Single-stage power-factor-corrected (S^2PFC) power supplies usually suffer from high voltage stress, due to lack of control on the intermediate bus capacitor voltage. In the past, analysis of such voltage stress was mostly based on steady-state condition without providing sufficient explanation during the transient circuit operation. This paper revisits the problem at circuit level and reports that the root cause is due to the inherent negative current feedback property of the output inductor or the transformer operating in continuous conduction mode (CCM). Based on the finding, this paper further proposes a new approach to reducing the voltage stress by adding an auxiliary circuit branch to existing S^2PFC converters. The additional circuit branch limits the effect of negative current feedback by suppressing the change of output current slope due to change of load. This assists the pulsewidth modulation controller to track the change of load better such that the bus capacitor voltage range is reduced through duty cycle control. The auxiliary circuit branch also reduces reverse-recovery-related losses of the converter under CCM operation. A laboratory prototype using the popular boost PFC converter combined flyback dc/dc converter was built and tested to confirm the analysis and effectiveness of the approach.