ABSTRACT INTRODUCTION:
Previous work at our institute has documented evidence of aggressive allograft remodeling when used with rhBMP-2, in both lumbar and cervical interbody fusion. When rhBMP-2 was used with simple femoral allograft spacers for lumbar interbody fusion, in the absence of additional stabilizing instrumentation, an inordinately high rate of nonunion was observed, with graft subsidence and fragmentation. Anterior cervical interbody fusion (ACDF) with rhBMP-2, allograft, and plate had a perfect rate of 1 and 2-level fusion (100%), although early postoperative CT scans showed evidence of extensive allograft remodeling and areas of resorption. This study analyzes our extensive experience with multi-level (3 and 4-levels) ACDF with rhBMP-2, allograft, and semi-constrained dynamic plating, and reports on the fusion rate, graft settling, radiographic incorporation, and complications in this more challenging environment for rhBMP-2.

METHODS:
This is a prospective cohort study of 33 consecutive patients who underwent 3 and 4-level ACDF by a single surgeon, with fibular allograft, rhBMP-2, and dynamic plating with the Stryker Reflex or Hybrid semi-constrained plate with variable angle screws. Mean patient age was 56. The average FU was 18 months (12 – 42 months). Radiographic fusion rates were determined with plain radiographs (including flexion-extension) and CT scans when ambiguous. Cervical segmental lordosis was measured immediately post-operatively and at last follow-up to study graft settling. Moreover, as a perhaps more reliable measure, the angle subtended by the superior and inferior screws of the plate was also recorded – since any settling or translation of the fusion construct would result in a change in the angle of the variable screws. A modified Bridwell-Lenke grading system was used to rate the incorporation of allografts into the vertebrae. Finally, perioperative and long-term complications were noted.

RESULTS SECTION:
The radiographic fusion rate was 97% of patients (32/33) and 99% of levels (101/102). This rate is significantly higher than published historical controls by the same senior author, using the same surgical technique but without rhBMP-2 (33/40 patient, 82%). Graft settling occurred, and even though aggressive remodeling occurs, the use of a dynamic plate did not result in settling in excess of that described in the literature for non-BMP fusion constructs. Moreover, the settling did not effect a significant change in segmental cervical lordosis, and did not compromise fusion rates. Graft incorporation by radiographic criteria was almost uniformly Grade I by the modified Bridwell-Lenke criteria, which correlates with the almost 100% fusion rate (Figure 1). With the conservative BMP-use techniques used by surgeons in our institute, which confines the BMP inside the allografts, there were no incidents of respiratory complications. Other complications were also not any more frequent than those reported in the literature.

DISCUSSION:
RhBMP-2 is effective in significantly increasing anterior multi-level cervical fusion rates when used with allograft and dynamic plating. There is measurable graft settling, but not significantly higher than reported in the literature, and without significantly affecting cervical lordosis or fusion rate. It remains to be seen if the fusion rate would differ with fixed-angle plate and screws. The radiographic quality of fusion is also improved, with allograft incorporation seen uniformly. When the rhBMP-2 containing sponge is confined entirely within the graft (Figure 2), no untoward complications related to excessive neck swelling were observed.

Figure 1. Note how the graft is still discernible in (A) 18 months after ACDF without rhBMP-2, versus almost complete incorporation in (B) 6 months after ACDF with rhBMP-2. (C) and (D) illustrate aggressive graft remodeling with rhBMP-2 leading to graft settling (bottom level), which still went on to complete union.

Figure 2. A more "conservative" use of rhBMP-2 in the cervical spine, using the bur to remove any extraneous BMP-containing sponge and confining it to inside the allograft, yields good results while minimizing tissue swelling complications.