

LETTER TO EDITOR

The zebrafish model in dental research: an alternative experimental approach for Türkiye

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ABSTRACT

Zebrafish (*Danio rerio*) is widely used in medical and biomedical research because of its rapid development, transparent embryos, genetic similarity to humans, and cost-effective maintenance. In recent years, it has also gained attention in dental research, particularly in craniofacial development, oral pathogen models, and toxicity assessment of dental biomaterials. Although its use in dental research in Türkiye remains limited, the zebrafish model may provide an ethical, economical, and translationally valuable alternative to conventional animal models.

Keywords: Zebrafish, *Danio rerio*, biomedical research, dentistry, animal model.

ÖZET

Diş hekimliği araştırmalarında zebra balığı modeli: Türkiye için alternatif bir deneysel yaklaşım

Zebra balığı (*Danio rerio*), hızlı gelişimi, embriyolarının saydamlığı, genetik benzerliği ve düşük maliyetli bakım koşulları nedeniyle tıp ve biyomedikal araştırmalarda yaygın kullanılan bir model organizmadır. Son yıllarda diş hekimliği alanında da kraniofasial gelişim, oral patojenler ve dental biyomateriyallerin toksisite değerlendirmeleri dikkat çekmektedir. Türkiye’de dental araştırmalarda kullanımı henüz sınırlı olan zebra balığı modeli, geleneksel hayvan modellerine etik, ekonomik ve translasyonel açıdan güçlü bir alternatif sunabilir.

Anahtar Kelimeler: Zebra balığı, *Danio rerio*, biyomedikal araştırmalar, diş hekimliği, hayvan modeli.

Dear Editor in Chief,

Animal models utilized in experimental research are increasingly being debated not only in terms of scientific validity but also regarding ethical compliance, cost-effectiveness, applicability, and translational value. Although rodent models have traditionally held a prominent position in medical, pharmacological, toxicological, and dental research, their high maintenance costs, prolonged experimental durations, and ethical limitations have driven growing interest in alternative model organisms. In this context, the zebrafish (*Danio rerio*) has emerged as a robust experimental model, garnering significant attention in both medical research and the field of dentistry in recent years [1].

Currently, the zebrafish model is employed across numerous biomedical disciplines, including developmental biology, genetics, toxicology, pharmacology, infectious diseases, cancer research, and regenerative medicine. Its high degree of genetic homology with humans, embryonic transparency, external fertilization, and rapid embryonic development make this model particularly invaluable for *in vivo* imaging and toxicity screening. Consequently, the zebrafish can be considered a crucial bridging model not only for fundamental sciences but also for translational research aimed at clinical application [2,3].

From a dental perspective, one of the primary applications of the zebrafish is in craniofacial development research. Owing to the transparent nature of the embryos, craniofacial cartilage and bone

development can be monitored *in vivo*, allowing for the assessment of developmental disorders associated with neural crest cells. This characteristic provides a substantial advantage in investigating cleft lip and palate, craniofacial anomalies, odontogenic developmental disorders, and developmental alterations induced by environmental or pharmacological agents [4,5].

The zebrafish model also offers a valuable platform for oral microbiology and infection research. The ability to track fluorescently labeled microorganisms *in vivo* through transparent larvae enables the real-time evaluation of host-pathogen interactions. The virulence mechanisms, biofilm-forming capacities, and responses to antimicrobial agents of oral health-related microorganisms can be investigated utilizing the zebrafish model. In this regard, the model harbors significant potential for research concerning endodontic infections, periodontal pathogenesis, and preventive dentistry.

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Another highly applicable area for the zebrafish in dental research is the assessment of toxicity and biocompatibility of dental biomaterials. Restorative materials, endodontic materials, orthodontic acrylic resins, 3D-printed dental materials, and oral care products can be evaluated on zebrafish embryos and larvae. Numerous parameters—including survival rate, hatching rate, morphological anomalies, heart rate, apoptosis, behavioral responses, and developmental alterations—can be analyzed within a short timeframe. This facilitates a critical contribution to the preliminary biological safety assessment of dental materials before their clinical application [6,7].

Nevertheless, the zebrafish model should not be regarded as a system that completely replaces mammalian models or clinical trials. A more appropriate approach is to consider this model as an effective intermediate step bridging *in vitro* assays and more complex animal studies or clinical research. Thus, researchers can rapidly and systematically screen the potential risks of materials or biological agents before advancing to more costly and ethically sensitive experimental phases.

Although there are existing studies utilizing zebrafish in the field of dentistry in Türkiye, the application of this model remains limited [8–10]. However, there is a substantial need to further promote this model within the country. In particular, establishing interdisciplinary collaborations between dentistry and basic medical sciences could contribute to the more effective utilization of the zebrafish model in dental research.

In conclusion, the zebrafish is a well-established model organism in medical and biomedical research and is gaining increasing traction in dentistry as a robust experimental platform. The broader adoption of this model in Türkiye could contribute to the design of experimental research that is more ethically sensitive, economically viable, and scientifically efficient.

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