TABLE 4
Intranasal Drug Delivery System.

S. No.	Formulation	Material and Methods	Observation	References?
1.	Intranasal drug delivery of frovatriptan succinate–loaded PNPs for brain targeting	Frovatriptan, poly(vinyl alcohol), poly(lactic-*co*-glycolic acid) Double emulsion (w/o/w) method	Frovatriptan-loaded nanoparticle size was found to be 264.4 ± 0.04 nm, zeta potential −35.17 ± 0.07 mV, and 65.2 ± 0.06% entrapment efficiency was obtained. Sustained release up to 72 h was achieved	[42]
2.	An enhanced charge-driven intranasal delivery of nicardipine attenuates brain injury after intracerebral hemorrhage	Chitosan, tripolyphosphate, poly(lactic acid), poly(methyl methacrylate), nicardipine, ionic cross-linking	Nicardipine particle size was found to be 439.6 ± 11.9 nm with a PDI of 0.307, and the zeta potential was +21.05 ± 0.48 mV	[43]
3.	To deliver ziconotide to cerebrospinal fluid by intranasal pathway for the treatment of chronic pain	Ziconotide acetate, chitosan, Krebs-ringer bicarbonate, acetone, hydrochloric acid	The elimination rate was found to be constant of ziconotide in cerebrospinal fluid intranasal and intravenous administration of ziconotide solution was found to be 0.54 ± 0.08 h^{-1} and 0.42 ± 0.10 h^{-1}, respectively	[44]

permeability. AR modulation leads signaling to brain endothelial cells causing opening of the BBB and facilitate permeability of the drug across the cells into the CNS. AR is used for improved drug delivery into the brain by activating A2A receptors or blocking the entry of neurotoxic agents or inflammatory immune cells into the brain [46].

3.6. Carbon Nanotubes

Carbon nanotubes (CNTs) are novel cylindrical nanomaterial consisting of hexagonal arrangement of hybridized carbon with attractive physical, chemical, and electronic properties made from graphene. CNTs have the unique property of translocating across plasma membrane, which makes it novel alternative for the delivery of the drug across BBB. The nanomeshworks of single-walled CNTs proved to show support to the neuron growth. Kafa et al. studied the penetration ability of amino-functionalized multiwalled carbon nanotubes (f-MWNT) to cross the BBB in vitro using a co-culture BBB model. Co-culture model proved the maximum transportation of 13.0 ± 1.1% after 72 h. After intravenous injection in mice, f-MWNT exhibited substantial brain uptake (1.1 ± 0.3% injected dose/g) at 5 min [47].

4. CONCLUSION

Intrathecal drug delivery system has significant approach to treat patients with the chronic pain. The new strategies for the ITDT show the effect of the delivery to increase the bioavailability and permeability through the BBB. BBB is considered to be the main barrier for the delivery of actives through the brain cell. The new strategies help in the disruption of the BBB indirectly helping in the penetration of the drug through the thick cell wall. The upcoming nanotechnology has proved its effect for the delivery of the brain through noninvasive method. The nanotechnology helps to overcome the barrier through techniques such as lipid solubility, polymer coating, small molecular weight polymer, and use of magnetic drug delivery system increasing the bioavailability of the drug. The nasal and in situ hydrogel drug delivery has proved its effect for the brain delivery. Computational fluid dynamics (CFD) is the novel forthcoming approach used to study the pharmacokinetics for ITDT. CFD is paradynamic studies used for equation solving of fluid motion to produce the data of fluid flow phenomena. Some of the recent advantages in the intrathecal pump such as Prometra pump, Synchromed II pump, and Flowonix pump proved its advantage over the traditional pump