Long-term Results of Cervical Arthroplasty
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ABSTRACT
Although cervical disk replacement has been used for a decade, and despite a large number of implanted artificial disks, the cost effectiveness of this technique remains debated, and only few reports present follow-ups exceeding 2 years. This work focuses on cervical arthroplasty publications reporting a follow-up of more than 2 years. Patient selection, implant type and surgical technique seem to influence greatly the quality of the clinical and radiological results. Wear debris and occurrence of heterotopic ossifications around the implant are frequently reported. The progressive decrease in the range of motion of the prosthetic level observed in most long-term studies does not seem to have any influence on the clinical evolution. It seems reasonable to say that cervical disk prosthesis is not inferior to discectomy and fusion, probably slightly superior in terms of neck pain, and that these implants allow a short-term preservation of cervical mobility. Their efficacy in preventing adjacent segment disease is still being assessed and will determine the cost/effectiveness ratio of cervical disk replacement.

Keywords: Cervical disk prosthesis, Cervical arthroplasty, Cervical discopathy.

INTRODUCTION
When looking for the results of cervical arthroplasty in the now abundant literature, we see that although many cervical disk prostheses have been implanted over the last 10 years, the quality of the published studies remains poor, and few series report a follow-up longer than 2 years.

Anderson et al1 reporting a 2-year follow-up (FU) study comparing the Brian cervical disk and anterior cervical discectomy and fusion, concluded that both are safe procedures, with low incidence of significant adverse events related to the procedure, slightly more numerous in the total disk replacement (TDR) group but more serious in the anterior cervical discectomy and fusion (ACDF) group.

Likewise, most short-term studies on TDR report good results, no neurological deficit, few or little complications or reoperations, good motion preservation (Fig. 1) and a general impression that, although TDR increases the cost of surgery, it is worth the investment.

However, we still miss reliable information about long-term mobility, subsidence, migration, heterotopic ossifications and, finally, wear debris for metal or polyethylene.

LONG-TERM CLINICAL RESULTS AND RANGE OF MOTION
Several series of long-term FU can be found in the literature, usually reporting about one single type of implant, the ones that have been on the market for a long time offering the longest FU studies.

Zhao et al2 studied their TDR patients treated with the Bryan prosthesis during 5 years, with X-ray and magnetic resonance imaging (MRI) evaluation, and reported a good range of motion (ROM) preservation (7.8° vs 7.2 at baseline). Fusion was observed in 8% of the cases and heterotopic ossification (HO) with motion preservation in 33%, adjacent segment disease in 22%. In a similar study on the Bryan disk with a 8 years FU, Quan et al3 reported radiological evidence of adjacent segment degeneration in 19% (always pre-existing degenerative disk disease at these levels), 10.6° ROM and 48% HO. This indicates good long-term results but HO restricting...

Fig. 1: Motion preservation in a C4C5 cervical disk replacement with the Baguera C prosthesis.
prosthesis ROM appeared to increase with time, especially in bilevel procedures. Finally, a 10-year FU study published by Walraevens et al\(^4\) reported 82% of good to excellent long-term clinical outcome, 85% ROM preservation but 4.5% reoperations for adjacent segment deterioration (ASD) and 39% HO.\(^4\)

The two longest FU studies on the Mobi-C disk reach 2 years. Although this cannot be considered ‘long-term’ follow-up, it is worth mentioning that even after such a short period, the HO rate fluctuated between 27.7% for Guérin et al\(^5\) and 64.3% for Lee et al.\(^6\) However, in both studies, clinical symptoms were not significantly influenced by the occurrence of HO.

Several 4 years FU studies on the Prodisc-C have been published. Hrabálek\(^7\) presented good initial clinical results, lasting over time, but an HO rate of 56.25% and 18.75% fusion. There too, there were no statistically significant differences between severe HO patients with restricted ROM, and patients without ROM restriction, suggesting that ROM has no influence on pain. These findings are shared by Suchomel et al\(^8\) who reported 63% HO, also with no influence on clinical results.

A 5-year FU study on the Prestige LP disk reported good clinical results lasting throughout the study, with preservation of a 6.5° ROM at 5 years.\(^9\)

Finally, a 7-year FU study has been reported by Pimienta et al\(^10\) with the PCM disk, with 7.7% HO and 5.7% symptomatic ASD.

### HETEROOTOPIC OSSIFICATIONS

Heterotopic ossifications are increasingly regarded as an inevitable postoperative complication, with a high occurrence rate. Park et al report that HO may appear as early as 2 years after surgery. A systematic review of the rate of HO occurrence shows that HO are the rule rather than the exception, but are well tolerated and do not seem to affect the clinical result of the surgery (Table 1).

There could be definite differences in occurrence rate according to the prosthesis type. Yi et al\(^11\) reported in his retrospective series an overall HO rate of 40.6%, but ranging from 21% in the Bryan disk group to 71.4% in the Prodisc-C group, whereas the Mobi-C group scored in between with 52.5% HO (Fig. 2).

The reason for HO could also be related to the indication for surgery. Wu et al\(^12\) reported that TDR performed for soft-disk herniation was complicated by only 6.25% HO, when the same surgery for spondylosis had a 58.3% HO rate. As their FU was short, 2 years, all disks remained mobile but long-term results could be different.

Finally, HO formation does not seem to be inhibited by the use of nonsteroidal anti-inflammatory drugs. Comparing two similar groups of Bryan TDR patients having received postoperative NSAID or not with a 3 years FU, Cheng et al\(^13\) observed that clinical outcomes [visual analog scale (VAS) of neck, arm and neck disability index] in both groups were similarly good, and that the rate of HO formation was as high as 53%, but showed no significant difference between the groups.

### WEAR DEBRIS

In vivo studies on wear debris are rare. Anderson et al\(^15\) compared the wear pattern of a series of explanted Bryan (6 cases—metal on polyurethane) and Prestige (2 cases—metal on metal) artificial disks to the in vitro produced wear obtained by a wear simulator. Also, histological specimens were obtained and assessed for wear particles and host inflammatory response. None of the reoperations were conducted for wear debris, implant fracture, polymeric oxidation or metal corrosion. Minimal inflammatory reaction was observed. Overall, there was 5 to 10 times less wear in real life than in simulator.

Studies on polyethylene wear debris are just as uncommon, with only one case report of a histological analysis of an explanted artificial disk in a patient that died from another cause. In this case, radiolucencies were found at the cranial interface between bone and implant, raising doubts about direct bone-implant contact. Metal and PE debris without signs of severe inflammatory reaction were found in the surrounding soft-tissue shell of the operated segment, and a thin layer of soft-connective tissue covered most of the implant endplate.\(^16\)

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Table 2: Frequency of adjacent segment degeneration (ASD) with regards to the type of prosthesis and length of follow-up

<table>
<thead>
<tr>
<th>Authors</th>
<th>Prosthesis</th>
<th>Follow-up</th>
<th>ASD Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhao et al</td>
<td>Bryan</td>
<td>5 years</td>
<td>22%</td>
</tr>
<tr>
<td>Quan et al</td>
<td>Bryan</td>
<td>8 years</td>
<td>19% (always pre-existing)</td>
</tr>
<tr>
<td>Walraevens et al</td>
<td>Bryan</td>
<td>10 years</td>
<td>4.5% reoperations for symptomatic ASD</td>
</tr>
<tr>
<td>Hrabalek et al</td>
<td>ProDisc</td>
<td>4 years</td>
<td>0% symptomatic ASD</td>
</tr>
<tr>
<td>Pimienta et al</td>
<td>PCM</td>
<td>7 years</td>
<td>5.7% symptomatic ASD</td>
</tr>
</tbody>
</table>

ADJACENT SEGMENT DISEASE PREVENTION

The results on the wished preventive effect of motion preservation on ASD are only starting to appear in the literature. There, one must separate radiological ASD and symptomatic ASD leading to reoperation. Radiological ASD has only been reported with the Bryan disk, and could reach 20% (19 to 22%) in series having followed the patients between 5 and 8 years.14 On the other hand, reoperation for ASD seems more uncommon, evaluated between 0 and 5.7%, depending on the type of prosthesis and on the FU (Table 2). Interestingly, in his series, Hacker reported a similar rate of adjacent segment disease in his ACDF patients than in his TDR patients.17

OSTEOLYSIS

Osteolysis has also been rarely reported. Hacker described five cases of peridevice vertebral body bone loss, in a long FU series of 95 patients operated with Bryan and Prestige cervical disks. Tumialan and Gluf published a similar case report of progressive osteolytic process in the vicinity of the keel of the superior metallic endplate. Both authors report osteolysis to cause symptoms of recurrent arm and neck pain.18

Treatment is surgical and, usually, the implant was removed, which stopped the osteolytic process and ACDF was performed. The cause of osteolysis is still unknown, but an immune-mediated process has been suggested. This complication, although uncommon, stresses the potential for late device-related complications and underlines the need for long FU.

INFECTION

Infections in cervical TDR surgery are very uncommon and hardly reported. A few rare cases of infections have been related to preoperative esophageal tear.

DISCUSSION

The results reported by Wu et al12 underline the importance of patient selection and the influence of clinical indication on surgical success. This is also the recommendation of some scientific societies, such as the Belgian society for neurosurgery that recommended cervical TDR to be performed within a frame of recommendations.

In this work, Depreitere et al19 suggest that acceptable candidates for this type of surgery should be between 18 and 60, suffer from radiculopathy due to soft-disk herniation and present no or moderate uncarthrosis, on no more than two levels. Patients with severe uncarthrosis, severe facet arthritis, clinical or radiological myelopathy, spinal canal narrowing, fracture or deformity should be considered as contraindications.19

Still, many questions remain unanswered regarding the choice of implant, or even the optimal surgical technique for prosthesis implantation. Most authors agree on opening systematically the posterior longitudinal ligament, but issues like drilling, chiselling the endplates or resecting the uncus are still debated. Achieving correct positioning of the implant is also one of the cornerstones of obtaining good implant mobility. Although midline landmarks are used, oblique positioning is often seen and may reduce ROM, particularly for prosthesis with a fixed center of rotation.

CONCLUSION

Although the main question about how long we should follow our arthroplasty cases remains unanswered, we have learned that indications, surgical technique and implant choice are crucial, that HO are the rule rather than the exception, that long-term mobility of the implants is far from demonstrated but that the long-term decrease of the segmental ROM does not seem to affect the clinical results. However, adjacent segment disease may therefore still occur. Finally, wear debris will probably be found if we look for them.20

So, it is fair to state that TDR is not inferior to ACDF, allows short-term motion preservation, but its superiority, efficacy on adjacent segment disease prevention and cost effectiveness is not yet demonstrated. A more extensive use of TDR could only be recommended if these questions are answered by long-term studies.

REFERENCES

6. Zhao et al. Bryan—5 years 22%
7. Quan et al. Bryan—8 years 19%—always pre-existing degenerative disk disease at these levels
8. Walraevens et al. Bryan—10 years 4.5% reoperations for symptomatic ASD
9. Hrabalek et al. ProDisc—4 years 0% symptomatic ASD
10. Pimienta et al. PCM—7 years 5.7% symptomatic ASD


149


