The convergence of regenerative sciences: a cross-disciplinary approach to skeletal reconstruction

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Introduction

Bone regeneration is a biologically regulated process critical to multiple dental and surgical disciplines, including orthopedics, maxillofacial surgery, prosthodontics, orthodontics, and periodontal surgery. Despite variations in anatomical location and biomechanical requirements, successful skeletal reconstruction relies on the coordinated progression of inflammation, angiogenesis, osteogenesis, and remodeling. While technological advancements have enhanced clinical precision, biological capacity remains the principal determinant of regenerative outcomes.

Objective

This review systematically evaluates shared biological principles, biomaterials, and regenerative technologies across orthopedic and dental-surgical disciplines, emphasizing interdisciplinary translational integration using a defined methodology.

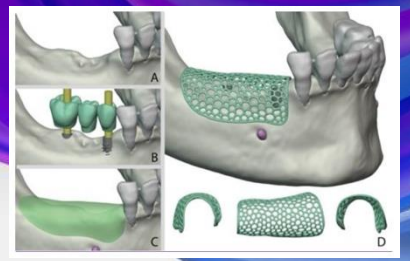


Fig.2 represents the step of designing the customized mesh: (**A**) the initial situation with the defective bone; (**B**) the proposed implant placement in the defected ridge; (**C**) the defective ridge was augmented to estimate the required volume of augmentation; (**D**) the final design of the customized mesh to accommodate the required augmentation volume with the required design.

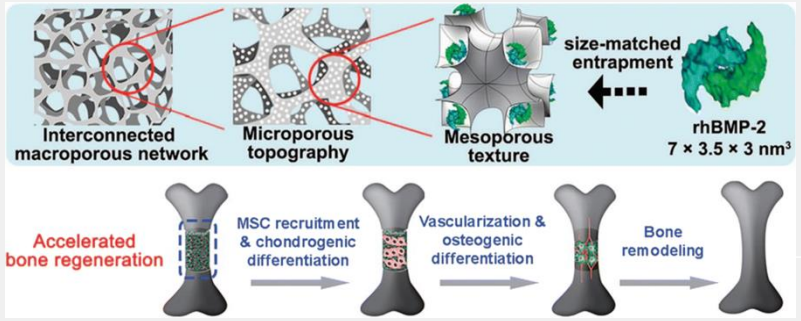


Fig.1 Schematic presentation of macro/micro/nano-porous scaffold loaded with active biomolecules for accelerate bone regeneration (Yi et al., 2016)

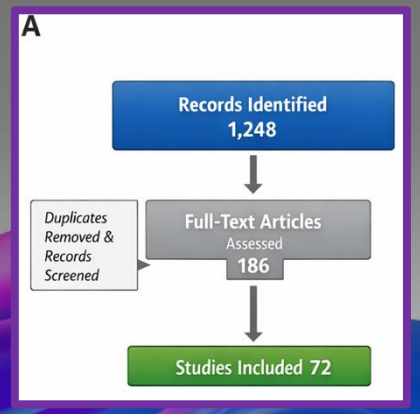
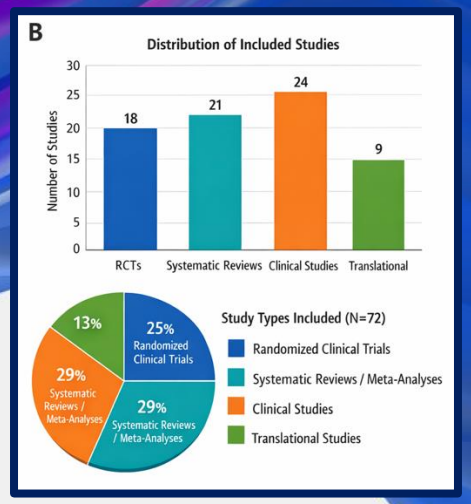


Fig.3 Distribution of included studies



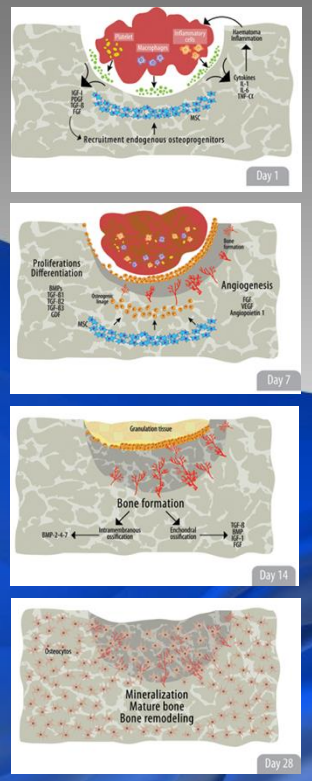


Fig.4 Bone healing process

Material and Methods

A structured literature review was conducted using PubMed, Scopus, and Web of Science databases for peer-reviewed publications between 2005 and 2025. Keywords included "bone regeneration," "orthopedic reconstruction", "maxillofacial surgery", "prosthodontics", "orthodontics", "periodontal regeneration", "biomaterials", "mesenchymal stem cells", "BMP", and "digital surgical planning". Clinical trials, systematic reviews, meta-analyses, and translational experimental studies involving appendicular and craniofacial models were included.

Results

The database search yielded 1,248 records, of which 186 full-text articles were assessed for eligibility. After applying inclusion criteria, 72 studies were included: 18 randomized clinical trials, 21 systematic reviews/meta-analyses, 24 prospective or retrospective clinical studies, and 9 translational experimental investigations.

Conclusion

Autologous bone remains the gold standard; however, synthetic scaffolds, biologics (PRF, PRP, BMP-2), and mesenchymal stem cells enhance regenerative predictability. Digital planning and 3D technologies increase precision but remain biologically dependent.

Biologically guided, technology - enhanced regenerative protocols—incorporating autologous grafts, growth factors, and 3D-printed scaffolds—are transforming orthopedic and dental practice, with interdisciplinary collaboration improving predictability in patient - specific skeletal reconstruction.