Level Specific Hounsfield Unit Thresholds as a Predictor of Subsidence following Transforaminal and Posterior Lumbar Interbody Fusion

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INTRODUCTION:

Subsidence after interbody cage placement is a complication that can lead to adverse surgical outcomes such as recurrence of radiculopathy, deformity, and aggravation of axial pain. Recent literature has shown that there is a correlation between bone mineral density (BMD) and risk of subsidence. Hounsfield Units (HU) derived from computed tomography (CT) scans have been proposed as a complementary method for assessing BMD outside dual-energy X-Ray absorptiometry.

The purpose of this study was to 1) determine if HU values are associated with radiographic settling following transforaminal and posterior lumbar interbody fusion (TLIF/PLIF), 2) determine clinically sensitive level-specific HU thresholds for subsidence, 3) evaluate which vertebral level is most predictive for radiographic settling, and 4) identify if there is a difference in radiographic settling between expandable and non-expandable cages.

METHODS:

A retrospective analysis was performed identifying orthopaedic spine and neurosurgical patients who underwent single-level TLIF or PLIF from 2007-2022 in an integrated health system. Exclusion criteria included a non-degenerative diagnosis, inadequate radiographs, multilevel and revision surgery, and postoperative follow up less than one month. HUs from L1-S1 were measured on either preoperative or postoperative CT scans taken within one year of the index surgery. Measurements at the same level as instrumentation were excluded. Changes in segmental lordosis (SL) were measured on intraoperative and postoperative lateral spinal radiographs. Cage subsidence was defined as >5 degrees difference of SL from the intraoperative to the latest postoperative period. Student's t-tests were used to compare the average HUs between the subsidence and non-subsidence groups. Univariate and multivariate logistic regression analyses were performed to identify the relationships between HU, cage type, and cage subsidence using odds ratio (OR). Receiver operating characteristic (ROC) curves were also utilized to identify the most sensitive and specific HU cutoffs for cage subsidence at each vertebral level.

RESULTS:

A total of 50 patients met inclusion criteria. Average follow-up time was 22.7 months. Eighteen (36%) patients had evidence of radiographic cage subsidence. When comparing both subsidence and non-subsidence groups, there was no difference in average HU at any vertebral level. A univariate logistic regression analysis revealed that HU measured at L1-L5 were significantly associated with cage subsidence [L1<145 HU (OR 3.958, p=0.039), L2<145 HU (OR 3.740, p=0.049), L3<110 (OR 14.4, p=0.02), L4<150 (OR 5.333, p=0.047), and L5<155 (7.071, p=0.033)]. Multivariate analysis using L1-S1 HU and fusion level as covariates, HU measured at L1-L3 remained significantly associated with subsidence.

ROC curve analysis revealed that a cutoff of 106.9 HU at L1 correlated to 92.6% sensitivity/31.2% specificity for cage subsidence [area under curve (AUC) = 0.692], 94.1 HU at L2 with 92.6%/18.7% (AUC=0.613), 120.4 HU at L3 with 92%/50% (AUC=0.750), 118.5 HU at L4 with 100%/45.5% (AUC=0.747), 109.6 HU at L5 with 93.3%/44.4% (AUC=0.726), and 140.6 HU at S1 with 90.5%/25% (AUC=0.675).

Both univariate and multivariate logistic regression analyses showed no difference in subsidence between static and expandable cages.

DISCUSSION AND CONCLUSION:

A significant association was found between HU and radiographic subsidence following TLIF/PLIF. Highly sensitive HU thresholds for subsidence were found to be 107 HU at L1, 94 HU at L2, 120 HU at L3, 119 HU at L4, 110 HU at L5, and 141 HU at S1. Measurements taken at the L3 and L4 vertebral levels were overall most predictive and accurate of radiographic settling at the above cut-offs. No difference was found in radiographic settling between expandable and non-expandable cages. These findings suggest the use of HU derived from CT scans shows promise as a tool to predict risk of cage subsidence and guide clinical decision making.

Subsidence Odds Ratios		
Variable	Univariate OR	P-Value
L1<145	3.958	**0.039**
L2<145	3.740	**0.049**
L3<110	14.4	**0.02**
L4<150	5.333	**0.047**
L5<155	7.071	**0.033**
S1<160	2.0	0.448

Lumbar Level	AUC	Cutoff (HU)	Sens, Spec
L1	0.692	106.9	0.926, 0.312
L2	0.613	94.1	0.926, 0.187
L3	**0.750**	**120.4**	**0.92, 0.5**
L4	0.747	118.5	1.0, 0.455
L5	0.726	109.6	0.933, 0.444
S1	0.675	140.6	0.905, 0.25