had a lower incidence of death and robot-guided operations were associated with shorter hospital stays. Longer hospital stays were associated with higher patient ages, multidrug-resistant bacteria, neurological deficits on admission, higher number of operated levels, interbody cages, general postoperative complications, and surgical site infection.

4.3   Patient demographics and comorbidities

The demographics of spondylodiscitis are shifting to an increasingly elderly population with related comorbid diseases. Men are more commonly affected than women (Sapico and Montgomerie 1979; Grammatico et al. 2008; Mylona et al. 2009; Gouliouris et al. 2010). The age and demographics of our cohort confirmed these findings; 61.47% patients were male and 38.53% were female, the average age by admission was 69.41 ± 11.90 years. Furthermore, age distribution presented a notable maximum in the 71 - 80 years of age category (38.99%).

Spondylodiscitis occurs more frequently in patients with multiple comorbidities. Tumor diseases, renal failure, acquired immunodeficiency syndrome (AIDS), obesity, diabetes mellitus, conditions of the cardiovascular and liver system as well as alcohol and drug abuse are common in patients with spondylodiscitis (Ahlhelm et al. 2006; Frangen et al. 2006; Cebrián Parra et al. 2012; Fleege et al. 2012). This was confirmed in our cohort. 182 Patients (83.49%) suffered from one or more of these ailments. In keeping with previous studies, the most common patient comorbidities included diabetes mellitus (36.24%) followed by a moderate or severe kidney disease (31.20%) and cerebrovascular disease (23.39%) (McHenry et al. 2002; Giordan et al. 2019). The prevalence of risk factors in large studies conducted on spondylodiscitis patients vary widely. Diabetes mellitus and intravenous drug abuse, for example, were found to be present in 10 - 37% and 2 - 79% of patients, respectively (Akiyama et al. 2013; Urrutia et al. 2013; Kehrer et al. 2014; Loibl et al. 2014). The high variability may be due to the inhomogeneous global distribution of comorbidities.

Obesity was documented in 13.76% of our patients. In a German retrospective analysis of obesity in spondylodiscitis patients between 2013 and 2018, 32.8% of the patients were classified as pre-obese and 24.8% of the patients were classified as obese. Here, obese patients were younger, showed a higher revision operation rate, increased postoperative complications and higher rates of abscesses and neurological failures, presenting risk factors for a severer course of spondylodiscitis (Schoof et al. 2020). These observations could not be confirmed in our clinical findings, possibly because our population presented a lower proportion of obese patients.

Previous studies identified several risk factors for poor outcome among patients with spondylodiscitis such as diabetes mellitus or rheumatoid arthritis (Beronius et al. 2001; McHenry et al. 2002; Gupta et al. 2014). Unfavorable outcomes were defined as incomplete recovery, death, residual disability, or relapse infection. In our study, higher age, drug abuse and higher

Charlson Comorbidity Indices predicted an unfavorable outcome in terms of residual disabilities and relapse rate. No further assessment was conducted in terms of the importance or impact of an individual comorbidity on the prognosis of the disease. Furthermore, as the Charlson Comorbidity Index summarizes nineteen comorbidity items, it is probable that more comorbidities existed in the patient cohort.

4.4 Clinical presentation

In line with previous studies, almost all patients (91.74%) had spinal pain at admission (Fantoni et al. 2012; Giordan et al. 2019; Waheed et al. 2019). Furthermore, 111 patients (50.92%) presented neurological deficits. The number of patients with neurological deficits at diagnosis was higher compared to earlier analyses (McHenry et al. 2002; Dragsted et al. 2017; Giordan et al. 2019). This may be due to late clinical presentation at admission. In agreement with our findings, a retrospective analysis of 253 patients correlated death or incomplete recovery with neurological deficits at diagnosis (McHenry et al. 2002). Similarly, a prospective study of 81 patients revealed that the presence of a neurological deficit at diagnosis and a delay in presentation of greater than 60 days were significantly associated with persistence of neurological deficit or relapse of infection (D'Agostino et al. 2010). In addition to these findings, patients with neurological deficiencies at diagnosis in our study had a longer hospital stay, increasing the risk of infection and other hospital-acquired complications. These results mark the significance and severity of neurological compromise at admission and suggest an increased awareness and caution if clinical presentation is present.

4.4.1 Epidural abscess

Imaging showed an epidural abscess in 68 patients (31.2%) and over half of these patients (57.4%) presented neurological deficits at diagnosis. The occurrence of an epidural abscess was not found to be correlated with relapse rate, length of hospital stay, death or residual disabilities. These findings indicate that an epidural abscess may not directly affect a patient's outcome, clinicians should however consider frequently abscess-associated neurological deficits. This relation may be due to myeloradicular compression caused by the abscess and is described in other studies (Skaf et al. 2010; Rutges et al. 2016; Mavrogenis et al. 2017; Giordan et al. 2019).

4.5 Diagnosis

4.5.1 MRI and blood cultures

MRI combined with lab tests is the gold standard for detecting spondylodiscitis with scintigraphy reserved for exceptional cases in case of diagnostic uncertainty (Lazzeri et al. 2008). Blood cultures were taken in only 37.6% of our patients. This low figure surprised us, given that it presents part of the standard of care (Skaf et al. 2010; Herren et al. 2017; Pola et al. 2017; Giordan et al. 2019). A potential explanation includes lost data or a systematic inadequacy in documenting and filing laboratory results, or on the retrieving end, lack of knowledge of the archiving location for laboratory work.

Staphylococcus aureus was the most frequent pathogen, consistent with existing reports (Sobottke et al. 2010; Gupta et al. 2014; Dragsted et al. 2017; Pola et al. 2017; Widdrington et al. 2018). Nonetheless, in a large number of patients no microbiological diagnosis could be established, in accordance with literature (McHenry et al. 2002; Mylona et al. 2009; Mavrogenis et al. 2017). While Staphylococcus aureus could not be identified as a risk factor for poor patient outcome, MRSA strains were associated with higher wound infection rates and longer hospital stays. The incidence of spondylodiscitis infections caused by MRSA organisms has been reported to be increasing (Torda et al. 1995; Hadjipavlou et al. 2000; Al-Nammari et al. 2007). In our report, MRSA strains were found in 49.15% of patients with a Staphyloccocus aureus infection. The reported incidence of MRSA infections in pyogenic spondylodiscitis in literature varies from 6.8 to 30% (Aspinall et al. 1995; Torda et al. 1995). MRSA osteomyelitis is a well-recognized late consequence of unsatisfactorily treated bacteremia (Fowler et al. 1998). The higher incidence of MRSA organisms in our cohort compared to other studies could therefore be attributed to an insufficient treatment of a previous infectious condition. Our findings highlight the importance of blood cultures and screening smears prior to the administration of antibiotics as the presence of multidrug-resistant bacteria significantly correlate with unfavorable clinical consequences.

4.5.2 CRP

As shown in other studies, CRP values were elevated in almost all patients (Beronius et al. 2001; Schimmer et al. 2002; Gouliouris et al. 2010). CRP values are described as helpful to follow up on the progression of treatment (Hsieh et al. 2004; Kang et al. 2010). Carragee et al. observed a normalization of CRP levels within 3 months of the initiation of treatment (Carragee et al. 1997). In our cohort CRP levels continually dropped from date of admission to discharge. Higher

preoperative inflammation markers correlated with adverse patient outcomes; higher WBC count correlated with wound infection and higher CRP values with death. Thus, the laboratory markers represent a relatively simple and inexpensive method when estimating patient disease severity and treatment progress and should be ideally performed at clinical presentation. In our study, ESR was not measured and its relevance therefore cannot be further explored.

4.6 Location of infection

The most common location of infection, as shown in previous reports and in line with literature, was the lumbar region (Pola et al. 2017). Patients with pyogenic infection mostly present isolated lesions, involving one or two adjacent vertebrae and multifocal involvement occurs in only 4% of cases (Mylona et al. 2009). In our cohort, multi-segmental (two or more vertebrae affected) spondylodiscitis was identified in 67.9% cases. Length of hospitalization was prolonged in patients who received multilevel operation. Little research on multisegmented spondylodiscitis is present and further studies are warranted to provide more data on the optimal management of this particularly challenging subset.

4.7 Therapy

4.7.1 Antibiotic therapy

Antibiotic therapy was given for an average of 10 weeks. Limited research has been conducted on the most effective route and length of antibiotic treatment. The duration of therapy varies widely based on retrospective case studies, expert opinions and data extrapolated from animal and laboratory data (Mylona et al. 2009). In a multicenter prospective examination, the average worldwide antibiotic therapy length for spondylodiscitis was calculated to be 14.7 weeks (Legrand et al. 2001). Sapico and Montgomerie found a significantly increased risk of treatment failure in patients treated for a total of less than 4 weeks compared with those treated for longer (Sapico and Montgomerie 1979). Undoubtedly, many aspects (such as high vs. low virulent pathogens, acute vs. chronic infection, type of infection, presumed primary focus, embedded foreign material, etc.) must be considered when choosing the correct antimicrobial therapy. In general, antibiotic treatment is recommended for 6 to 12 weeks, while tuberculosis or fungal spondylodiscitis requires significantly longer antibiotic/antimycotic therapy (Lew and Waldvogel 2004; Lazzarini et al. 2005; Butler et al. 2006; Sobottke et al. 2008a).

4.7.2 Surgery

All patients in our cohort received operative treatment for spondylodiscitis. There is a broad agreement regarding surgical debridement and adequate stabilization in the presence of neurological deficits, biomechanical instability, bone destruction, existing abscess formations or a septic clinical picture (McHenry et al. 2002; Sobottke et al. 2008a; Akbar et al. 2012; Fushimi et al. 2012). However, the existing different treatment algorithms in operative care make a comparison difficult. From a purely anterior or purely posterior restoration to a combined approach to a single or multiple approach, there are many options that are still the subject of intense discussions (Klöckner et al. 2001; Schinkel et al. 2003; Lerner et al. 2005; Butler et al. 2006; Frangen et al. 2006). Conservative therapy is also an option in uncomplicated and subacute infections. Non-surgical versus surgical approaches are discussed controversially in the literature (Schinkel et al. 2003; Lerner et al. 2005; Butler et al. 2006; Frangen et al. 2006; Linhardt et al. 2007).

In our cohort, spinal canal decompression was performed in 80 patients (36.7%) and corpectomy with interbody fusion in 45 patients (20.6%). Furthermore, robot-assisted spinal surgery was performed in 47.3% of patients. Little is known about the impact of minimally invasive surgical techniques. Nevertheless, these procedures have become increasingly popular. Reasons for implementation in spondylodiscitis include reduced collateral tissue damage, a high precision of screw location and minimized radiation dosage compared to open surgical techniques (Faciszewski et al. 1995; Stokes et al. 2000; Kim et al. 2005; Deininger et al. 2009; Devito et al. 2010). However, some clinicians argue that the perioperative outcome depends more on the surgical access to infected disc regions (percutaneous versus open). Kantelhardt et al. showed that duration of postoperative hospitalization, postoperative analgesic administration, wound infection, and revision rates ranked lower in the percutaneous robotic-controlled procedures versus conventional and open robotic-guided techniques. (Kantelhardt et al. 2011).

Recent studies in degenerative pathologies (degenerative spondylolisthesis) have addressed complication rates of spine surgery in detail, suggesting that decompression surgery alone is equivalent to decompression with instrumented fusion regarding QoL, leg and back pain, duration of surgery, length of hospital stay and reoperation rates (Austevoll et al. 2021).

4.7.3 Robot-assisted techniques

Our study showed significantly reduced perioperative adverse events in robot-guided percutaneous operations in comparison to free-hand conventional operations. Radiation exposure from X-rays in robot-guided percutaneous operations was significantly shorter than in free-hand surgeries (mean: 127.71 seconds vs. 161.02 seconds). Furthermore, operating time was reduced in patients with robotically assisted navigations with a significant difference of 38.8 minutes. Mean hospital stay was 25.1 days for patients operated with robot-assisted screw insertions compared to 34.1 days for patients operated with free-hand procedures. Moreover, death of patients was seen more often in patients operated conventionally ($p = 0.0143$). Nevertheless, the number of postoperative wound infections appeared equal in the robot-assisted operations and in the conventional surgeries. Thus, this study cannot confirm other findings that suggest a decreased rate of wound healing abnormalities in robot-navigated operations (Keric et al. 2017; Alaid et al. 2018). Long-term postoperative outcome showed no significant difference in both groups. Better outcomes in robot-assisted cases could possibly be explained by the elective nature of their use. Sepsis and emergency spondylodiscitis patients in our clinic routinely receive free-hand conventional procedures. Therefore, it can be argued that the improved results seen in robot-assisted procedures reflects better outcomes in the less critically affected patient cohort rather than operative technique itself. Zhang et. al found that obesity, osteoporosis and congenital scoliosis are risk factors for unsatisfactory robot-assisted spinal pedicle screw placement and clinicians are advised to perform other surgical methods when these risk factors are present (Zhang et al. 2019).

4.8   Postoperative complications

This analysis additionally confirmed the high incidence of postoperative complications in patients after surgically treated spondylodiscitis with a total of 70.18% patients who experienced post-surgical problems. In line with earlier studies, the most common postoperative complications included wound infection (18.35%) and screw misplacement or loosening (13.30%) (Bellabarba et al. 2006; Frangen et al. 2006; Schildhauer et al. 2006). Respiratory difficulties (9.18%) and new sensorimotor deficits (7.80%) were also common postoperative complications. Wound infections required revision in 95% of cases, resulting in prolonged hospital stays ($p < 0.001$). Higher age, elevated preoperative WBC and a MRSA-associated infection ($p = 0.0484$, $p = 0.0297$, $p = 0.0006$ respectively) increased rates of wound infection in our patient cohort.

4.8.1 Infection relapse

Infection relapse occurred in 16 patients (7.34%) at an average of 28.9 weeks after initial surgery. One study reported having a relapse rate of 14% (McHenry et al. 2002). Patients with active drug abuse and/or a misplaced or loosened screw had a significantly higher chance of developing a spondylodiscitis relapse in our cohort. In several studies, relapse of spondylodiscitis was associated with severe vertebral destruction, recurrent bacteremia, undrained paravertebral and psoas abscesses and chronic draining sinuses (McHenry et al. 2002; Herren et al. 2017). In another study, the relapse rate was significantly higher for patients with endocarditis compared to patients without endocarditis (8% vs. 1.9%) (Pigrau et al. 2005). Spondylodiscitis relapse may occur as late as two years after the initial treatment, as shown in our patient population. Therefore, follow-up and monitoring for persistent or recurrent infection for a sufficient period after treatment appears important, especially when there is renewal or intensification of pain, unexplained fever, elevation of CRP or recurrent bacteremia. Prolonged administration of antibiotics can be given if there is suspicion of residual disease (McHenry et al. 2002).

4.9 Hospital stay

Spondylodiscitis often affects a fragile and elderly population and longer hospital stays could pose a threat for this patient group due to prolonged immobilization and increased infection risk. Mean hospital stay after surgical treatment of spondylodiscitis in our cohort was 29.86 days (min: 4, max: 162). Other studies have shown longer lengths of hospital stays, with a mean of over 40 days (Schinkel et al. 2003; Isenberg et al. 2005; Frangen et al. 2006). Patients undergoing surgical treatment for spondylodiscitis were at a higher risk for longer hospital stay in case of multidrug-resistant bacteria, vertebrectomy and surgical site infection. Improved postoperative care and wound management should be considered to minimize surgery-related complications and reduce length of hospital stay.

4.10 Death and long term-disabilities

At final follow up, death occurred in one hundred cases with a total mortality rate of 45.9%. The relatively long follow-up time of 260 weeks must be considered in our cohort and presumably accounts for the high mortality seen. The overall thirty-day postoperative mortality rate was calculated to be 2.3%. The overall one-year crude mortality rate was 6.9%. Obesity predicted in-hospital mortality and last CRP value and preoperative neurological deficits predicted one-year death. Length of hospital stay, last CRP value, age at admission and Charlson

Comorbidity Index predicted death at follow up. Kehrer et al. portray similar results, where severe neurologic deficits at the time of admission, epidural abscess and comorbidities are associated with higher one-year mortality (Kehrer et al. 2015). In our series, the in-hospital mortality rate was lower than the rate reported in a large Japanese series including 6,087 patients with pyogenic spondylodiscitis, the majority of whom received a conservative treatment, 1.83% vs. 6% (Akiyama et al. 2013). The mortality rate at one year in our series was also lower than the rate reported in the French series including 351 patients who were treated conservatively for pyogenic spondylodiscitis, 6.9% vs. 7.4% (Courjon et al. 2017). In our case, results applied specifically to operated patients. Whether this would apply for conservatively treated patients would have required a comparative approach, which was not possible in our purely surgical cohort. Moreover, whether the total mortality in spondylodiscitis patients differed to the average population was not examined but studies suggest there is no difference between the two groups and higher mortality rates depend solely on existing comorbidities (Aagaard et al. 2014). Research shows that after the first year of spondylodiscitis, patients did not die from the disease itself, but from accompanying pre-existing illnesses. (Kehrer et al. 2015; Aagaard et al. 2016).

Longer-term disabilities were defined as significant ongoing or renewed back pain requiring regular analgesia and/or further surgical revision, persisting or renewed motor and/or sensory deficits, incontinence, new spinal bone destruction and epidural abscess following treatment of the infection and occurred in 35 patients (16.1%). Subsequent analysis revealed that active drug abuse at the time of diagnosis of spondylodiscitis was significantly predictive of an unfavorable outcome. Other research has revealed that diabetes mellitus, clinical evidence of neurological impairment, longer duration of symptoms prior to presentation and radiological findings indicative of spinal cord/cauda equina compression at time of presentation were associated with long-term disabilities (Widdrington et al. 2018).

4.11   Quality of life

Patients who underwent surgery for spondylodiscitis remained prone to long-term limitations in all domains of quality of life. This was true especially for physical health and working ability. This data was consistent with other retrospective studies. O'Daly et al. recorded a poorer functional outcome after successfully treated spondylodiscitis compared to a standard population (O'Daly et al. 2008). Yagdiran et. al showed a significant improvement of quality of life over the course of 2 years after surgical treatment of spondylodiscitis compared to infection onset. Nevertheless, this report similarly presented a significantly decreased quality of life compared to a normal population (Yagdiran et al. 2020). Overall, little research is present on

the quality of life after spondylodiscitis and its treatment. Our study confirmed that higher patient age, higher Charlson Comorbidity scores, documented residual disabilities and preoperative neurological impairment were predictors of adverse outcome, contributing to higher disability rates and lower quality of life. The experiment provided new insight into the relationship between mental and physical health in patients after spondylodiscitis, demonstrating that the two often correlated with one another.

4.11.1 ODI

In our study, highest disability rates were seen in lifting, standing, sex life and walking. Lower disability rates were seen in sleeping, sitting and personal care. Social life and travel were also limited in many cases, which, in turn, could have potentially further worsened the emotional and psychological well-being of patients. Mean overall disability was calculated to be 38.45%. The ODI results confirmed high impairment rates in physical functioning and suggested that most patients experienced severe disability after spondylodiscitis, even after successful treatment. Higher disability rates were seen in older and previously documented residual disability patients.

Sobottke et al. reported clinical mid-term results of QoL in a cohort of 32 patients aged ≥65 years with pyogenic spondylodiscitis, half of whom were treated surgically. They reported ODI scoring that are comparable to ODI scoring in our series including a minimal disability in 38.9% vs. 23%, a moderate disability 22.2% vs. 21%, a severe disability 22.2% vs. 19% and a complete disability 11.1% vs. 33% of patients; 5.6% vs. 4% of patients were bed-ridden (Sobottke et al. 2010). A shift toward a higher complete disability in our series is notable and might be explained by the difference in follow-up period, mean 3.6 years vs. 4.8 years.

Our cohort mean ODI value (38.45%) was above that of a standard population and of a long-term back pain population. The results exceeded the scores of Fairbank et al. for a healthy population and of Tonosu et al. for an age-adjusted back pain population with a sum of 22% (Fairbank and Pynsent 2000; Tonosu et al. 2012). Moreover, the mean ODI value in our study was also above the mean values in spondylodiscitis patients in other reports, where scores ranged from 23 to 30% (Pee et al. 2008; Robinson et al. 2009; Gonzalvo et al. 2011). These results suggested a particularly unsatisfactory outcome in our cohort for disability rates and may be explained by the high rate of postoperative residual disabilities seen in our patient cohort (25%).

4.11.2 SF-36

The mean SF-36 values of this study compared to values for an age-accordant general German population were dramatically reduced (Bullinger 1995). The mean PCS value (29.87) was not only well below the value of a healthy population (PCS = 81.29), but also below that of a back pain population (PCS = 38.35). The average MCS value (47.48) was below the average value of a normative sample (MCS = 74.22) and below that of a back pain patient (MCS = 51.51). Mean SF-36 for all items in our cohort and component scores for a German reference group were compared in Figure 26 below. Woertgen et al. compared QoL measured by SF-36 between surgically and conservatively treated patients. Their results suggest that surgery, especially in conjunction with the placement of instrumentation, may be more beneficial than conservative treatment in patients with a spinal infection. The SF-36 values reported in the surgical groups were higher than those of our cohort in all domains, which can also be attributed to the relatively short follow-up period of 1.34 years in mean (Woertgen et al. 2006). Physical functioning among patients in our cohort was poorer than emotional functioning, suggesting a greater impact of the disease on physical health and bodily functionality.

Linear regression showed a high correlation between mental and physical scores. Patients with lower mental scores generally showed lower physical scores and vice versa. This consequence underlines the significant role of mental health on physical health and contrariwise. Ideally, both parameters should always be considered when attempting to measure patient satisfaction and/or treat patients with spondylodiscitis. Preoperative neurological deficits had a significant impact on physical component scores, emphasizing the severity of the effects if clinically present.
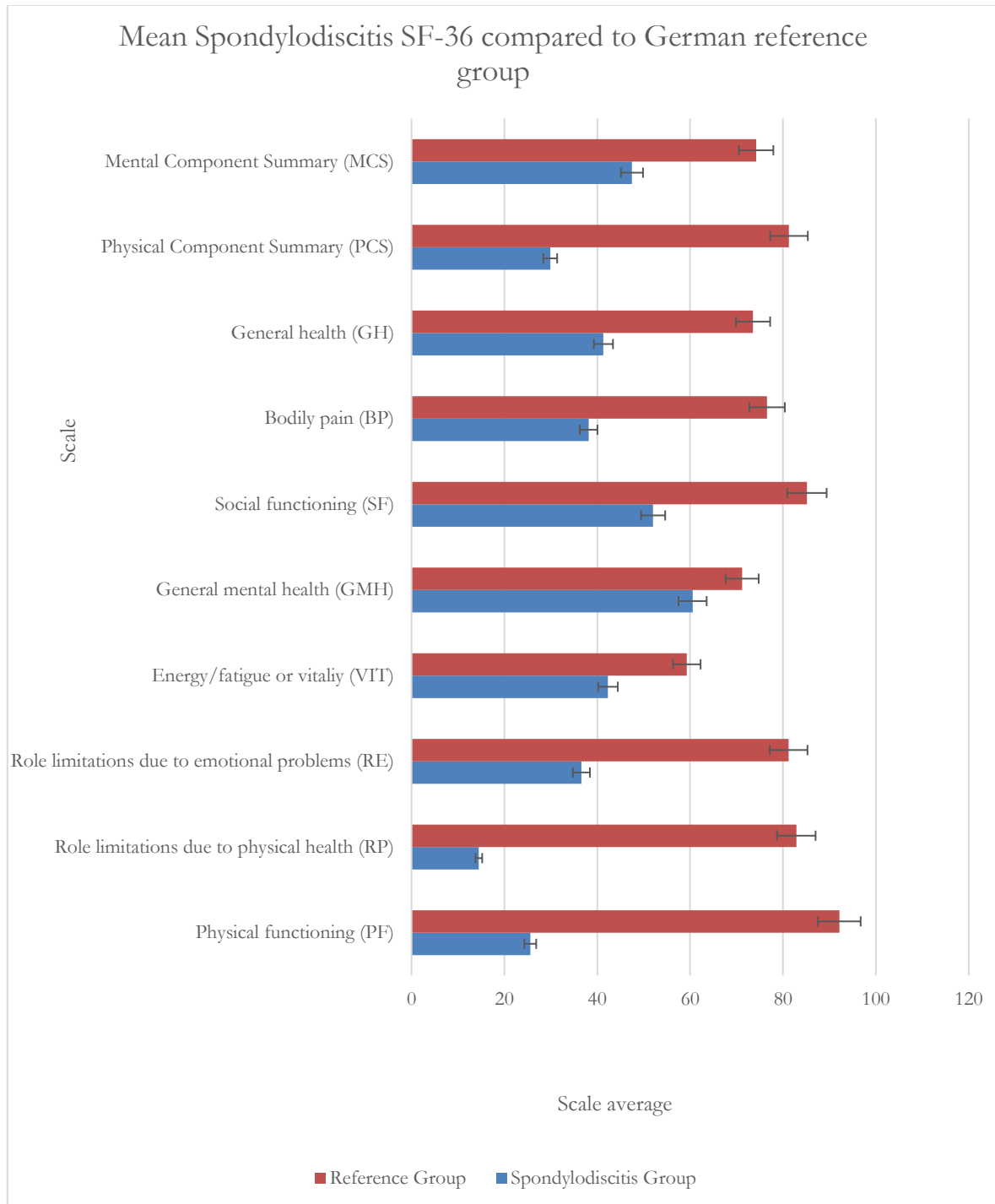
Figure 21: Mean cohort SF-36 values compared to German reference group

4.11.3 SF-MPQ

The average sensory pain index was calculated to be 19.21%. Sixteen patients (36.36%) did not complete the average affective pain index item accurately. Thus, this item did not reflect pain in our cohort accurately. The average total pain index could not be considered as truthful as this score is the sum of the average sensory and affective pain index. The total average current pain

intensity on a visual analogue scale was 4.57 and overall patient pain appraisal on a scale from zero (pain-free) to five (agonizing pain) averaged to be 45.8%. Consequently, the results of the first part of the questionnaire could not be objectively assessed and considered, as too much information was missing. As more patients completed the second part of the questionnaire, it could be said that patients in our cohort experienced intense pain. The degree of difficulty of this questionnaire must be discussed in the light of the high non-response rate. Melzack et al. described the MPQ as a highly valid instrument to evaluate pain in patients as it improves communication between patient and clinician and aids with identification of pain etiology by providing an extensive lexicon of pain quality. However, the complexity of the existing terms can be a problem for patients of lower IQ and other measures should be used in cases of below average IQ (Melzack 1975). No other studies on SF-MPQ with spondylodiscitis patients exist and more research should be done in this direction to provide a clearer outlook on the sort of pain experienced. Further investigation could also clarify the causes of lower-response rates among these patients. This study indicated that the rating of pain intensity relied on residual disabilities present in patients.

4.11.4 SF-WAI

In this questionnaire, the majority of patients (70.45%) were classified in the category "bad" and only 2.27% in the category "very good" in terms of working ability. Most patients (65%) who answered this survey were in retirement age (≥ 65 years old) and largely suffered from other physically restricting comorbidities, that had little or nothing to do with spondylodiscitis. Therefore, it was difficult to assess the number of patients after spondylodiscitis in this cohort who could not return to work because of the disease itself. The low work ability in our patient group could be due to the high population age and high comorbidity rate. Kehrer et al. examined employment status one year before and during two years after infectious spondylodiscitis among 112 working-age patients in Denmark during 1994 and 2009 (Kehrer et al. 2017). The patients' ability to work was significantly reduced both before and after the disease compared to a Danish reference population. Among the 112 patients with spondylodiscitis, only 48 were part of the workforce one year before diagnosis. Lower employment rates among spondylodiscitis patients may be explained by the higher number of comorbidities accompanied with the disease, such as intra-venous drug abuse (Endress et al. 1990; Hadjipavlou et al. 2000; Przybylski and Sharan 2001). The study demonstrated that being part of the workforce one year before diagnosis predicted being part of the workforce after two years. Of the 48 patients who were part of the workforce one year before diagnosis, 21% did not return to work and 6% died within two years, resulting in low return to work rates. Larger investigations on a working-age population before

and after infection are suggested to correctly measure and predict work ability index and return to work rate among spondylodiscitis patients.

The data contributed a clearer understanding of the influence of patient age and Charlson Comorbidity Indices on Work-Ability-Index. Higher patient age and number of comorbidities correlated significantly with unsatisfactory work ability.

4.12 Clinical implications

Based on our data, three out of four patients operated for spondylodiscitis portrayed a severely reduced work ability. Of those who were under 65 years old, i.e. in working age, the majority (64.3%) was unable to work. This implies that, in addition to potentially high treatment costs including surgery and long-term antibiotics, the socioeconomic burden of spondylodiscitis should also be evaluated in terms of lost productive life-years. Loss of work ability after spondylodiscitis may also adversely impact patients' self-esteem and stress levels, further worsening quality of life. Improving rapid rehabilitation efforts can play a role in the management of these patients. Early mobilization with orthosis, for example, should be planned and controlled by clinicians.

Moreover, every fifth patient still suffered from severe or debilitating pain, 4.8 years after treatment. Since we did not evaluate whether these patients were followed up by a dedicated pain service, we can only assume that routine follow-up care and management, e.g. from a pain specialist, could yield more favorable results.

Emotional-wellbeing was lower than the age-matched average in a third of patients. As with pain, we did not find any routine psychotherapeutic follow-up or newly administered antidepressant treatment in these patients. Therefore, the psychological domain may equally deserve more attention. Routine screening of patients for emotional distress after treatment for spondylodiscitis appears justified in light of the high numbers found.

The MRI examination as the "golden standard", together with consistent laboratory and physical check-ups are to be carried out to evaluate patient response to the given antimicrobial therapy. The choice of antibiosis should, if possible, be based on the antibiogram. Routine screening of patients for multi-resistant bacteria could also protect against MRSA-associated wound infections. Standard screening for neurological and motor deficits should also be performed as presence prognosticate a worse long-term outcome. Furthermore, the increased usage of robot-

assisted operations could be considered as our results showed better outcomes for patients (lower mortality rates, shorter hospital stays, etc.).

Lastly, quality of life surveys can be given to measure the effectiveness of treatment and patient satisfaction. These tests can be provided at several times, for example, before treatment, on discharge and then annually. It is expected that the prospective collection of data will enable an improved long-term clinical assessment of patients' quality of life and aid targeted therapeutic strategies, optimizing physical, physiotherapeutic, and psycho-social aftercare concepts.

4.13   Strengths and limitations

The primary strengths of this dissertation consisted of a high patient population size compared to other studies of patients after surgical treatment for spondylodiscitis. This study included four questionnaires consisting of ODI, SF-36, SF-MPQ and SF-WAI. These diverse surveys allowed an accurate evaluation of the QoL for an extremely diverse patient population. The analysis follow-up time of over five years provided a reasonable long-term evaluation of patient well-being after spondylodiscitis. Furthermore, various preoperative factors were considered and effects on short and long-term patient outcomes were examined.

Major limitations of this study were those inherent to the retrospective study design. The validity of this data was impacted by the method of patient information storage. Electronic medical records were reviewed to evaluate patient data. Many of these files were lost or only partially completed on inspection. Death was recorded as reported by electronic files, postal service, or patient family. Many patients did not have follow-up WBC or CRP values performed, which limited the power to analyse improvement of inflammatory markers as predictive of treatment success. Additional perioperative factors (e.g. degree of pain) should ideally be measured to improve the effective evaluation of QoL results in patients.

A further limitation of this report may have been a patient selection bias because many cases were problematic and/or pretreated, resulting in a possibly sicker patient population. Moreover, the type of surgical procedure performed was decided by the treating clinician. Thus, selection bias may have impacted results.

Statistical analysis with fishers one-sided test in wound infection, length of hospital stay, death and residual disabilities could have been skewed as the nature of the test depends on the confidence of one-direction influence of the independent variable on the dependent variable.

As a general shortcoming of QoL data, QoL scores were not obtained in patients prior to development of spinal infection. Due to the lack of available data, the results could not compare pre- and postoperative QoL results among spondylodiscitis patients, and it was possible that their QoL was lower than that of a reference population prior to disease manifestation. Additionally, the generalizability of the results was limited by a lost to follow-up rate of 79.8% and due to the high overall mortality and disability rate, data from the most severe patients was missing. This created a patient response bias, allowing only the "healthier" patients to respond.

It was beyond the scope of this study to compare the QoL in patients after conservative treatment and in patients after operative treatment. Finally, QoL results should be viewed critically because multiple, individual components such as current comorbidities, financial situation, education, and social integration could influence patient outcome. People also constantly reevaluate their quality of life, compare it with what they have already experienced and adapt it to their current living conditions. Additionally, an individual's self-assessment can be vastly different due to different perceptions and coping mechanisms (such as fighting, denial, avoidance, etc.). The individual time interval between a decisive life event and the time of the analysis is also significant. Only after a certain time do positive impressions dominate over negative impressions (Herschbach 2002). The individual quality of life is therefore dependent on many, partly unknown, factors.

5   Conclusion

The objective of this report was to determine the quality of life of patients after operatively treated spondylodiscitis and the predicator factors that play a role to patients' satisfaction and success. This dissertation described the analysis of 218 patients with spondylodiscitis who underwent surgical treatment at Universitätsmedizin Göttingen Klinik für Neurochirurgie in the years 2008 - 2017. On examination of electronic records, emphasis was put on patient comorbidities, clinical symptoms, surgical aspects, and outcomes. Long-term quality of life of patients was measured through a prospective experiment that entailed distributing four questionnaires (ODI, SF-36, SF-MPQ, SF-WAI) to respondents. These surveys contained questions regarding patients' physical, emotional, and working abilities.

The responses received after an average of 4.8 years after initial treatment from 44 patients show a decreased quality of life and work ability in all aspects compared to an age-matched reference group. Three out of four patients operated for spondylodiscitis portrayed a severely reduced work ability, every fifth patient suffered from severe or debilitating pain and emotional-wellbeing was lower than the age-matched average in a third of patients. These results indicated that patients after surgically treated spondylodiscitis still suffered from pain, physical disabilities and emotional distress, years after infection.

Despite low in- hospital and one-year mortality rates, patients with surgically treated spondylodiscitis were prone to long-term limitations in all domains of quality of life, especially in physical health and work ability. Overall mortality of patients remained high, confirming the life-threatening potential of the disease. In our cohort, higher ages at surgery, higher comorbidity numbers and preoperative neurological impairment were identified as risk factors for adverse outcomes in patients with spondylodiscitis.

Patients undergoing surgical treatment for spondylodiscitis were at higher risk of prolonged hospital stay in case of multidrug-resistant bacteria, higher number of operated levels, surgical site infection and preoperative neurological deficits. Wound infection was more frequent in patients presenting multi-drug resistant bacteria, higher age, and elevated preoperative WBC levels.

Future challenges include improving rapid rehabilitation and postoperative follow-up management, standardizing measures to assess response to therapy, and clarifying the most appropriate surgical approach. Given the low incidence of this disease, these challenges will be best met through multicentre trials and well-matched cohort studies.

6   Attachments

Short-Form McGill Pain Questionnaire – Deutsche Version (MPQ-D)

Basierend auf Radvila et al.(1987) (*) und nicht validierten Übersetzungen der Autoren (Amir Tal Akabi und Peter Oesch)

Name: _____ Geburtsdatum: _____ Datum:_____

I. Normativ geschätzter Schmerzindex: Die unterstehenden Worte beschreiben den durch-
schnittlichen Schmerztyp. Setzen Sie ein Häkchen (✓) für alle nachstehenden Schmerzty-
pen in diejenige Spalte, die ihrer gefühlten Schmerzstärke/ Intensität entspricht.

		keine		gering/leicht		mässig		stark
klopfend*		0		1		2		3
einschiessend*		0		1		2		3
stechend*		0		1		2		3
scharf*		0		1		2		3
klemmend*		0		1		2		3
nagend*	a	0		1		2		3
heiss-brennend*		0		1		2		3
schmerzend		0		1		2		3
schwer*		0		1		2		3
empfindlich*		0		1		2		3
durchtrennend*		0		1		2		3
ermüdend - erschöpfend*		0		1		2		3
Übelkeit erregend	b	0		1		2		3
beängstigend*		0		1		2		3
strafend - grausam		0		1		2		3

II. Momentane Schmerzintensität - Visual Analog Skala (VAS).
Markieren Sie auf der untenstehenden Skala Ihre Schmerzintensität.

schmerzfrei |————————————————————| denkbar
schlimmster
Schmerz

III. Beurteilung der Intensität der gesamten Schmerzerfahrung: Setzen Sie ein Häkchen (✓)
in die passende Zeile.

Beurteilung		
0	schmerzfrei*	
1	gering/ leicht*	
2	unangenehm	
3	belastend	
4	fürchterlich	
5	qualvoll	

IV. Punktzahl:

Nicht ausfüllen, nur für Auswertung		Punkt
I-a	sensorischer Schmerzindex	
I-b	affektiver Schmerzindex	
I-	total Schmerzindex	
II	aktuelle Schmerzintensität	
III	Gesamtbeurteilung der Schmerzintensität	

Figure 1A.: Short-Form McGill Questionnaire

Fragebogen zu Behinderung bei Rückenbeschwerden:
Oswestry Disability Index – Deutsche Version (ODI-D)

Quelle: Mannion AF, Junge A, Fairbank JC, Dvorak J, Grob D. Development of a German version of the Oswestry Disability Index. Part 1: cross-cultural adaptation, reliability, and validity. Eur Spine J 2006a; 15:55-65.

Abschnitt zu beantworten. Kreuzen Sie in jedem Abschnitt nur die Aussage an, die Sie heute am besten beschreibt.

Abschnitt 1: Schmerzstärke
_0 Ich habe momentan keine Schmerzen
_1 Die Schmerzen sind momentan sehr schwach
_2 Die Schmerzen sind momentan mässig
_3 Die Schmerzen sind momentan ziemlich stark
_4 Die Schmerzen sind momentan sehr stark
_5 Die Schmerzen sind momentan so schlimm wie nur vorstellbar

Abschnitt 2: Körperpflege (Waschen, Anziehen etc.)
_0 Ich kann meine Körperpflege normal durchführen, ohne dass die Schmerzen dadurch stärker werden
_1 Ich kann meine Körperpflege normal durchführen, aber es ist schmerzhaft
_2 Meine Körperpflege durchzuführen ist schmerzhaft, und ich bin langsam und vorsichtig
_3 Ich brauche bei der Körperpflege etwas Hilfe, bewältige das meiste aber selbst
_4 Ich brauche täglich Hilfe bei den meisten Aspekten der Körperpflege
_5 Ich kann mich nicht selbst anziehen, wasche mich mit Mühe und bleibe im Bett

Abschnitt 3: Heben
_0 Ich kann schwere Gegenstände heben, ohne dass die Schmerzen dadurch stärker werden
_1 Ich kann schwere Gegenstände heben, aber die Schmerzen werden dadurch stärker
_2 Schmerzen hindern mich daran, schwere Gegenstände vom Boden zu heben, aber es geht,
wenn sie geeignet stehen (z.B. auf einem Tisch)
_3 Schmerzen hindern mich daran, schwere Gegenstände zu heben, aber ich kann leichte bis
mittelschwere Gegenstände heben, wenn sie geeignet stehen
_4 Ich kann nur sehr leichte Gegenstände heben
_5 Ich kann überhaupt nichts heben oder tragen

Abschnitt 4: Gehen
_0 Schmerzen hindern mich nicht daran, so weit zu gehen, wie ich möchte
_1 Schmerzen hindern mich daran, mehr als 1-2 km zu gehen
_2 Schmerzen hindern mich daran, mehr als 0.5 km zu gehen
_3 Schmerzen hindern mich daran, mehr als 100 m zu gehen
_4 Ich kann nur mit einem Stock oder Krücken gehen
_5 Ich bin die meiste Zeit im Bett und muss mich zur Toilette schleppen

Oswestry Disability Index – Deutsche Version (ODI-D)
Aus: Oesch, Hilfiker, Keller, Kool, Tal-Akabi, Schädler, Verra, Widmer Leu
Assessments in der muskuloskelettalen Rehabilitation. © Verlag Hans Huber 2007. Alle Rechte vorbehalten.

Abschnitt 5: Sitzen
_0 Ich kann auf jedem Stuhl so lange sitzen wie ich möchte
_1 Ich kann auf meinem Lieblingsstuhl so lange sitzen wie ich möchte
_2 Schmerzen hindern mich daran, länger als 1 Stunde zu sitzen
_3 Schmerzen hindern mich daran, länger als eine halbe Stunde zu sitzen
_4 Schmerzen hindern mich daran, länger als 10 Minuten zu sitzen
_5 Schmerzen hindern mich daran, überhaupt zu sitzen

Figure 2A.: Oswestry Disability-Index Page 1

Abschnitt 6: Stehen

_0 Ich kann so lange stehen wie ich möchte, ohne dass die Schmerzen dadurch stärker werden

_1 Ich kann so lange stehen wie ich möchte, aber die Schmerzen werden dadurch stärker

_2 Schmerzen hindern mich daran, länger als 1 Stunde zu stehen

_3 Schmerzen hindern mich daran, länger als eine halbe Stunde zu stehen

_4 Schmerzen hindern mich daran, länger als 10 Minuten zu stehen

_5 Schmerzen hindern mich daran, überhaupt zu stehen

Abschnitt 7: Schlafen

_0 Mein Schlaf ist nie durch Schmerzen gestört

_1 Mein Schlaf ist gelegentlich durch Schmerzen gestört

_2 Ich schlafe auf Grund von Schmerzen weniger als 6 Stunden

_3 Ich schlafe auf Grund von Schmerzen weniger als 4 Stunden

_4 Ich schlafe auf Grund von Schmerzen weniger als 2 Stunden

_5 Schmerzen hindern mich daran, überhaupt zu schlafen

Abschnitt 8: Sexualleben (falls zutreffend)

_0 Mein Sexualleben ist normal, und die Schmerzen werden dadurch nicht stärker

_1 Mein Sexualleben ist normal, aber die Schmerzen werden dadurch stärker

_2 Mein Sexualleben ist nahezu normal, aber sehr schmerzhaft

_3 Mein Sexualleben ist durch Schmerzen stark eingeschränkt

_4 Ich habe auf Grund von Schmerzen fast kein Sexualleben

_5 Schmerzen verhindern jegliches Sexualleben

Abschnitt 9: Sozialleben

_0 Mein Sozialleben ist normal, und die Schmerzen werden dadurch nicht stärker

_1 Mein Sozialleben ist normal, aber die Schmerzen werden dadurch stärker

_2 Schmerzen haben keinen wesentlichen Einfluss auf mein Sozialleben, ausser dass sie meine eher aktiven Interessen, z.B. Sport einschränken

_3 Schmerzen schränken mein Sozialleben ein, und ich gehe nicht mehr so oft aus

_4 Schmerzen schränken mein Sozialleben auf mein Zuhause ein

_5 Ich habe auf Grund von Schmerzen kein Sozialleben

Abschnitt 10: Reisen

_0 Ich kann überallhin reisen, und die Schmerzen werden dadurch nicht stärker

_1 Ich kann überallhin reisen, aber die Schmerzen werden dadurch stärker

_2 Trotz starker Schmerzen kann ich länger als 2 Stunden unterwegs sein

_3 Ich kann auf Grund von Schmerzen höchstens 1 Stunde unterwegs sein

_4 Ich kann auf Grund von Schmerzen nur kurze notwendige Fahrten unter 30 Minuten machen

_5 Schmerzen hindern mich daran, Fahrten zu machen, ausser zur medizinischen Behandlung

Viele Dank für Ihre Mitarbeit. Bitte überprüfen Sie ob Sie **alle** Fragen beantwortet haben.

Figure 3A.: Oswestry Disability-Index Page 2

Source: Mannion AF, Junge A, Fairbank JC, Dvorak J, Grob D. Development of a German version of the Oswestry Disability Index. Part 1: cross-cultural adaptation, reliability, and validity. Eur Spine J 2006a; 15:55-65.

Work Ability Index (WAI) - Fragebogen (Kurzversion)

Sind Sie bei Ihrer Arbeit...	
vorwiegend geistig tätig?	O_1
vorwiegend körperlich tätig?	O_2
etwa gleichermaßen geistig und körperlich tätig?	O_3

1. Derzeitige Arbeitsfähigkeit im Vergleich zu der besten, je erreichten Arbeitsfähigkeit

Wenn Sie Ihre beste, je erreichte Arbeitsfähigkeit mit 10 Punkten bewerten: Wie viele Punkte würden Sie dann für Ihre derzeitige Arbeitsfähigkeit geben? (0 bedeutet, dass Sie derzeit arbeitsunfähig sind)

O_0 O_1 O_2 O_3 O_4 O_5 O_6 O_7 O_8 O_9 O_{10}

völlig   derzeit die beste

arbeitsunfähig   Arbeitsfähigkeit

2. Arbeitsfähigkeit in Bezug auf die Arbeitsanforderungen

Wie schätzen Sie Ihre derzeitige Arbeitsfähigkeit in Bezug auf die körperlichen Arbeitsanforderungen ein?

sehr gut	O_5
eher gut	O_4
mittelmäßig	O_3
eher schlecht	O_2
sehr schlecht	O_1

Wie schätzen Sie Ihre derzeitige Arbeitsfähigkeit in Bezug auf die psychischen Arbeitsanforderungen ein?

sehr gut	O_5
eher gut	O_4
mittelmäßig	O_3
eher schlecht	O_2
sehr schlecht	O_1

Figure 4A.: Work Ability Index Page 1

3. Anzahl der aktuellen ärztlich diagnostizierten Krankheiten

Kreuzen Sie in der folgenden Liste Ihre Krankheiten oder Verletzungen an. Geben Sie bitte
auch an, ob ein Arzt diese Krankheiten diagnostiziert oder behandelt hat.

		eigene Diagnose	Diagnose vom Arzt	liegt nicht vor
1	Unfallverletzungen (z.B. des Rückens, der Glieder, Verbrennungen)	$\square_2$	$\square_1$	$\square_0$
2	Erkrankungen des Muskel-Skelett-Systems von Rücken, Gliedern oder anderen Körperteilen (z.B. wiederholte Schmerzen in Gelenken oder Muskeln, Ischias, Rheuma, Wirbelsäulenerkrankungen)	$\square_2$	$\square_1$	$\square_0$
3	Herz-Kreislauf-Erkrankungen (z.B. Bluthochdruck, Herzkrankheit, Herzinfarkt)	$\square_2$	$\square_1$	$\square_0$
4	Atemwegserkrankungen (z.B. wiederholte Atemwegsinfektionen, chronische Bronchitis, Bronchialasthma)	$\square_2$	$\square_1$	$\square_0$
5	Psychische Beeinträchtigungen (z.B. Depressionen, Angstzustände, chronische Schlaf-losigkeit, psychovegetatives Erschöpfungssyndrom)	$\square_2$	$\square_1$	$\square_0$
6	Neurologische und sensorische Erkrankungen (z.B. Tinnitus, Hörschäden, Augenerkrankungen, Migräne, Epilepsie)	$\square_2$	$\square_1$	$\square_0$
7	Erkrankungen des Verdauungssystems (z.B. der Gallenblase, Leber, Bauchspeicheldrüse, Darm)	$\square_2$	$\square_1$	$\square_0$
8	Erkrankungen im Urogenitaltrakt (z.B. Harnwegsinfektionen, gynäkologische Erkrankungen)	$\square_2$	$\square_1$	$\square_0$
9	Hautkrankheiten (z.B. allergischer Hautausschlag, Ekzem)	$\square_2$	$\square_1$	$\square_0$
10	Tumore / Krebs	$\square_2$	$\square_1$	$\square_0$
11	Hormon- / Stoffwechselerkrankungen (z.B. Diabetes, Fettleibigkeit, Schilddrüsenprobleme)	$\square_2$	$\square_1$	$\square_0$
12	Krankheiten des Blutes (z.B. Anämie)	$\square_2$	$\square_1$	$\square_0$
13	Angeborene Leiden / Erkrankungen	$\square_2$	$\square_1$	$\square_0$
14	Andere Leiden oder Krankheiten: Welche? _____ (bitte eintragen)	$\square_2$	$\square_1$	$\square_0$

4. Geschätzte Beeinträchtigung der Arbeitsleistung durch die Krankheiten

Behindert Sie derzeit eine Erkrankung oder Verletzung bei der Arbeit?
Falls nötig, kreuzen Sie bitte mehr als eine Antwort-Möglichkeit an.

- Keine Beeinträchtigung / Ich habe keine Erkrankung O_6
- Ich kann meine Arbeit ausführen, habe aber Beschwerden O_5
- Ich bin manchmal gezwungen, langsamer zu arbeiten oder meine Arbeitsmethoden zu ändern O_4
- Ich bin oft gezwungen, langsamer zu arbeiten oder meine Arbeitsmethoden zu ändern O_3
- Wegen meiner Krankheit bin ich nur in der Lage Teilzeitarbeit zu verrichten O_2
- Meiner Meinung nach bin ich völlig arbeitsunfähig O_1

Figure 5A.: Work Ability Index Page 2

5. Krankenstand im vergangenen Jahr (12 Monate)

Wie viele ganze Tage blieben Sie auf Grund eines gesundheitlichen Problems (Krankheit, Gesundheitsvorsorge oder Untersuchung) im letzten Jahr (12 Monate) der Arbeit fern?

überhaupt keinen	O_5
höchstens 9 Tage	O_4
10-24 Tage	O_3
25-99 Tage	O_2
100-365 Tage	O_1

6. Einschätzung der eigenen Arbeitsfähigkeit in zwei Jahren

Glauben Sie, dass Sie, ausgehend von Ihrem jetzigen Gesundheitszustand, Ihre derzeitige Arbeit auch in den nächsten zwei Jahren ausüben können?

unwahrscheinlich	O_1
nicht sicher	O_4
ziemlich sicher	O_7

7. Psychische Leistungsreserven

Haben Sie in der letzten Zeit Ihre täglichen Aufgaben mit Freude erledigt?

häufig	O_4
eher häufig	O_3
manchmal	O_2
eher selten	O_1
niemals	O_0

Waren Sie in letzter Zeit aktiv und rege?

immer	O_4
eher häufig	O_3
manchmal	O_2
eher selten	O_1
niemals	O_0

Waren Sie in der letzten Zeit zuversichtlich, was die Zukunft betrifft?

ständig	O_4
eher häufig	O_3
manchmal	O_2
eher selten	O_1
niemals	O_0

Figure 6A.: Work Ability Index Page 3

Fragebogen zum Gesundheitszustand (SF-36)

In diesem Fragebogen geht es um Ihre Beurteilung Ihres Gesundheitszustandes. Der Bogen ermöglicht es, im Zeitverlauf nachzuvollziehen, wie Sie sich fühlen und wie Sie im Alltag zurechtkommen.

Bitte beantworten Sie jede der folgenden Fragen, indem Sie bei den Antwortmöglichkeiten die Zahl ankreuzen, die am besten auf Sie zutrifft.

1. Wie würden Sie Ihren Gesundheitszustand im Allgemeinen beschreiben ?

(Bitte kreuzen Sie nur eine Zahl an)

Ausgezeichnet... 1

Sehr gut.. 2

Gut.. 3

Weniger gut... 4

Schlecht... 5

2. Im Vergleich zum vergangenen Jahr, wie würden Sie Ihren derzeitigen Gesundheitszustand beschreiben ?

(Bitte kreuzen Sie nur eine Zahl an)

Derzeit viel besser als vor einem Jahr........................... 1

Derzeit etwas besser als vor einem Jahr........................2

Etwa so wie vor einem Jahr... 3

Derzeit etwas schlechter als vor einem Jahr.................. 4

Derzeit viel schlechter als vor einem Jahr...................... 5

Figure 7A.: SF-36 Page 1

3. Im folgenden sind einige Tätigkeiten beschrieben, die Sie vielleicht an einem normalen Tag ausüben. Sind Sie durch Ihren derzeitigen Gesundheitszustand bei diesen Tätigkeiten eingeschränkt ? Wenn ja, wie stark ?

(Bitte kreuzen Sie in jeder Zeile nur eine Zahl an)

TÄTIGKEITEN	Ja, stark eingeschränkt	Ja, etwas eingeschränkt	Nein , überhaupt nicht eingeschränkt
a. anstrengende Tätigkeiten, z.B. schnell laufen, schwere Gegenstände heben, anstrengenden Sport treiben	1	2	3
b. mittelschwere Tätigkeiten, z.B. einen Tisch verschieben, staubsaugen, kegeln, Golf spielen	1	2	3
c. Einkaufstaschen heben oder tragen	1	2	3
d. mehrere Treppenabsätze steigen	1	2	3
e. einen Treppenabsatz steigen	1	2	3
f. sich beugen, knien, bücken	1	2	3
g. mehr als 1 Kilometer zu Fuß gehen	1	2	3
h. mehrere Straßenkreuzungen weit zu Fuß gehen	1	2	3
i. eine Straßenkreuzung weit zu Fuß gehen	1	2	3
j. sich baden oder anziehen	1	2	3

4. Hatten Sie in den vergangenen 4 Wochen aufgrund Ihrer körperlichen Gesundheit irgendwelche Schwierigkeiten bei der Arbeit oder anderen alltäglichen Tätigkeiten im Beruf bzw. zu Hause ?

(Bitte kreuzen Sie in jeder Zeile nur eine Zahl an)

SCHWIERIGKEITEN	JA	NEIN
a. Ich konnte nicht so lange wie üblich tätig sein	1	2
b. Ich habe weniger geschafft als ich wollte	1	2
c. Ich konnte nur bestimmte Dinge tun	1	2
d. Ich hatte Schwierigkeiten bei der Ausführung (z.B. ich mußte mich besonders anstrengen)	1	2

Figure 8A.: SF-36 Page 2

5. Hatten Sie in den vergangenen 4 Wochen aufgrund seelischer Probleme irgendwelche Schwierigkeiten bei der Arbeit oder anderen alltäglichen Tätigkeiten im Beruf bzw. zu Hause (z.B. weil Sie sich niedergeschlagen oder ängstlich fühlten) ?

(Bitte kreuzen Sie in jeder Zeile nur eine Zahl an)

SCHWIERIGKEITEN	JA	NEIN
a. Ich konnte nicht so lange wie üblich tätig sein	1	2
b. Ich habe weniger geschafft als ich wollte	1	2
c. Ich konnte nicht so sorgfältig wie üblich arbeiten	1	2

6. Wie sehr haben Ihre körperliche Gesundheit oder seelischen Probleme in den vergangenen 4 Wochen Ihre normalen Kontakte zu Familienangehörigen, Freunden, Nachbarn oder zum Bekanntenkreis beeinträchtigt?

(Bitte kreuzen Sie nur eine Zahl an)

Überhaupt nicht... 1

Etwas... 2

Mäßig.. 3

Ziemlich... 4

Sehr... 5

7. Wie stark waren Ihre Schmerzen in den vergangenen 4 Wochen ?

(Bitte kreuzen Sie nur eine Zahl an)

Ich hatte keine Schmerzen.. 1

Sehr leicht 2

Leicht... 3

Mäßig... 4

Stark... 5

Sehr stark... 6

Figure 9A.: SF-36 Page 3

8. Inwieweit haben die Schmerzen Sie in den vergangenen 4 Wochen bei der Ausübung Ihrer Alltagstätigkeiten zu Hause und im Beruf behindert ?

(Bitte kreuzen Sie nur eine Zahl an)

Überhaupt nicht.. 1

Ein bißchen... 2

Mäßig... 3

Ziemlich.. 4

Sehr.. 5

9. In diesen Fragen geht es darum, wie Sie sich fühlen und wie es Ihnen in den vergangenen 4 Wochen gegangen ist. (Bitte kreuzen Sie in jeder Zeile die Zahl an, die Ihrem Befinden am ehesten entspricht). Wie oft waren Sie in den vergangenen 4 Wochen...

(Bitte kreuzen Sie in jeder Zeile nur eine Zahl an)

BEFINDEN	Immer	Meistens	Ziemlich oft	Manch- Mal	Selten	Nie
a. ...voller Schwung	1	2	3	4	5	6
b. ...sehr nervös	1	2	3	4	5	6
c. ...so niedergeschlagen, daß Sie nichts aufheitern konnte ?	1	2	3	4	5	6
d. ...ruhig und gelassen	1	2	3	4	5	6
e. ...voller Energie?	1	2	3	4	5	6
f. ...entmutigt und traurig	1	2	3	4	5	6
g. ...erschöpft	1	2	3	4	5	6
h. ... glücklich	1	2	3	4	5	6
i. ...müde	1	2	3	4	5	6

Figure 10A.: SF-36 Page 4

9. Wie häufig haben Ihre körperliche Gesundheit oder seelischen Probleme in den vergangenen 4 Wochen Ihre Kontakte zu anderen Menschen (Besuche bei Freunden, Verwandten usw.) beeinträchtigt?

(Bitte kreuzen Sie nur eine Zahl an)

Immer.. 1

Meistens.. 2

Manchmal...3

Selten...4

Nie... 5

10. Inwieweit trifft jede der folgenden Aussagen auf Sie zu ?

(Bitte kreuzen Sie in jeder Zeile nur eine Zahl an)

	AUSSAGEN	Trifft ganz zu	Trifft weit-gehend zu	Weiß nicht	Trifft weitgehend nicht zu	Trifft überhaupt nicht zu
a.	Ich scheine etwas leichter als andere krank zu werden	1	2	3	4	5
b.	Ich bin genauso gesund wie alle anderen, die ich kenne	1	2	3	4	5
c.	Ich erwarte, daß meine Gesundheit nachläßt	1	2	3	4	5
d.	Ich erfreue mich ausgezeichneter Gesundheit	1	2	3	4	5

11. Wie würden Sie Ihren derzeitigen Gesundheitszustand beschreiben ?

sehr gut o   gut o   mittelmäßig o   schlecht o   sehr schlecht o

Figure 11A.: SF-36 Page 5

12. Im Folgenden finden Sie eine Reihe von Aussagen. Bitte Kreuzen (X) Sie in jeder Reihe an, ob diese für Sie zutrifft oder nicht.

	JA	NEIN
Ich bin andauernd müde.	0	0
Ich habe nachts Schmerzen.	0	0
Ich fühle mich niedergeschlagen.	0	0
Ich habe unerträgliche Schmerzen.	0	0
Ich nehme Tabletten, um schlafen zu können.	0	0
Ich habe vergessen, wie es ist Freude zu empfinden.	0	0
Ich fühle mich gereizt.	0	0
Ich finde es schmerzhaft, meine Körperposition zu verändern.	0	0
Ich fühle mich einsam	0	0
Ich kann mich nur innerhalb des Hauses bewegen.	0	0
Es fällt mir schwer mich zu bücken	0	0
Alles strengt mich an.	0	0
Ich wache in den frühen Morgenstunden auf.	0	0
Ich kann überhaupt nicht gehen	0	0
Es fällt mir schwer, zu anderen Menschen Kontakt aufzunehmen.	0	0
Die Tage ziehen sich.	0	0
Ich habe Schwierigkeiten Treppen hinauf- und hinunterzugehen.	0	0
Es fällt mir schwer nach Gegenständen zu greifen.	0	0
Ich habe Schmerzen beim Gehen.	0	0
Mir reißt derzeit oft der Geduldsfaden.	0	0
Ich fühle, daß ich niemanden nahestehe.	0	0
Ich liege nachts die meiste Zeit wach.	0	0
Ich habe das Gefühl, die Kontrolle zu verlieren.	0	0
Ich habe Schmerzen, wenn ich stehe	0	0
Es fällt mir schwer mich selbst anzuziehen.	0	0
Meine Energie läßt schnell nach.	0	0
Es fällt mir schwer lange zu stehen (z.B. am Spülbecken, an der Bushaltestelle)	0	0
Ich habe andauernd Schmerzen.	0	0
Ich brauche lange zum Einschlafen.	0	0
Ich habe das Gefühl für andere Menschen eine Last zu sein.	0	0
Sorgen halten mich nachts wach.	0	0
Ich fühle, daß das Leben nicht lebenswert ist.	0	0
Ich schlafe nachts schlecht.	0	0
Es fällt mir schwer mit anderen Menschen auszukommen.	0	0
Ich brauche Hilfe, wenn ich mich außer Haus bewegen will (Stock oder jemand, der mich stützt).	0	0
Ich habe Schmerzen, wenn ich Treppen hinauf- und hinuntergehe.	0	0
Ich wache deprimiert auf.	0	0
Ich habe Schmerzen, wenn ich sitze.	0	0

Figure 12A.: SF-36 Page 6

Table 1A.: Wound infection

Wound infection				
Risk factor	**Total (n = 218)**	**Wound infection developed (n = 40)**	**No wound infection developed (n = 178)**	**p-Value**
Background				
Gender (n female (%))	84 (38.53)	21 (25)	63 (75)	0.0723
Diabetes Mellitus (n (%))	79 (36.24)	18 (22.78)	60 (75.95)	0.168
Obesity (n (%))	30 (13.76)	8 (26.67)	22 (73.33)	0.1827
Active drug abuse (n (%))	5 (2.29)	1 (20)	4 (80)	0.6602
Osteoporosis (n (%))	14 (6.42)	4 (28.57)	10 (71.43)	0.3117
Smoking (n (%))	24 (11.01)	4 (8.51)	20 (11.70)	0.4926
Charlson Comorbidity Index (mean (range))	6.56 (0-23)	7.63 (2 - 17)	6.44 (0-23)	0.1341
Presenting features				
Preoperativeeerative neurological deficits (n (%))	111 (50.92)	24 (21.81)	86 (78.18)	0.2954
Epidural abscess (n (%))	68 (31.19)	15 (22.39)	52 (77.61)	0.4509
CRP value on admission (mean mg/L(range))	112.99 (2 - 467)	117.36 (3 - 387)	112.12 (2 - 467)	0.767
Surgical features				
Number of levels operated (mean (range))	2.65 (1-8)	2.60 (1 - 6)	2.64 (1 - 8)	0.8856

Duration of surgery (mean (range))	200.43 (65 - 469)	209.55 (78 - 410)	197.84 (65 - 469)	0.4809
Spondylodesis (n (%))	209 (95.87)	39 (18.66)	169 (80.86)	0.3454
Corpectomy (n (%))	43 (19.72)	8 (18.60)	35 (81.40)	1
Interbody cage (n (%))	45 (20.64)	10 (22.22)	35 (77.78)	0.5269
Spinal Canal decompression (n (%))	80 (36.70)	20 (25)	60 (75)	0.1047
Robot Surgery (n (%))	103 (47.25)	16 (15.53)	85 (82.52)	0.2954
Post-surgical features				
General post-surgical complications (n (%))	55 (25.23)	11 (20)	44 (80)	0.8436
Misplaced or loosened screw (n (%))	29 (13.30)	9 (31.03)	20 (68.97)	0.0714
Revision surgery (n (%))	40 (18.35)	11 (27.5)	29 (72.5)	0.1073
Relapse infection (n (%))	17 (7.80)	2 (11.76)	15 (88.24)	0.5367

Table 2A: Relapse infection

Relapse infection				
Risk factor	**Total (n = 218)**	**Relapse infection developed (n = 17)**	**No relapse infection developed (n = 201)**	**p-Value**
Background				
Age at surgery (mean (range))	69.41 (30 - 91)	67.06 (48 - 89)	69.55 (30 - 91)	0.42

Gender (n female (%))	84 (38.53)	6 (7.14)	77 (91.67)	0.8
Diabetes Mellitus (n (%))	79 (36.24)	6 (7.59)	71 (89.87)	1
Obesity (n (%))	30 (13.76)	2 (6.67)	28 (93.33)	1
Osteoporosis (n (%))	14 (6.42)	0 (0)	13 (92.86)	0.606
MRSA-associated infection (n (%))	29 (13.30)	2 (6.90)	24 (82.76)	1
Smoking (n (%))	24 (11.01)	2 (8.33)	22 (91.67)	1
Charlson Comorbidity Index (mean (range))	6.56 (0 -23)	5.71 (2 - 10)	6.75 (0 - 23)	0.362
Presenting features				
Preoperativeeerative neurological deficits (n (%))	111 (50.92)	9 (8.18)	101 (91.81)	1
Epidural abscess (n (%))	68 (31.19)	4 (5.97)	62 (92.54)	0.591
CRP value on admission (mean mg/L (range))	112.99 (2 - 467)	118.14 (10 - 290)	113.18 (2 - 467)	0.842
WBC count on admission (mean x 10^9/L (range))	10.07 (0.8-35.8)	12.16 (5.6 - 22.8)	9.91 (0.8 - 35.8)	0.055
Surgical features				
Number of levels operated (mean (range))	2.65 (1 -8)	2.7 (1 - 6)	2.6 (1 - 8)	0.855
Duration of surgery (mean (range))	200.43 (65 - 469)	241.54 (65 - 458)	195.42 (68 - 469)	0.07
Spondylodesis (n (%))	209 (95.87)	17 (8.13)	190 (90.91)	1

Corpectomy (n (%))	43 (19.72)	5 (11.63)	38 (88.37)	0.353
Interbody cage (n (%))	45 (20.64)	5 (11.11)	40 (88.89)	0.3732
Spinal Canal decompression (n (%))	80 (36.70)	6 (7.5)	74 (92.5)	1
Robot Surgery (n (%))	103 (47.25)	11 (10.68)	89 (86.41)	0.2053
Post-surgical features				
General post-surgical complications (n (%))	55 (25.23)	4 (7.27)	51 (92.73)	1
Post-surgical wound infection (n (%))	40 (18.35)	2 (5)	38 (95)	0.5367
Length of hospital stay (mean (range))	29.86 (4 - 162)	34.18 (13 - 101)	29.36 (4 - 162)	0.395

Table 3A.: Length of hospital stay

Length of hospital stay			
Risk factor	**Total (n = 218)**	**Length of hospital stay > 21 days (n = 125)**	**Length of hospital stay = < 21 days (n = 89)**	**p-Value**
Background				
Gender (n female (%))	84 (38.53)	53 (63.10)	29 (34.52)	0.1563
Diabetes Mellitus (n (%))	79 (36.24)	48 (60.76)	30 (37.97)	0.4744
Obesity (n (%))	30 (13.76)	18 (60)	11 (36.67)	0.6905
Active drug abuse (n (%))	5 (2.29)	2 (40)	3 (60)	0.6517
Osteoporosis (n (%))	14 (6.42)	7 (50)	6 (42.86)	0.7774

Smoking (n (%))	24 (11.01)	12 (50)	11 (45.83)	0.6552
Charlson Comorbidity Index (mean (range))	6.56 (0 - 23)	7.04 (0 - 23)	5.93 (0 - 15)	0.072
Presenting features				
Epidural abscess (n (%))	68 (31.19)	35 (52.24)	32 (47.76)	0.234
CRP value on admission (mean mg/L (range))	112.99 (2 - 467)	116.72 (2 - 467)	107.68 (2 - 389)	0.52
WBC count on admission (mean x 10^9/L (range))	10.07 (0.8 - 35.8)	10.28 (0.8 - 35.8)	9.78 (2.9 - 22.9)	0.44
Surgical features				
Duration of surgery (mean (range))	200.43 (65 - 469)	204.73 (68 - 458)	194.71 (65 - 469)	0.463
Duration of radiation (mean (range))	141.92 (1.03 - 500)	144.07 (1.03 - 500)	139.11 (1.37 - 447.0)	0.75
Spondylodesis (n (%))	209 (95.87)	120 (57.42)	87 (41.63)	0.512
Corpectomy (n (%))	43 (19.72)	31 (72.09)	12 (27.91)	0.056
Spinal Canal decompression (n (%))	80 (36.70)	47 (58.75)	32 (40)	0.77
Post-surgical features				
Misplaced or loosened screw (n (%))	29 (13.30)	18 (62.07)	10 (34.48)	0.3115
Durotomy (n (%))	7 (3.21)	6 (85.71)	1 (14.29)	0.1341
Revision surgery (n (%))	40 (18.35)	25 (62.5)	14 (35)	0.2371

Table 4A.: Death

Death			
Risk factor	**Total (n = 218)**	**Death (n = 100)**	**No death (n = 118)**	**p-Value**
Background				
Gender (n female (%))	84 (38.53)	39 (46.43)	45 (53.57)	1
Diabetes Mellitus (n (%))	79 (36.24)	40 (50.63)	39 (49.37)	0.1905
Osteoporosis (n (%))	14 (6.42)	9 (64.29)	5 (35.71)	0.1282
MRSA-associated infection (n (%))	29 (13.30)	17 (58.62)	12 (41.38)	0.1005
Smoking (n (%))	24 (11.01)	12 (50)	12 (50)	0.4678
Presenting features				
Epidural abscess (n (%))	68 (31.19)	30 (44.12)	38 (55.88)	0.7704
WBC count on admission (mean x 10^9/L (range))	10.07 (0.8 - 35.8)	10.45 (0.8 - 35.8)	9.75 (3.3 - 22.9)	0.281
Surgical features				
Number of levels operated (mean (range))	2.65 (1 - 8)	2.71 (1 - 8)	2.6 (1 - 8)	0.633
Duration of surgery (mean (range))	200.43 (65 - 469)	205.41 (68 - 462)	196.51 (65 - 469)	0.513
Duration of radiation (mean (range))	141.92 (1.03 - 500)	150.28 (15 - 500)	135.90 (1.03 - 447)	0.349
Spondylodesis (n (%))	209 (95.87)	96 (45.93)	113 (54.07)	0.1875
Corpectomy (n (%))	43 (19.72)	21 (48.84)	22 (51.16)	0.8645
Interbody cage (n (%))	45 (20.64)	22 (48.89)	23 (51.11)	0.8667
Spinal Canal decompression (n (%))	80 (36.70)	37 (46.25)	43 (53.75)	1

Post-surgical features				
Misplaced or loosened screw (n (%))	29 (13.30)	12 (41.38)	17 (58.62)	0.3288
Durotomy (n (%))	7 (3.21)	2 (28.57)	5 (71.43)	0.276
Revision surgery (n (%))	40 (18.35)	20 (50)	20 (50)	0.3875
Residual disabilities (n (%))	35 (16.06)	15 (42.86)	20 (57.14)	0.4993
Relapse infection (n (%))	17 (7.80)	8 (47.06)	9 (52.94)	0.5943

Table 5A.: Residual disabilities

Residual disabilities				
Risk factor	Total (n = 218)	Residual disabilities developed (n = 35)	No residual disabilities developed (n = 183)	p-Value
Background				
Age at surgery (mean (range))	69.41 (30 - 91)	68.14 (48 - 89)	69.59 (30 - 91)	0.518
Gender (n female (%))	84 (38.53)	16 (19.05)	67 (79.76)	0.4515
Diabetes Mellitus (n (%))	79 (36.24)	13 (16.46)	66 (83.54)	0.5547
Obesity (n (%))	30 (13.76)	6 (20)	24 (80)	0.3857
Osteoporosis (n (%))	14 (6.42)	3 (21.43)	10 (71.43)	0.4604
MRSA-associated infection (n (%))	29 (13.30)	2 (6.90)	24 (82.76)	0.1501
Smoking (n (%))	24 (11.01)	6 (25)	18 (75)	0.194

Charlson Comorbidity Index (mean (range))	6.56 (0 - 23)	5.97 (2 - 15)	6.67 (0 - 23)	0.4
Presenting features				
Preoperativeeerative neurological deficits (n (%))	111 (50.92)	20 (18.18)	90 (81.82)	0.3335
Epidural abscess (n (%))	68 (31.19)	11 (16.42)	56 (83.58)	0.5589
CRP value on admission (mean mg/L (range))	112.99 (2 - 467)	92.55 (2 - 290)	117.33 (2 - 467)	0.178
WBC count on admission (mean x 10^9/L (range))	10.07 (0.8 - 35.8)	10.05 (5.1 - 22.8)	10.07 (0.8 - 35.8)	0.984
Surgical features				
Number of levels operated (mean (range))	2.65 (1 - 8)	2.43 (1 - 6)	2.67 (1 - 8)	0.415
Duration of surgery (mean (range))	200.43 (65 - 469)	208.75 (65 - 458)	198.80 (68 - 469)	0.594
Duration of radiation (mean (range))	141.92 (1.03 - 500)	135.21 (1.37 - 336)	142.03 (1.03 - 500)	0.74
Spondylodesis (n (%))	209 (95.87)	35 (16.75)	173 (82.78)	1
Corpectomy (n (%))	43 (19.72)	11 (25.58)	32 (74.42)	0.1061
Interbody cage (n (%))	45 (20.64)	11 (24.44)	34 (75.56)	0.1197
Spinal Canal decompression (n (%))	80 (36.70)	13 (16.25)	67 (83.75)	1
Robot Surgery (n (%))	103 (47.25)	17 (16.50)	83 (80.58)	1
Post-surgical features				

General post-surgical complications (n (%))	55 (25.23)	8 (14.55)	47 (85.45)	0.3907
Post-surgical wound infection (n (%))	40 (18.35)	6 (15)	34 (85)	0.4819
Durotomy (n (%))	7 (3.21)	0 (0)	7 (100)	0.2734
Length of hospital stay (mean (range))	29.86 (4 - 162)	31.46 (11 - 101)	29.34 (4 - 162)	0.604

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