2.2. Metformin Attenuated the Abnormal Testicular Structure Induced by Microwave Radiation

The basic pathological changes in the rat testis after exposure to microwave radiation were characterized by loosening of the germinal epithelium, disorganization of the spermatogenic cells, vacuolation, degeneration, necrosis, and interstitial edema [9,32]. In our experiment, the most significant changes were observed 6 h after exposure to 2.856 GHz microwave radiation, and abnormalities of the testicular structure were reduced after metformin administration. As shown in Figure 2, the histological structures of the testicular tissue of the control rats were normal and clear. Compared to the control group, seminiferous tubules with loose arrangement and spermatogenic cells with vacuolation, disorganization, necrosis, degeneration, and desquamation were observed after microwave radiation. The pathological changes of testicular tissue in the R + L group were similar to those in the radiation group, but to a lesser degree. In the R + M group, a loosening of the spermatogenic epithelium and interstitial edema of the testicular tissue were observed. In the R + H group, only occasional loosening of the spermatogenic epithelial arrangement of the testicular tissue was observed.

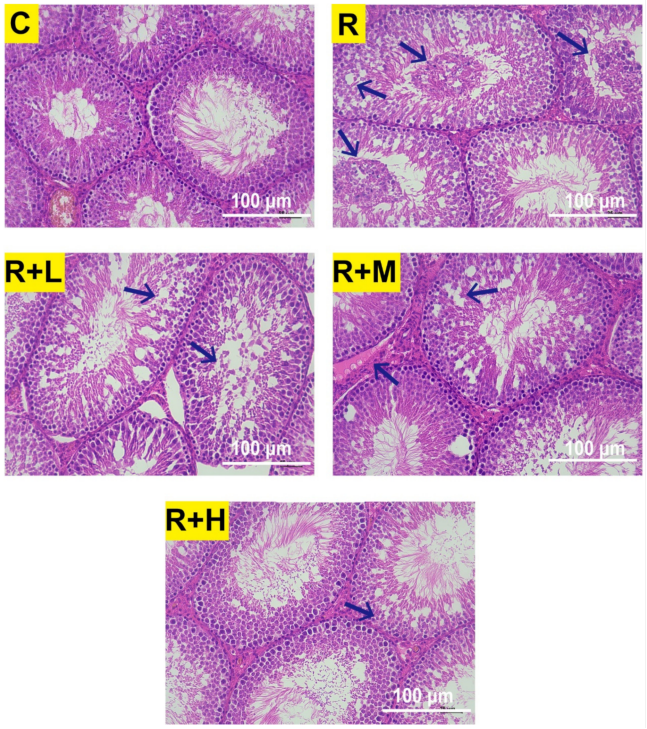


Figure 2. Metformin alleviated the abnormalities of the testicular structure caused by microwave radiation (HE staining, scale bar = 100 μm, n = 5 for each group). In the C group, normal testicular tissues were observed. The R group showed loosened structure of seminiferous tubules, disorderly arrangement, vacuolation, necrosis, degeneration and desquamation of spermatogenic cells at 6 h after microwave radiation. The abnormalities were reduced in the R + L, R + M, and R + H groups, and the R + H group had the lowest number of abnormalities. The arrows show the sites of the injuries.

Ultrastructural changes in the testis were evaluated by electronic microscopy. In spermatogonia, spermatocytes and spermatids, cytoplasmic swelling and cavitation, chromatin condensation, mitochondrial swelling and hollowing were observed 6 h after microwave radiation, and these ultrastructural alterations were significantly alleviated by metformin. As shown in Figure 3, the ultrastructure of testicular tissue of the control group rats was normal. After radiation, large edema of spermatogonia, apoptotic necrosis of spermatocytes, edema of spermatids and swollen and cavitated mitochondria were observed. In the R + L group, condensation and border shift of sperm chromatin, spermatocytes and spermatids edema, and mitochondrial swelling and cavitation were observed. The damage