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Prevalence, Progression, And Clinical Implications Of Heterotopic Ossification Formation Following Cervical Disc Replacement.

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ABSTRACT

Anterior cervical discectomy and fusion (ACDF), which is surgical treatment of choice for cervical degenerative disk disease, has shown long-term clinical success. However, recently, cervical disk arthroplasty (CDA) is being widely used as an alternative to ACDF. Cervical disc replacement (CDR) is a relatively new technique. We aimed to determine the prevalence, progression, and clinical implications of heterotopic ossification after CDR. We retrospectively collected the data of patients who had undergome single- and two-level CDR using the Prestige- LP from April 2020 to June 2022 and who had been followed up for a minimum of 2 years. The average age of the patients was 43.3 years. The patients were followed up for 24 to 130 months, with a median of 41 months (interquartile range, 35–56 months). A total of 196 segments in 129 patients were analysed, of whom 102 underwent single-stage CDR and 27 underwent two-level CDR. C5/6 (n = 116) was the frequently operated level, followed by C4/5 (n = 42), C6/7 (n = 26), and C3/4(n=12). Preoperative cervical spondylosis significantly impacted post-CDR HO formation in the posterior disc area. Thus, when choosing suitable patients for CDR, a strict criteria should be utilized regarding the amount of preoperative disc height loss.

Keywords: Heterotopic ossification, cervical spondylosis, cervical disc replacement, intervertebral disc height.

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INTRODUCTION

Anterior cervical discectomy and fusion (ACDF) is the optimum surgical treatment for cervical degenerative disc disease, and it has shown long-term clinical success [1]. However, recently, cervical disc arthroplasty (CDA) is being widely used as an alternative to ACDF [2]. Cervical disc replacement (CDR) is a relatively new technique in cervical spine surgery. The initial idea of CDR was to restrict motions at the index level, decrease motions at the adjacent segments, and transfer stresses, which would theoretically decrease the degenerative changes occurring at the adjacent segments.

CDR has been associated with the development of heterotopic ossification (HO), which decreases movement at the index level and eventually leads to complete intervertebral fusion. This goes against the motion-preserving design of disc replacement. HO is the formation of bone outside the skeletal system within the muscles and soft tissue. It commonly occurs in patents immobilized following hip or knee arthroplasty. Several studies have analyzed the prevalence, predisposing factors, and medical implications of HO development in CDR since its discovery. However, the underlying mechanism of HO remains unknown [3].

Analysis of patients who have undergone hip arthroplasty indicate that patient's sex is an important risk factor for HO development. Several factors have been hypothesized to cause HO in CDR, including non-usage of nonsteroidal anti-inflammatory drugs (NSAID) postoperatively, sex, age, surgical stage, level treated, preoperative degenerative changes, and surgical method [4]. Although multiple studies have tried to determine the correlation between risk factors and the development of CDR-associated HO, the results have been inconclusive [5].

Degenerative cervical spondylosis refers to age-related wear and tear over several years, affecting the intervertebral discs, facet joints, and different connective-tissue systems. Preoperative degenerative spondylosis is considered to be a contributor to HO formation after CDR. However, the independent factors related to preoperative spondylosis causing HO formation remains unclear. Furthermore, previous studies have indicated that the mechanism of HO formation anterior and posterior to the disc may differ. However, the impact of preoperative spondylosis on the occurrence of HO in distinct areas has not been well studied.

The rate of HO following CDA remains unclear. The suggested factors range substantially, creating debate regarding the genuine factors affecting HO formation. The long-term results of HO-induced unintentional fusion have not been sufficiently studied. We aimed to determine the prevalence, progression, and clinical implications post-CDR HO.

MATERIAL AND METHODS

This retrospective study protocol was approved by the Ethics Committee of Sri Lakshmi Narayana Institute of Medical sciences. Informed consent was obtained from all patients. Patients who underwent one- and two-level CDR using the Prestige-LP (Medtronic Memphis, YN, USA) from 20019 to 2022, with a minimum of 2 years of follow-up data, were included in this study.

The inclusion criteria

- Age of 18–65 years,
- One- or two-level cervical disc disease (C3–C7) causing radiculopathy or myelopathy,
- Failure of conservative treatment for at least 12 weeks.

The exclusion criteria

- Instability, irreducible kyphosis, or severe degeneration at the surgical segment,
- Ossification of the posterior longitudinal ligament,
- Ankylosing spondylitis, rheumatoid arthritis, or other autoimmune or metabolic bone diseases,
- Osteoporosis (T-score ≤ -2.5),
- Prior cervical spine surgery.

All surgeries were carried out by a senior spine surgeon. The patient was positioned with the neck turned slightly to the opposite side after general anesthesia. The Smith-Robinson approach was used to reach the affected level. After exposing the affected level, the anterior longitudinal ligament, intervertebral disc, posterior longitudinal ligament and osteophytes were removed to obtain complete discectomy and decompression.

A high-speed burr was used to carefully prepare the endplate and a trial implant was used to determine the appropriate prosthesis size. Thereafter, a rail cutter bit and guide were used to prepare the fixation channels in the endplate and an appropriately sized disc was inserted into the intervertebral space. After verification of the appropriate implant placement using anterior- posterior and lateral fluoroscopic images, copious irrigation with normal saline was used to wash away the bone dust produced during preparation. The same procedure was performed at the second level in patients with two involved levels. After achieving meticulous hemostasis, closure was performed over a drainage tube. Nonsteroidal anti-inflammatory capsules were not administered in this cohort.

Radiological evaluation

The preoperative, 1-week post-operative and final follow-up radiological data were collected. The degree of degeneration at the index level was evaluated preoperatively on the lateral radiographs using a quantitative scoring system proposed by Walraevens et al. It consists of the assessment of vertebral height loss (score 0–4), anterior osteophytes (score 0–3) and endplate sclerosis (score 0–2), with higher scores representing more severe degeneration. Height loss was defined based on the disc height at the affected level with respect to that of a normal disc at the adjacent level. Anterior osteophytes were assessed based on its length relative to the anteroposterior diameter at the middle of the corresponding vertebral body [6]. Endplate sclerosis was distinguished from no sclerosis, just detectable sclerosis, and definite sclerosis.

The uncovertebral joint was assessed preoperatively using reconstructed computed tomography (CT) images to identify osteophytes. Park et al. reported a CT-based grading system for evaluating facet joint degeneration (grades 1–4), with higher grades denoting advanced degeneration. HO was classified based on the McAfee criteria into low-grade (grades 1–2) and high-grade (grades 3–4). According to the HO location on lateral neutral radiographs, index segments were divided into anterior HO (AHO) non-AHO, posterior HO (PHO), and non-PHO groups [7].

RESULTS

This retrospective analysis included 129 patients (64 men and 65 women) with a minimum of 24 months of follow-up data. The average age of the patients was 43.3 years. The patients were followed up for 24 to 130 months, with the median being 41 months (interquartile range, 35–56 months). A total of 196 segments in 129 patients were analysed, of whom 102 underwent single- stage CDR and 27underwent two-level CDR. C5/6 (n = 116) was the most frequently operated level, followed by C4/5 (n = 42), C6/7 (n = 26), and C3/4(n=12). Eighty-two levels (44.90%) had low-grade HO, and 29 levels (constituent ratio: 14.80%) exhibited high-grade HO. Furthermore, 43 patients and 45 levels (22.96%) had AHO, and 68 patients and 82 levels (41.84%) had PHO. The Japanese Orthopaedic Association (JOA), neck disability index (NDI), and neck and arm VAS scores had significantly improved at the most recent follow-up. No patients required a reoperation on the index or adjacent levels.

Univariate analysis of HO and the influence on clinical outcomes

According to the site of HO occurrence, all segments were separated into AHO, non-AHO, PHO, or non-PHO groups. Age, sex, follow-up period, index level, and preoperative spondylosis status were included in the univariate analysis. Compared to the non-PHO group, the PHO group had significantly higher levels of overall disc degeneration (P=.001), disc height loss (P=.002), and anterior osteophytes (P=.004).

Similar to the prevalence of preoperative uncovertebral joint osteophytes (P =.042), the presence of facet joint degeneration (P =.025) was substantially more common in the PHO group than in the non-PHO group.

The postoperative shell angle and ROM were not significantly different between the AHO and non-AHO groups. At the last follow-up, ROM at the index level was lower in the PHO group than in the non-PHO group; however, the difference was not significant. Additionally, the incidence of ASD was significantly higher in the PHO group than in the non-PHO group (32.9% vs 14.9%; P =.003).

At the last follow-up, there were no significant differences in the JOA, NDI, VAS scores between patients with and without AHO and those with and without PHO. However, larger ROM of C2–C7 was noted in patients without AHO than in those with AHO; however, the difference was not statistically significant.

DISCUSSION

Motion restriction at the treated level is a potential side effect of HO, which goes against the core objective of CDR. Thus, determining the actual risk factors for HO and choosing suitable candidates are crucial for the improvement of CDR. Our study reveals that only the posterior disc space of the HO is impacted by preoperative degeneration. Reduction in disc height may be an independent risk factor for PHO formation in the presence of complex preoperative spondylosis [8].

Parkinson and Sekhon originally reported that preoperative cervical spondylosis is a significant risk factor for HO [3]. A series of age-related degenerative changes that occurs in the cervical spine is known as cervical spondylosis. The pathophysiology involves the uncovertebral joints bilaterally and the three-joint complex, which includes two posterior joints and the intervertebral disc.

In this study, preoperative spondylosis was thoroughly evaluated, including the components of the three-joint complex, uncovertebral joints, and ligaments. The univariate analysis revealed that preoperative height loss, anterior osteophytes, uncovertebral joint osteophytes, and facet joint degeneration were important variables for the development of post- CDR PHO. However, a multivariate logistic regression analysis revealed that the preoperative disc height was the only risk factor for the development of PHO. This is most likely a result of the interdependent degenerative processes affecting each cervical segment's components.

Reactive osteophyte formation may be caused by the combination of disc height decrease and osseous attachment of annulus fibers to the vertebral surface [9]. Xinghua et al. demonstrated that osteophyte production is an adaptive bone remodeling process in response to a modification in the mechanical environment, which is primarily driven by intervertebral disc degeneration [10].

Spondylosis of the uncovertebral joint is characterized by the presence of osteophytes at the uncinate process. Thus, in this study, uncovertebral joint degeneration was assessed in relation to the presence of osteophytes. This factor was confirmed to be statistically important in the univariate analysis; however, it was insignificant in the multivariate logistic regression analysis. This is may be attributable to the intervertebral disc degeneration. Instability-induced traction pressure might also cause uncinate osteophyte formation [11].

Cao et al [12] also discovered a significant correlation between preoperative intervertebral space degeneration and uncovertebral joint degeneration. With the revolutionary diminution of disc height associated with cervical intervertebral joint degeneration, HOs around the uncovertebral articulations are pressed firmly together causing reactive osteophyte formation.

We determined that the disc height loss in high-grade HO was significant more compared to that in low-grade HO, which is similar to the finding of the study by Kim et al [13]. Therefore, high-grade HO could restabilize the altered biomechanical environment at the segments that have undergone surgery.

Surgical techniques and postoperative biomechanical adjustments because of disc height loss might also contribute to the development of HO. Patients with preoperative disc height loss may produce more bone dust during endplate preparation and decompression, that is considered a critical factor for HO formation [14]. Segments with preoperative disc height loss undergo more distraction, resulting in more changes in the postoperative biomechanical environment, intervertebral height, and segmental mobility.

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CONCLUSION

The study results revealed that preoperative cervical significantly impacted post-CDR HO production in the area of the posterior disc. The degree of preoperative disc height loss, anterior osteophytes, uncovertebral joint osteophytes, and facet joint degeneration were more severe in individuals with PHO than in those without PHO. However, the disc height loss alone was a risk factor for PHO development in patients with complex preoperative cervical spondylosis. Thus, when choosing suitable patients for CDR, a strict criterion should be utilized regarding the amount of preoperative disc height loss.

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