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Artificial intelligence-based imaging analysis of stem cells: a systematic scoping review protocol

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Method Article

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Abstract

Objective: This scoping review aims to map and identify the available artificial intelligence-based imaging analysis of different stem cells types and characterization of stem cells differentiation and transdifferentiation pathways.

Introduction: Stem cells are cells that can transform into more specialized cells and include pluripotent, embryonic, and adult subtypes. They are currently receiving huge attention due to the advancing technology of artificial intelligence(AI), a field that has found its way into many disciplines and reaching clinical settings. AI adopts multiple algorithms such as machine learning (ML), and the more useful deep learning (DL) as it provides convolutional neural networks (CNNs) capable of characterizing various stem cell differentiation pathways and classifying images based on their morphology, textures, and physical features thus allowing for future clinical utilization in regenerative medicine.

Methods: Five different electronic databases (PubMed, Medline, Web of Science, Cochrane, and Scopus) will be searched, based on a specific searching strategy, for published studies investigating the artificial intelligence-based imaging analysis technique on various types of stem cells. Two independent reviewers will be screening the titles and abstracts of the collected studies, stored in Zotero 5.0, against the inclusion criteria; all potential studies will be subjected to a second examination for the full text before the final decision. Afterward, data will be extracted from the included articles and presented in a table.

Introduction

Therapeutic regimens in regenerative medicine are witnessing an unprecedented interest in stem cells. Stem cells are undifferentiated human cells capable of self-renewal division, as creating more cells, setting the foundation for a pool of unspecialized stem cells. Such division generates two cells where one maintains its self-renewal ability while the other becomes more differentiated into a special type of cell[1]. Stem cells are organized into three categories, induced pluripotent stem cells (iPSCs), embryonic stem cells (ECSs), and adult stem cells (ACSs)[2]. Both iPSCs and ECSs fall under the category of pluripotent stem cells (PSCs) that are characterized by their ability to differentiate into the three germ cell layers.

While ESCs can differentiate into all the germ layer derivatives, the endoderm, mesoderm, and ectoderm, iPSCs are reprogrammed somatic cells generating pluripotent patient-specific cell lineages capable of aiding model human diseases[3]. Unlike iPSCs and ECSs, ACSs have a lower differentiation level, termed multipotent, and hence, differentiate into more tissue-specific stem cells[4]. ACSs are rare undifferentiated cells spreading within the body that transform from their quiescent state into proliferative and dividing cells when naturally dying cells are to be replaced.

Artificial Intelligence (AI) is a computer engineering and science advancing field already implemented in multiple disciplines such as home automation, robotics, health care, agriculture, banking, and transportation[5]. AI has achieved such momentum by mimicking human cognitive intelligence in multiple

areas, including face and speech recognition. Currently, AI is further advanced by deep learning (DL) and machine learning (ML) in numerous domains like text analysis, autonomous automobiles, image classification, and medicine[6]. Its role in medicine has been tremendous due to its ability to analyze complex medical data and utilize meaningful connections within a dataset to produce results that can help in diagnosis and outcome prediction[7].

In the context of artificial intelligence (AI), stem cell research has gained massive traction in recent years. AI has been utilized in multiple forms, including the DL algorithm, a subset of ML in which the human neural circuit is simulated into a digital multilayered neural network, convoluted neural networks (CNNs), capable of automatically obtaining the features of a specific image[8]. The branch of induced pluripotent stem cells (iPSC) in the field of regenerative medicine has mainly witnessed the merits of AI technology by facilitating the process of image classification through CNNs[8]. Basic data from image features are processed by CNNs, where the image passes through a series of convolutional layers followed by layers of feature extraction and, finally, the classification layers. These layers are responsible for identifying the basic structures, such as lines, blobs, and edges present in the image[9]. Therefore, in this review, we highlight the analysis of stem cell imaging under the field of AI covering multiple algorithms and techniques utilized in clinical settings. Moreover, the possibilities of application of AI in the characterization of various pathways of stem cells differentiation were also presented.

Review Question:

What are the available applications of AI-based imaging analysis for various types of stem cells?

Inclusion and exclusion criteria:

The inclusion criteria have been set based on the mnemonics PCC[1] (Population, Concept, and Context). Additionally, the type of study, language of publication, and date will be considered.

Inclusion criteria:

- Studies involving any type of Stem cells (iPSCs, ECSs, and ACSs, PSCs)
- Studies using AI-based imaging analysis
- Published studies in any language and the full text is accessible
- No date restriction

Exclusion criteria:

- Studies investigating different types of cells rather than stem cells
- Studies using AI technology for other purposes than imaging analysis
- Preprints, reviews, and conference papers
- Full text not accessible

Methods

The proposed systematic review will be conducted in accordance with JBI (Joanna Briggs Institute) methodology for scoping review[1] and PRISMA- ScR(Transparent Reporting of Systematic Reviews and Meta-analyses extension for Scoping Reviews) Checklist[11].

Search strategy: The search strategy will collect all published articles related to the review question. A primary limited search to MEDLINE (PubMed) has been already conducted to identify relevant articles, the title and abstract have been analyzed in order to develop the searching strategy based on the implemented words. A complete search strategy for MEDLINE (PubMed) is stipulated in table 1. Afterward, the searching strategy will be developed based on the results of the primary phase and it will be customized for each included information source. Add to the electronic searching strategy, reference lists of all the included data will be screened for additional articles.

Source of information: Data will be collected electronically from five different databases (PubMed, Medline, Web of Science, Cochrane and Scopus) and manual searching.

Study selection:

The retrieved articles from the database search will be uploaded into Zotero 5.0 (Corporation for Digital Scholarship, Virginia, USA) library, and all duplicates will be removed. Two independent reviewers (Issa Julien and Abou Chaer Mazen) will be screening the collected data against the inclusive criteria after a pilot test of the method. The potential articles resulting from the primary screening will be kept, and the full text will be assessed in detail according to the inclusive criteria by the two independent reviewers, in case of exclusion reasons will be recorded and reported in the systematic review. Any disagreements that arise between the reviewers at any stage of the process will be resolved through discussion or with a third reviewer (Dyszkiewicz Konwinska Marta).

Data extraction:

Data will be extracted from the included studies by one reviewer (Abou Chaer Mazen) and evaluated independently by the second reviewer (Issa Julien), any disagreement between them will be resolved by discussion or by the opinion of third reviews (Dyszkiewicz Konwinska Marta). The data extraction tools have been developed based on JBI methodology for scoping review[1]. The extracted data will include studies author(s), year of publication, study location, the aim of the study, sample size, used algorithm, and findings (Table 2).

Data Synthesis:

The extracted data will be presented in tables relying on the data extraction table tools. The results will be accompanied by a narrative synthesis approach demonstrating the relationship between the results and the review objectives.

Declarations

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Conflict of interest:

The authors declare no conflict of interest

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Tables

Tables 1-2 are available in the Supplementary Files section.

Supplementary Files

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