4 Cervical Motion Preserving Procedures (TDR)

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4.1 Introduction

Symptomatic cervical degenerative disc disease leading to radiculopathy is a common problem with an incidence of 0.83–1.79 per 1.000 person years. While many episodes of radicular symptoms can be successfully managed by conservative therapy, patients with refractory symptoms or a significant paresis are candidates for a surgical treatment. However, different surgical techniques have been available to treat cervical degenerative disc disease for a long period, as anterior cervical discectomy without fusion, anterior cervical discectomy with fusion or posterior foraminotomy. Anterior cervical discectomy with fusion as described in the 1960's (Chap. 3) is currently regarded as the gold standard. Although ACDF provides excellent results with regard to relief of cervical radicular symptoms and neck pain, the loss of motion at the fused level might be associated with secondary problems. Loss of motion at a fused segment is typically compensated by a significant increase in the ROM of flexion/extension, lateral bending and rotation at adjacent levels [22] which can accelerate degeneration of these adjacent levels. Therefore, up to 25% of cervically fused patients develop symptomatic adjacent segment degeneration within 10 years after fusion surgery associated with a high rates of revision surgery [16]. In order to overcome this problem the motion preservation concept developed and cervical disc prostheses maintaining segmental motion became available in the 1990ies. From there on a large selection of different cervical disc prostheses became available which are well studied in comparison to anterior cervical discectomy and fusion in several prospective randomized trials.

This chapter aims to provide indications and contraindication for cervical disc prosthesis, technical surgical considerations and outcome data for cervical disc prosthesis.

4.2 Case Description

A 31 y/o female patient suffered from progressive pain of the left shoulder and neck with radiation along the lateral upper arm reaching into the elbow. Additionally she complained of some restriction of mobility of the left upper extremity over the last 2 weeks. One week after the onset of symptoms a reduction in strength of the left upper extremity developed with limitation of the elevation of the left arm above the horizontal plane. A MRI scan showed soft herniations of the discs C4/5 and C5/6 with spinal cord and radicular compression on the left side as well as a slight disc protrusion at the level C6/7 (Fig. 4.1).

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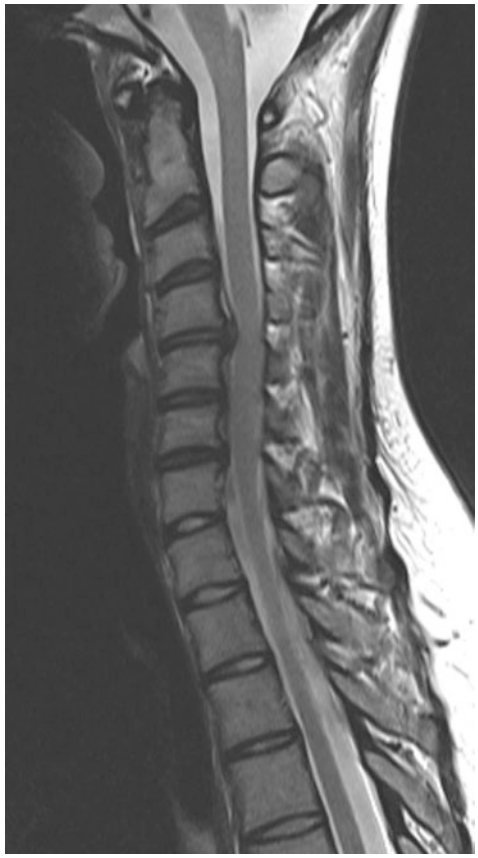

Fig. 4.1 MRI scan on outpatient visit. The MRI scan shows herniated discs in C4/5 and C5/6 and a minor protrusion in C6/7

No relevant further degenerative changes of the C-spine were seen. X-ray images in neutral position and flexion/extension of the C-spine revealed a proper lordotic alignment and regular motion of the affected segments (Fig. 4.2).

The patient was referred after MRI to our department. The neurological examination revealed a deltoid paresis 3/5 and a mild biceps paresis 4/5 on the left upper extremity. Due to the progression of symptoms during initial conservative management and the paresis there was a clear indication for surgical treatment. The patient was operated on the day after admission. The patient was operated in general anesthesia in supine position. The c-spine was positioned in neutral alignment any kyphotic or lordotic position was avoided. A standard anterior approach to the c-spine was performed followed by an anterior cervical discectomy at C4/5 and C5/6 with resection of the posterior longitudinal ligament and decompression of the spinal canal and nerve roots. After decompression artificial disc prostheses were implanted at both levels. Surgery was eventless.

Pain as well as the preoperative deltoid and biceps paresis of the left upper extremity completely recovered early after surgery. No new focal neurological deficits were detectable.

On the 2nd postoperative day, functional x ray images were taken and showed a correct position of the intervertebral disc prostheses and no abnormal segmental mobility (Fig. 4.3).

The patient was discharged on the 3rd postoperative day, she had an uneventful recovery without relevant neck pain.

4.3 Discussion of the Case

The patient described suffered from a cervical radiculopathy with pain and a motor deficit refractory to conservative therapy from cervical soft disc herniations involving two segments. This is a classical indication for a surgical treatment though not supported by prospective randomized studies which are not available, so far, but are currently recruiting patients [26].

The surgical gold standard for the treatment of a cervical disc pathology causing radiculopathy or myelopathy from a soft disc herniation or spondylosis would be an anterior cervical discectomy followed by fusion with or without segmental plating (see Chap. 3). While this technique is associated with excellent results with regard to the radicular symptoms and neck pain in more than 90% of patients, follow-up studies after ACDF could demonstrate a degeneration of adjacent segments mostly cranial to the fusion with increasing time after fusion [16]. Already in 1997 Hillibrand et al. reported a 2.9% revision rate per year after ACDF and predicted a 25% revision rate within 10 years for adjacent level degeneration [8]. In a systematic review the reported incidence of a radiographic adjacent segment degeneration ranges from 16-96% with a mean of 47.33% after 106 months of follow up, while 12% of patients developed a symptomatic

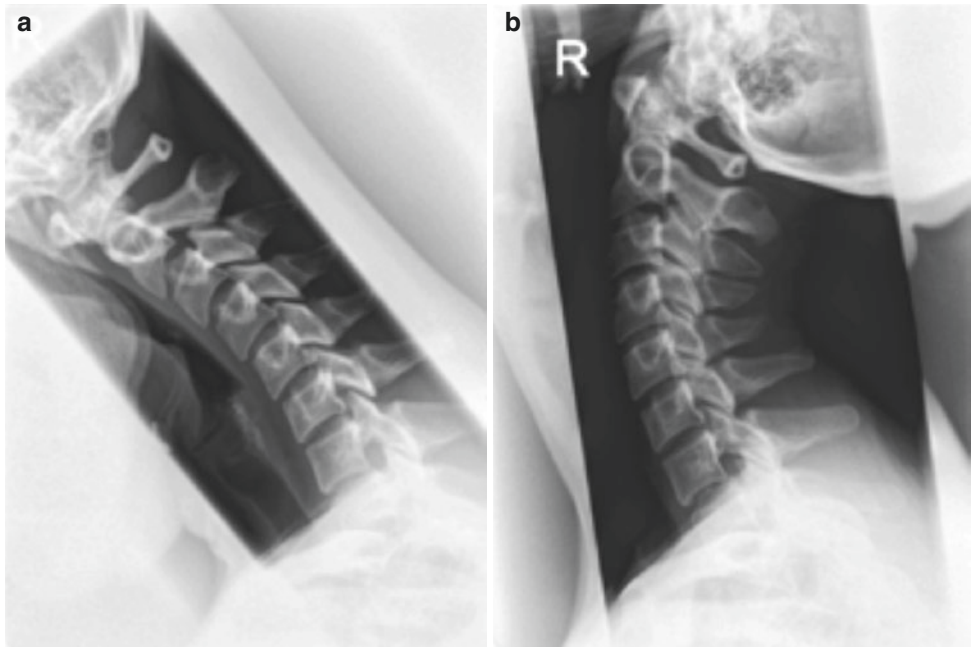

Fig. 4.2 Preoperative flexion/extension x-ray of the cervical spine. Flexion (**a**) and extension (**b**) x-rays demonstrate regular motion of the affected segments C4/5 and 5/6

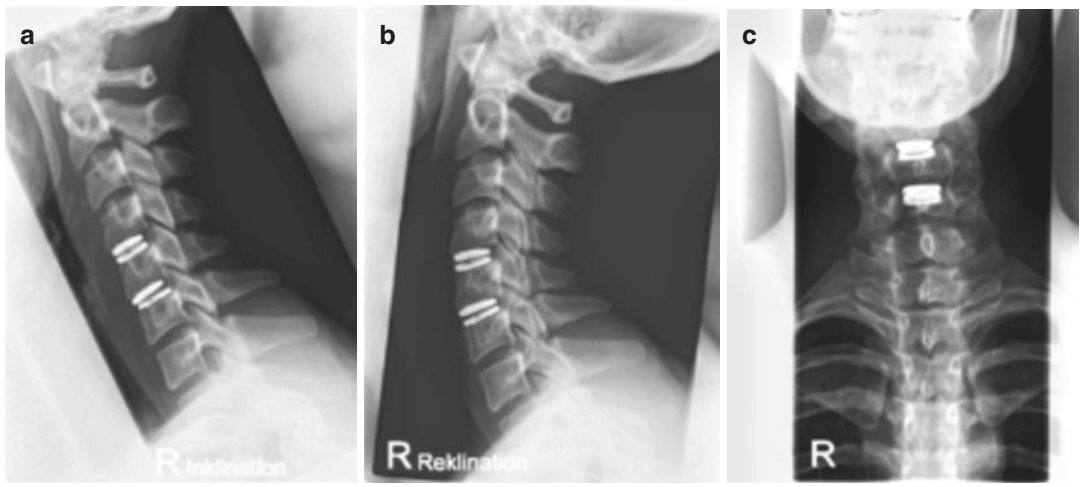

Fig. 4.3 Postoperative flexion (**a**), extension (**b**) and ap (**c**) x-ray of the cervical spine. The postoperative x-ray images show a regular position and function of the prostheses at C4/5 and C5/6

adjacent segment degeneration after fusion during the same follow-up [4]. Whether this is a natural progression of the underlying degenerative disease or a consequence of increased adjacent segment motion and biomechanical strains after fusion remains not fully elucidated at present [15]. However, in order to overcome this problem, the concept of motion preservation in contrast to fusion evolved to maintain mobility of the treated segment. Motion preserving total disc replacements or disc arthroplasty became available in the 1990ies and gained increasing importance [11]. Aim of total disc

replacement (TDR) is the removal of the pain generating structure, restoration of disc height, maintenance of segmental kinematics, a natural balance of the segment and protection of the adjacent segment. Up to now, many different designs of disc prostheses are available and have been evaluated in large multicenter prospective randomized non-inferiority trials regarding the clinical and radiographic outcome in comparison to fusion.

4.3.1 Indications and Contraindications for Cervical TDR

The best established indication for total disc replacement is a soft disc herniation in a biologically young patient with preserved segmental motion and a straight or lordotic alignment of the cervical spine. While the most beneficial typical indication would be radiculopathy, patients with myelopathic symptoms have been included in the IDE studies as well showing beneficial results.

TDR is usually limited to a maximum of 2 segments, in exceptional cases 3 segments. Only minor facet joint degeneration as well as no muscular degeneration should be present as this might result in persisting neck pain after TDR. In addition to soft disc herniation a mild spondylotic stenosis is seen as a good indication for TDR and data support the use of TDR in adjacent level degeneration following ACDF as well.

However, a significant spondylotic degeneration, ossification of the longitudinal ligament, bridging osteophytes, segmental height loss >50%, kyphotic deformity, hypo- or hypermobility (>3.5 mm sagittal plane translation, >20° sagittal plane angulation) of the segment and osteopenia or osteoporosis are contraindications for motion preserving techniques as well as non-degenerative pathologies as tumors, infection or trauma.

4.3.2 TDR Outcome

So far, several prospective randomized trials designed as non-inferiority trials against ACDF as IDE studies assessed the outcome up to 7 years after single-level TDR using different types of prostheses with different designs and thereby different kinematic characteristics [5, 7, 14, 19, 25]. All studies could prove, that the motion of the index segment is preserved during follow-up in comparison to ACDF. The clinical outcome with regard to pain and function was slightly but statistically significantly superior following TDR to the results after ACDF irrespective of the type of prosthesis implanted. However, the difference is small and probably not clinically relevant. The frequency of secondary surgery for the index segment was lower after TDR than after ACDF. Furthermore, some studies could reveal a lower incidence of adjacent segment degeneration and a lower rate of adjacent segment surgery during follow-up in the TDR treated patient group providing evidence for adjacent segment protection by TDR [3, 9, 18]. Whether any prosthesis design and kinematics are superior in comparison to others has not been assessed, so far.

While all studies show slightly superior results of TDR in comparison to ACDF criticism arose that most studies are prone to bias for missing blinding leading to confirmation bias and potential conflict of interest since most larger studies are industry-sponsored [21].

While many high quality studies are available for single level TDR few studies assessed the results of two level TDR as well. In comparison to two level ACDF two level TDR resulted in improved results for NDI, SF-12 and overall success with a lower rate of secondary surgery and adjacent segment degeneration [6, 10, 20]. Furthermore, no difference was detected in outcome 4 years after one or two level TDR, with a satisfaction rate of 85% and 4% of secondary surgery after two level TDR [1].

Another potential indication for TDR would be an adjacent segment disease after cervical fusion. Studies with small patient numbers and short follow-up duration show no difference in outcome of primary TDR versus TDR for adjacent segment degeneration after previous fusion [17].

Assessing hybrid surgery (ACDF plus TDR) for multilevel degeneration yielded similar if not superior results in comparison to multilevel ACDF [12].

Therefore, TDR is an option for single or two level degeneration, for adjacent segment degeneration following fusion or as a hybrid concept

with ACDF in multilevel degeneration if above mentioned exclusion criteria for ACDF are well considered.

4.3.3 Problems and Limitations of TDR

A common problem following cervical TDR is heterotopic ossification (HO) which is defined as an abnormal bone formation in extraskeletal tissue. HO can potentially reduce the extent of motion and is graded from 1–4 with 4 being a fusion of the segment [13]. Reported incidences of high grade HO (grade III: bridging ossification which still allows movement; grade IV:complete fusion) after 4 years ranges between 1.5 and 63% [2, 23, 24, 27]. However, a recent meta-analysis on the influence of HO on patient outcome could not reveal any significant influence [28]. The worst case of a grade 4 HO following TDR does lead to the same results as ACDF, i.e. fusion, without any adverse events by HO.

Further problems of TDR are implant failure and displacement which might occur as in all implants. But, reported numbers of implant-related problems are very low.

4.3.4 Accordance with the Literature Guidelines

The indication for treatment was given in the above described case. While ACDF would have been the gold standard for treatment TDR is an alternative supported by clinical data, as well as for two level indication.

Level of Evidence: I, Grade of Recommendation: A
The level of evidence available to date is high comprising several prospective randomized trials of TDR in comparison to ACDF.

4.4 Conclusions and Take Home Message

High quality data support the use of total disc replacement in single and two level mild to moderate cervical degeneration. TDR shows at least non-inferior clinical outcome in comparison to ACDF being superior in many studies. Furthermore, radiographic and symptomatic adjacent segment degeneration can be reduced by TDR in comparison to ACDF. The problem of heterotopic ossification which can lead to fusion of an artificial disc does not significantly influence clinical outcome.

Pearls
- Same/superior results as ACDF with prudent indication
- Maintained segmental motion, imitating the natural process of loss of ROM
- Reduced adjacent segment degeneration seen after long term follow up

Editorial Comment
A number of items in this chapter deserve a personal comment. Cervical TDR has partly fallen into disgrace, because an overuse with extended indications has taken place and 2 to 4 year follow up data in the cohorts of the above mentioned RCTs did not prove a significant reduction of ASD as compared to fusion, because the overall incidence was low. Only after 5 years and beyond a difference can be detected in favour of TDR. Thus cervical TDR has a place in the treatment of soft disc radiculopathy in biologically younger individuals, which will then give them a small but relevant advantage over ACDF in the long term. The key is to stick to a narrow indication to avoid the downsides such as HO, relevant persistent neck pain etc. It should be mentioned, that especially complex, i.e. 3-piece TDR constructs are more prone to produce significant morbidity due to implant failure, although this has not found its way into the literature. Several products had to be taken from the market, because of this with relevant liability sequelae.

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