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PŮVODNÍ PRÁCE

Cement Augmentation of the Cervical Spine – a Technique Enhancing Stability of Anterior Cervical Plating

Augmentace krční páteře kostním cementem – technika ke zlepšení stability fixace krční páteře dlahou

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ABSTRACT

PURPOSE OF THE STUDY
The aim of this study is to describe a new technique for cement augmentation of primary anterior cervical screw fixation in the sub-axial cervical spine.

MATERIAL AND METHODS
Seven patients underwent anterior cervical spine surgery for trauma (two) or tumor infiltration (five) between 2008 and 2015. The tumor cases underwent corpectomy and anterior plating, with the trauma cases undergoing anterior cervical decompression and fusion using iliac crest bone graft. All surgeries were performed through the standard anterior approach. 0.2–0.25 ml of Kyphon cement were introduced into the screw holes before the screws were locked into the plate of the anterior construct. Karnofsky Index, Spinal Instability Neoplastic score (SINS) were calculated and radiographic follow-up performed.

RESULTS
Median follow-up was 7 months (range 7 weeks–39 months). There were no complications from cement leakage or construct failure during the follow-up period. There were no wound infections or approach-related complications. We did not have to re-operate on any patient, cervical spine remained stable until the end of follow up.

DISCUSSION
Until now a limited number of papers on cement augmentation of cervical spine mainly dealt with revision surgeries, when cement was used as rescue technique to re-establish stability of previous fixation or cement augmentation was performed in form of vertebroplasty following plate fixation. Our technique intends to prevent revision surgeries and to anchor all screws in holes which are evenly filled with bone cement.

CONCLUSIONS
This technique of cement augmentation is a useful adjunct in those few patients where a secondary posterior surgery would be high-risk due to the general health of the patient, or when life expectancy is limited. We have shown that anterior alone reconstruction of the cervical spine with cement augmentation of screws did provide sufficient and sufficiently long stability of the cervical spine which prevented catastrophic collapse and quadriplegia in patients in poor general condition.

Key words: cement augmentation, cervical spine, corpectomy, tumor, stabilization, fusion.

INTRODUCTION

Anterior column reconstruction in the cervical spine is a recognized procedure for patients with cervical spine trauma or tumor infiltration. They will often need surgery spanning multiple levels putting increasing mechanical stress on the construct and placing it at increased risk of failure (20, 25). In these patients, bone quality can also be reduced either due to osteoporosis, or tumor infiltration, further increasing the risk of construct failure secondary to screw pull-out (10, 24).

One option is to perform anterior and posterior surgery to increase the stability of the surgery performed (12, 16, 27). However, this will involve putting patients through a second operation, which may be poorly tolerated (prone position, lengthy spine exposure with risks of infection, blood loss and an often prolonged operating time), in a frequently frail, or generally unwell, population.

Cement augmentation for the anterior cervical spine was originally described by Galibert et al (7), in their treatment of C2 vertebra haemangiomas. It has also been shown to be a successful adjunct both clinically and biomechanically in the fixation of fractures of the C2 vertebral body (26, 28).

Cement augmentation has also been described for anterior surgery in the subaxial cervical spine, but it has either been for salvage surgery (14), or using vertebroplasty after screw placement (29). The latter puts the patient at risk of cement leakage, especially with the small volume of the cervical spine vertebra (5, 11).

We introduce a simpler technique for cement augmentation in primary screw placement of anterior cervical spine surgery, which we believe decreases the risks of cement leakage, and increases the stability of the construct.

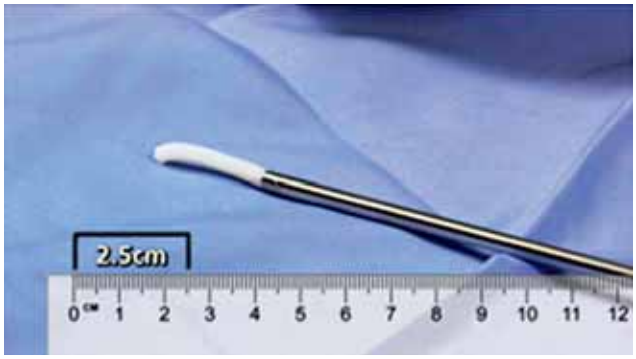


Fig. 1. Clinical photograph demonstrating the 2.5 cm cement column injected into each screw hole using the cement introduction system.

MATERIAL AND METHODS

Seven patients were identified as having cement augmented anterior cervical surgery between 2008 and 2015. Median age was 77 (range 39–84) and all surgeries were performed by the senior author (Z.K.) using the classic Smith-Robinson anterolateral approach to the cervical spine with the patient placed supine on a radiolucent table. Karnofsky Index (15) and Spinal Instability Neoplastic Score (SINS) (6) were calculated for each patient where appropriate. Institutional Review Board approval was not needed for this study.

Standard corpectomy was carried out in tumor patients where the bony defect was filled by titanium mesh cage (Nuvasive® Inc: CA, USA or DePuySynthes©: MA, USA), which was cut to measure and filled with bone cement. Care was taken not to over-distract the defect, which would place the cage at risk of sinking into the adjacent vertebral bodies. In trauma cases, anterior cervical decompression and fusion (ACDF) was performed in the standard way using anterior iliac crest bone graft.

The cages were bridged by a locking plate with fixed (C4–C7), or variable angle screws (C3 and T1). The screw holes were prepared by sharp awl and then 4.5 mm diameter screws (revision screws) were placed, using monocortical fixation. In general, screws were 15–17 mm long (Nuvasive® Inc, CA, USA).

The screws were placed but not initially locked in the plate. They were then removed and checked for breaches with a feeler in a similar way to performing a pedicle screw. The cement was allowed to become highly viscous (1), which can be checked by the ability to pass a small column from the end of the cement introducer without loss of shape (Fig. 1).

0.2–0.25 ml of Kyphon® cement (Kyphon® Medtronic: MN, USA) was then introduced into each screw hole through their cement introduction system (KyphX® Bone Filler Device), the diameter of which just fits the hole. Volume was calculated as this because we insert a 2.5 cm column of cement using the Bone Filler Device (Fig. 1).

Critically, whilst introducing the cement, and again whilst placing the screw, radiographs were taken at regular intervals to look for cement leakage. For ease, two screw holes were filled with cement at a time (through the plate), so that the plate remains placed on the anterior surface of the spine, and the final placement of the screws is performed sequentially.

As with any cement augmentation technique, care was taken to introduce high viscous cement to minimize risks of leakage into the spinal canal (1, 8, 21). According to our experience this is difficult to perform with the 1 ml or 2 ml syringes therefore we use the Bone Filler Device (Fig. 1). The position of bone cement in the vertebral body was monitored on intra-operative fluoroscopy in lateral view only. Then the screws were quickly introduced again, this time they were locked in the plate. This technique allows the screws to be evenly surrounded by bone cement enhancing fixation.

RESULTS

Patient demographics and surgeries performed are described in Table 1. There were five corpectomies performed for tumor, with two ACDF's carried for trauma. Median follow-up was 7 months (range 7 weeks–39 months). Six patients had died at time of writing this paper, with patient 4 still alive. One patient (patient 2) had anterior surgery following urgent posterior decompression and stabilization of C4–T4 for metastatic spinal cord compression.

There were no complications from cement leakage or construct failure during the follow-up period. There were no wound infections or approach-related complications. At final follow-up all patients were asymptomatic with no neurological deficits from the cervical spine.

Figures 2–5 demonstrate pre- and post-operative imaging of two patients (4 and 5) with multiple myeloma. Figures 6 and 7 shows the injury sustained and fracture fixation in a patient with ankylosed cervical spine (patient 3).

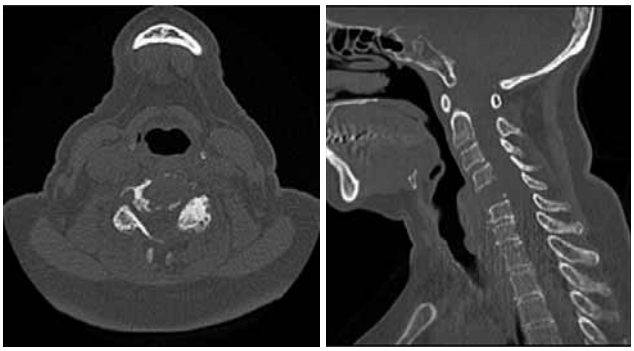
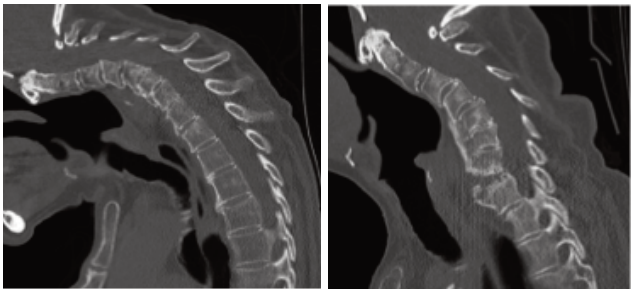


Fig. 2. Pre-operative sagittal and axial CT of patient with multiple myeloma (patient 4). The SINS score was 12 – indeterminate instability.

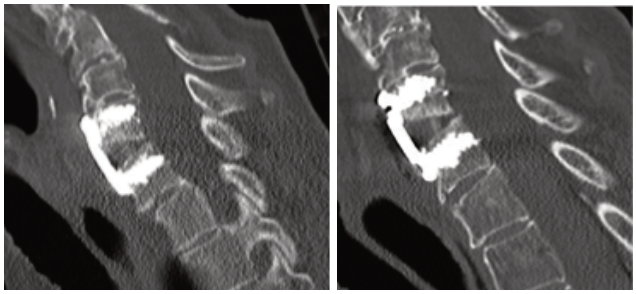
Fig. 3. Post-operative radiographs demonstrating surgical procedure in patient 4.

Figs. 4a and b. Sagittal MRI and CT scan showing extent of multiple myeloma (SINS score 13) (patient 5).

Fig. 5. Plain radiographs at 1-year follow-up (patient 5).



Figs. 6a and b. Pre- and post-operative sagittal CT images demonstrating pre-injury deformity and injury sustained in patient with ankylosing spondylitis (patient 3).



Figs. 7a and b. Post-operative sagittal CT (patient 3).

*Table 1. Patient demographics and surgeries performed KI Karnofsky Index, SINS Spinal Instability Neoplastic Score (0–6 = stable, 7–12 = indeterminate, >13 = unstable), AS Ankylosing Spondylitis, * still alive at time of writing*

Patient No.	Age at surgery	Gender	Diagnosis	KI	SINS score	Surgery performed	Follow-up (months)
1	81	female	AS, C6/7 fracture-dislocation	40	n/a	C6–C7 plating with iliac crest bone graft	7
2	60	male	prostate cancer	80	12	C7, T1 corpectomy, C6–T2 plate/posterior C4-T4 stabilisation	21
3	84	female	AS, C7/T1 extension injury	40	n/a	C7–T1 plate with iliac crest bone graft	1.5
4	65	female	multiple myeloma	90	12	C5 corpectomy, C4–6 plate	7*
5	77	female	multiple myeloma	90	13	C5, C6 corpectomy, C4–7 plate	39
6	77	male	multiple myeloma	30	13	C4 corpectomy, C3–5 plate	1.5
7	39	male	multiple myeloma	80	13	C7 corpectomy, C6–T1 plate, C5 vertebroplasty	23

DISCUSSION

Spinal surgery for instability (traumatic or destruction by tumor) can lead to significant mortality and morbidity (9, 13, 18, 31), especially if they have to undergo multiple operations. It has been shown that, especially in long constructs, secondary posterior surgery is beneficial to increase the stability of the anterior construct (12, 16, 27) and prevent failure of fixation (20, 25). We describe a technique of cement augmentation of anterior cervical spine fixation which may prevent the need for secondary surgery in those patients at high risk of complications.

Our technique differs from previous descriptions (14, 29) in that we place the cement in the carefully prepared screw holes as part of the standard technique. This guarantees that the screw-cement interface will be completely integrated, maximizing the biomechanical advantage. Waschke et al. (29) have previously published the largest series of anterior surgery with cement augmentation, but this was with a secondary vertebroplasty procedure after insertion of the screws. With this technique, there is no guarantee that the screws have significant purchase on the cement, and therefore may not be at a biomechanical advantage compared with normal screw placement.

The technique described in this paper is also beneficial because it allows the planned placement of cement in the carefully prepared screw holes, similar to that of filling the cavity of kyphoplasty. The limitation of Waschke et al. (29) technique is that one is relying on the principles of vertebroplasty and run the risk of cement leakage and the complications that it entails. It has been shown that the risks of cement extravasation are much lower in kyphoplasty (11) and so it would seem logical to expect a similar decrease in risks with this technique.

The trauma cases occurred in elderly patients with ankylosed cervical spine (one is shown in Figures 6a and b) where prognosis is poor (30). In this situation most surgeons would advocate both anterior and posterior multi segment fixation to improve construct stability (12, 16, 19, 27, 30). Both our patients were elderly, frail and had multiple medical co-morbidities and were therefore not fit enough to undergo two procedures. In this situation, our technique gives added stability to the anterior construct, allowing mobilization without construct failure. The patients survived the immediate post-operative period, which may not have happened if they had undergone two operations.

We have used the SINS assessment of stability (6) in the tumor cases to demonstrate the nature of the pathologies involved in our cohort, and the need for surgery. A score of 13 or greater suggests an unstable spine and the need for surgery. An interesting observation form this study is that the score appears to underestimate massive lytic lesions with almost complete loss of the vertebra without collapse or deformity (Figs. 2, 4 and 5). In these situations, it would be prudent to consider 360-degree fusion to ensure there is no construct failure in those where life expectancy is greater than three months (12, 16, 17, 20, 25, 27). However, in our series, utilizing primary cement augmentation, we had no episodes of failure despite only performing anterior surgery in the majority of cases.

Recently there has been growing interest in the effects of cement augmentation on the stability of constructs, and pull-out strength of screws, placed in the anterior cervical spine following on from successful biomechanical studies in the thoracolumbar spine (2, 23). Similar experiments have again shown that cement augmentation provides a biomechanical advantage in anterior cervical spine constructs with greater pull-out strength of the screws in a failed construct situation, and in osteoporotic bone (4, 22). However this is the first description of this technique being used in primary fixation, rather than salvage situations (14).

Limitations to this study include the small numbers and short-term follow-up. However, this elderly group of patients (except one) with significant medical co-morbidities are the patients where this technique is most useful as it will prevent them needing secondary posterior surgery, longer stays in hospital, and potentially increased morbidity during their remaining short lifespan. Surgical stabilisation of these pathologies, however, will allow easier nursing, ability to mobilise and the potential for quicker hospital discharge.

Another criticism is the fact that we have included both trauma and tumor patients with differing surgical techniques in a single paper. It has been shown that this can affect radiological outcomes (3) with more subsidence in those treated with bone graft rather than cage, although the addition of plate fixation can prevent this. In the long-term, there is likely to be subsidence in both groups due to the osteoporosis in the trauma cases, and the soft bone in the tumor cases, however, this is a niche group of patients who are unlikely to need long-term radiological follow-up.

In these seven patients we have shown that this surgery can be safely performed with no complications from cement leakage or construct failure. We have shown that the anterior approach to the cervical spine is associated with low post-operative morbidity and that these surgeries are fully justified, even in those with a short-term prognosis because it prevents the catastrophical consequences of quadriplegia.

CONCLUSIONS

We have described a technique for cement augmentation of screws in primary anterior cervical surgery. We believe our technique can be reproduced safely in specific patients where the risk of implant failure is high, and prevent the need for 360-degree fusion, or revision surgery. It is a useful adjunct in those patients where a secondary posterior surgery would be high-risk due to the general health of the patient, or when life expectancy is very limited.

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