Journal of Autonomous Intelligence (2023) Volume 6 Issue 2
doi: 10.32629/jai.v6i2.681

MINI REVIEW

Applications of Artificial Intelligence in the field of therapies focused on orofacial cleft repair and rehabilitation

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ABSTRACT

Orofacial clefts are common congenital malformations with genetic and environmental risk factors. The management of cleft lip and palate spreads over the course of the child's development into adulthood. Currently Artificial Intelligence (AI) has gained much popularity in the dental field. AI is of much help in the multidisciplinary management of cleft lip and cleft palate repair starting right from the prenatal period itself. This review focuses on the available documentation in the literature that has thrown light on the recent applications of AI in cleft lip and palate cases.

Keywords: orofacial clefts; dentistry; Artificial Intelligence

ARTICLE INFO

Received: 2 June 2023
Accepted: 28 June 2023
Available online: 31 July 2023

1. Introduction

Cleft lip with or without cleft palate, and cleft palate alone, are collectively referred to as orofacial clefts[1]. Cleft lip is characterized by a partial or complete fissure of the upper lip. It can be unilateral or bilateral. In bilateral cleft lip, a median remnant of the philtrum is present. The cleft lip can extend through the gum, but not beyond the incisive foramen. If the cleft extends further backwards into the secondary palate it becomes a cleft lip with cleft palate. Unilateral cleft lip is common than bilateral cleft lip. Left-sided cleft lip is more common than right-sided cleft lip. Cleft palate is characterized by a fissure in the secondary palate. It can involve the soft palate only or both the hard palate and the soft palate. The cleft can be narrow (V-shaped) or wider (U-shaped)[2].

Orofacial clefts are common congenital malformations with genetic and environmental risk factors[3]. All orofacial clefts (cleft lip, cleft palate, and cleft lip with cleft palate) have similar non-genetic risk factors. Non-genetic risk factors for cleft palate include maternal smoking, alcoholism, use of certain medications (barbiturates, valproate, topiramate), obesity and high fever. Additional risk factors include pregestational diabetes, folic acid antagonists, and systemic steroids.

Cleft lip occurs with a birth prevalence of approximately 3.5 per 10,000 births (or approximately 1 in 3000 births). Prevalence of cleft lip has been reported as higher in some Asian groups and possibly lower in people of African ancestry. Cleft palate occurs with a birth prevalence of approximately 6 per 10,000 births (or approximately 1 in 1500 births), but with a very wide variation in different studies and populations. Variability appears to be ethnicity, with higher prevalence in people of Northern European, Native American/First People, and Asian ancestry[4].

The management of cleft lip and palate spreads over the course of the child's development into adulthood[5,6]. The special needs of children with clefts are best served by a dedicated craniofacial team. This team is composed of nurses, dentists (orthodontists, oral surgeons, prosthodontist) otolaryngologists, geneticists, speech therapists, radiologists, psychologists, feeding specialists, and plastic surgeons. The dentist is responsible for encouraging good dental hygiene. The orthodontist manages tooth alignment and palatal expansion, often in preparation for orthognathic procedures for the oral surgeon. Both may be involved in presurgical molding of the cleft lip prior to surgical repair. While a prosthodontist replaces teeth and makes dental and alveolar molding devices.

Currently Artificial Intelligence (AI) has gained much popularity in dental field. Hence, there is no doubt that AI will be of much help in the multidisciplinary management of cleft lip and cleft palate repair starting right from prenatal period itself (**Figures 1–3**). This review focuses on the available documentation in literature that has thrown light on the recent applications of AI in cleft lip and palate cases.

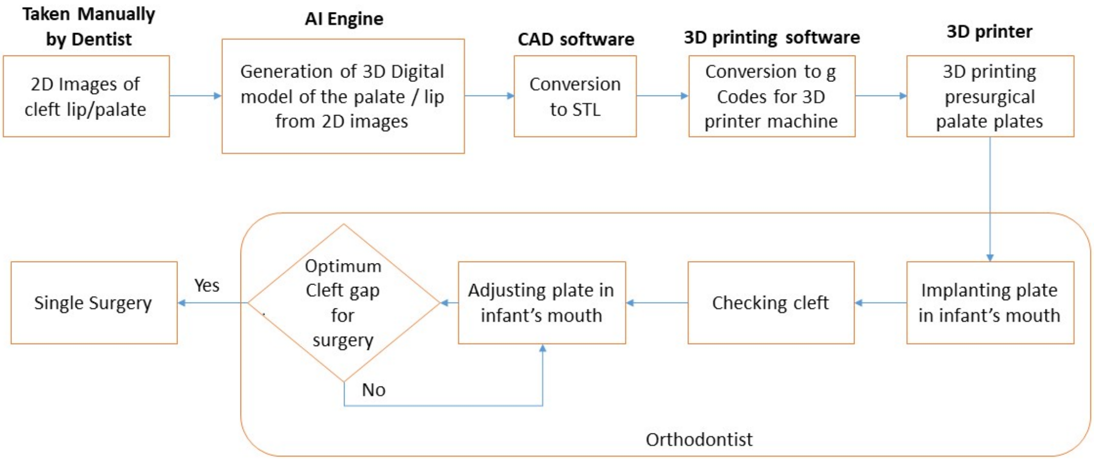

Figure 1. Application of AI in cleft lip/palate management using 3.D printed plates.

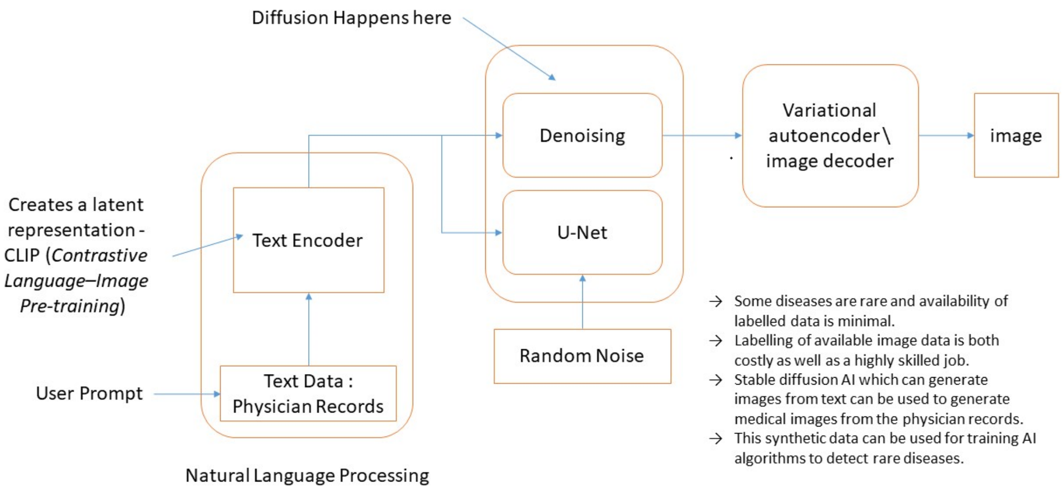

Figure 2. Medical radiography image data augmentation using stable diffusion for augmenting datasets of rare diseases.

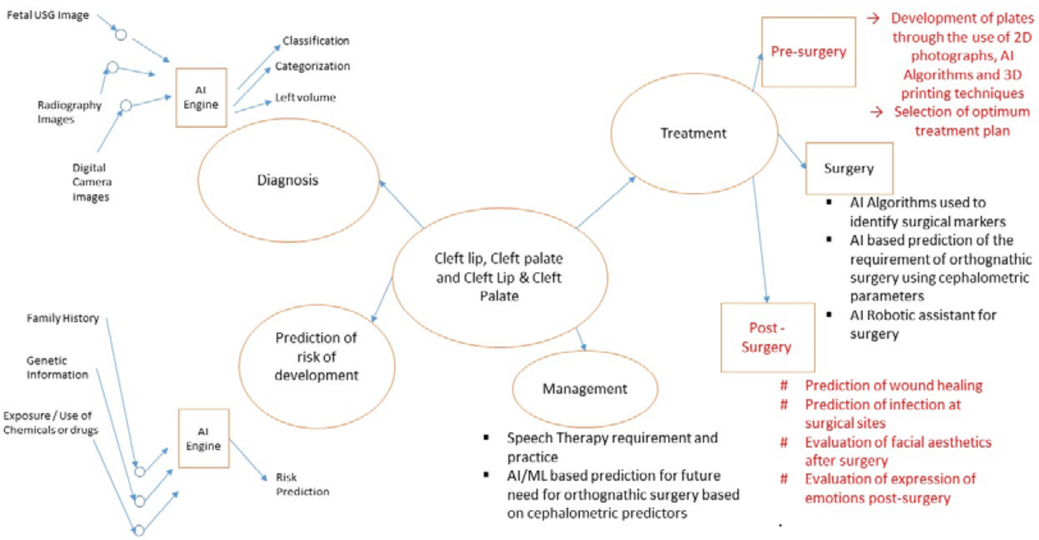

Figure 3. AI/ML in cleft lip/cleft palate prediction, diagnosis, treatment and management.

2. Recent trends in the applications of AI in the field of therapies focused on cleft lip and cleft palate repair and rehabilitation

A systematic review on the clinical applications of Artificial Intelligence and Machine Learning in children with cleft lip and palate was conducted by Huqh et al.[7] in 2022. The objective was to explore the current clinical applications of AI/ML (Artificial Intelligence and Machine Learning) techniques in diagnosis and treatment prediction in children with CLP (cleft lip and palate) and to create a qualitative summary of results of the studies retrieved. 12 papers were included in the review. They concluded that Artificial Intelligence employed in AI-enabled computerized programming software can help for accurate landmark detection, rapid digital cephalometric analysis, clinical decision-making, and treatment prediction. In children with corrected unilateral cleft lip and palate, ML can be of very use to detect cephalometric predictors of future need for orthognathic surgery.

Chen et al.[8] proposed a novel approach to provide a guidance image for cleft lip surgery by masking the cleft lip part and generating lip and nose without cleft. They designed a multi-task image inpainting model that can better protect patient privacy. It was a deep Machine Learning image inpainting method that is capable of covering a cleft lip and generating a lip and nose without a cleft. They collected two real-world patient datasets to demonstrate the feasibility of proposed approach. Three expert cleft lip surgeons assessed that their design outperforms state-of-the-art methods in both valid possibility and image quality, while the performance of another model on Celeb A also suppresses the state-of-the-art facial inpainting counterparts.

A study done by Patcas et al.[9] in 2019 evaluated the facial attractiveness of frontal and profile view of 20 cleft patients who had undergone treatments and compared them with controls by using the aid of Artificial Intelligence (AI) and comparing these results with panel ratings performed by common man, orthodontists, and oral surgeons using a visual analogue scale. The convolutional neural networks used in this study was trained on >17 million ratings for attractiveness. AI evaluation of cleft patients was comparable to human ratings but was not statistically different. Facial attractiveness of controls was rated significantly higher by humans than AI. The variance observed in panel ratings revealed a large imprecision and the authors explained that it may be due to absence of unity. The authors concluded that AI could become a helpful tool to describe facial attractiveness, but important adjustments are needed on AI models, to improve the interpretation of the impact of cleft features on facial attractiveness.

As the discovery of genetic variants associated with complex diseases increases, the demand for personalized health care services using genetic information is also rapidly increasing. To overcome the limitations of regression-based PRS and conventional ML algorithms, Artificial Intelligence (AI) has recently begun to be applied to risk prediction and the early diagnosis of complex diseases. Unlike traditional Machine Learning algorithms, deep learning is helpful in solving complex problems with far more parameters but requires a large-scale dataset. The genetic algorithm (GA) is a promising method for optimizing feature selection. Tong and Schierz[10] in 2011 have successfully applied a hybrid genetic algorithm neural network (GANN) to extract highly informative genes from a microarray-based gene expression dataset. In a separate study, Zhang et al.[11] in 2015 improved the performance of predicting immunogenic T-cell epitopes from epitope sequences through the use of an ensemble RF model that was trained on individual features selected with GA.

A Korean case-control study by Kang et al.[12] in 2023 on non-syndromic cleft lip (NSCL) with or without cleft palate (NSCL/P), compared the predictive performance of different models of AI. Models that were developed by using the genetic-algorithm-optimized neural networks ensemble (GANNE) technique was compared with other models generated by eight conventional risk classification methods, including polygenic risk score (PRS), random forest (RF), support vector machine (SVM), extreme gradient boosting (XG Boost), and deep-learning-based artificial neural network (ANN). GANNE, which is capable of automatic input single nucleotide polymorphism (SNP) selection, was functionally validated and exhibited the highest predictive power. The authors concluded that GANNE is an efficient disease risk classification method using a minimum optimal set of SNPs; however, further validation studies are needed to ensure the clinical utility of the model for predicting NSCL/P risk. This study represents the first application of the GANNE approach to disease risk assessment and the first genetic risk prediction study for NSCL/P in the Korean population. GANNE, a deep-learning-based approach for disease risk classification, has shown promise in overcoming the sample size limitations of population-based genetic association studies by utilizing genetic algorithms to select the optimal set of SNP markers.

3. Conclusions

With the advent of Artificial Intelligence, the day is not far when we can predict the chances on cleft lip or cleft palate development in child through susceptible parents. Much focus and research is still needed in this aspect. Technological advances and their clinical applications can best be integrated in this regard especially for early identification and management of orofacial clefts in a very cost-effective manner.

Author contributions

Conceptualization, RR and SGN; methodology, SGN; software, PS; validation, RR, SGN and PS; formal analysis, RR; investigation, SGN; resources, PS; preparation, SGN; writing—review & editing, RR, SGN and PS; visualization, RR; supervision, PS and SGN.

Conflict of interest

The authors declare no conflict of interest.

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