Systematic review and meta-analyses of spinal fusion rate: static versus dynamic plates with bone grafts in 1, 2 and 3 level anterior cervical decompression fusion procedures.

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Introduction/objectives: Cervical radiculopathy and myelopathy are conditions that can result in significant patient morbidity. Anterior cervical decompression and fusion (ACDF) is considered the gold standard for persistent cervical radiculopathy and is a commonly used to treat cervical myelopathy. The exact stability required to optimize fusion likelihood is unknown. Static or dynamic (translational, rotational or hybrid motion) plate designs exist to vary motion across the fusion site, however, the impact of plate design on fusion rate is unclear. The aim of this study was to establish whether current evidence supports the use of static or dynamic plating for improved fusion rates in adult cervical radiculopathy and myelopathy patients treated with (≥3 level) ACDF.

Methods: MEDLINE, Embase and Scopus databases were searched for published studies (January 1990 - September 2025) on clinical fusion rate in adult (≥18y/o) myelopathy and/or radiculopathy patients treated surgically with 1, 2 or 3 level ACDF using static, or dynamic (translational, rotational or hybrid motion) plate designs with autograft/allograft and a minimum follow up of 6 months. *Meta-analysis summary :* **Single arm studies:** fusion proportions were pooled using a binomial-normal generalized linear mixed model (GLMM) with logit link and a random study intercept with between study variance (τ^2) estimated by Restricted Maximum Likelihood (REML)). **Comparative studies**: study-specific risk ratios (RRs) for fusion proportion were pooled using a random-effects model to account for between-study heterogeneity, with inverse-variance weighting. Between-study variance (τ^2) was estimated using REML, and Hartung-Knapp small-sample adjustment applied to calculate the pooled 95% confidence intervals (CIs) (estimating using Clopper-Pearson intervals). Between study heterogeneity was assessed using I^2 statistic and 95% prediction interval for the pooled effect. Critical appraisal was conducted using the GRADE approach. Given insufficient studies for sub-groups meta-analysis, we report narrative statistics for fusion proportion (number of fusions/total population) for static plate brands (Orion, CSLP), dynamic plate subtypes (translational, rotational or hybrid motion) and levels fused.

Results: An initial search yielded 1576 papers. Twelve studies (four comparative) were included (222 static plates, 444 dynamic plates: 198 translational, 136 rotational,110 hybrid). GRADE critical appraisal identified 5 low quality and 7 very low-quality studies. Pooled meta-analysis demonstrated a non-significant 3% decrease in relative likelihood of achieving fusion with a dynamic plate vs. a static plate, however, single arm studies found a larger difference between static- (91%) and dynamic- (97%) plates. Calculated fusion proportion was overall high and comparable between static- (91%) and dynamic- (92%) plates. Fusion rate is influenced by static plate brands: Orion (94%) vs. CSLP (84%), dynamic subtypes: translational (96%), rotational (93%), hybrid (83%), number of levels fused for dynamic plates (single-level (94%) vs. multi- (2- and 3-) level (86%)), but not for static plates (single-level (90%) vs. multi- (2- and 3-level) (91%)).

Discussion/Conclusion: While there may be theoretical benefit to dynamic plates over static plate designs for fusion, which is reflected in our descriptive statistics dynamic plate, single level studies (94%) vs. static plate, single level studies (90%), our meta-analysis of comparative studies, found a non-significant 3% decrease in relative likelihood of achieving fusion with dynamic plates compared to static plates. However, given poor overall quality of included studies as per GRADE assessment and the small number of studies included in our descriptive statistics analysis - static plates (6 studies): Orion (63%) vs. CSLP (37%)) vs. dynamic studies (11 studies): translational (44%), rotational (31%), hybrid (25%)), the reported estimate of the effect of plate design on fusion must be interpreted with caution, as the true effect may be substantially different . While our descriptive analysis results also showed that plate brands appear to influence fusion rate, e.g. for static plate brands, Orion (94%) vs. CSLP (84%), inter-study variability was not assessed in depth. Differences in fusion rates for translational (96%) and rotational (93%) vs. hybrid (83%) plates, suggest translational and rotational motion is comparable, and preferred over hybrid motion. The fusion rates between single-level dynamic plate fusion (94%), and single- (90%) and multi- (2- and 3) (91%) level static plate result are comparable while, multi-level dynamic plating (86%) may introduce too much motion between fused vertebrae that compromises fusion.

To determine the true effect of plate designs on fusion rate, study quality must be improved by ensuring a clear and focused research question consistent reporting and minimising risk of bias wherever possible.

Significance/Clinical relevance: This paper highlights the ambiguity around optimal plate mechanism for fusion, and the need for further well-designed studies investigating this to help determine what plate is truly best practice. It updates the literature on previous static versus dynamic plate systematic reviews and further delves into the analysis of dynamic plate subtypes, which has not been done before.