Conventional amplify-and-forward (AF) protocol for half-duplex two-hop multiple-input-multiple-output (MIMO) relay systems assumes that the source node transmits the signal only at the first time slot. While making the source node silent at the second time slot simplifies the system design, it is strictly suboptimal. To improve the system performance, in this paper, we consider that the source node transmits signals during both time slots. We develop two novel iterative algorithms to optimize the source, relay, and receiver matrices in this new AF MIMO relay system. Both algorithms are based on the minimum mean-square error (MMSE) criterion. In particular, the first algorithm is applicable for general MIMO relay systems with multiple concurrent data streams, where the source, relay, and receiver matrices are optimized in an alternating fashion until convergence. The second algorithm is developed for MIMO relay systems with a single data stream, where the source precoding vectors and the relay precoding matrix are optimized iteratively and the receiver matrix is obtained after the convergence of the source vectors and the relay matrix. Simulation results show that compared with conventional AF MIMO relay systems, the proposed system provides better bit-error-rate performance for both multiple-data-stream and single-data-stream cases.