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Predictability of Kvaal's method in dental age estimation

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ABSTRACT

Background

Estimation of age in individuals has received considerable attention in forensic literature. Laccasagne in 1889 was the first to use changes in teeth of adult to estimate age. The application of radiography in forensic sciences was introduced in 1896, just few months after the discovery of X-ray by Reontgen. Dental radiography has been employed in age estimation since 1982. Teeth are considered to be best tool for age estimation, because teeth may be preserved long after all other tissues, even bone have disintegrated. In 1995, Kvaal et al developed a new method of dental age estimation based on relationship between age and the pulp size.

Objective

To evaluate the reliability of Kvaal's method in dental age estimation.

Methods

Electronic search of scientific papers was carried out in Pubmed Advanced, Science direct, Cochrane, Ingenta connect databases using specific keywords.

Conclusion

Review of the articles suggest that Kvaal's method can be considered as one of the radiological methods of age estimation in adults and the results of the included studies showed the difference between chronological age and estimated age is higher.

Keywords: Dental age estimation, Kvaal's method, radiological methods, Adults, human

INTRODUCTION

Forensic Odontology or Forensic Dentistry is the study of the teeth and jaws as evidence of law[1]. The first treatise on Forensic Odontology was written by Dr.Oscar Amoedo in 1898 and was entitled L'Art Dentaire en Medicine Legale and he is considered as the father of Forensic Odontology[2]. An increasing demand for age calculation in living persons exists specially in a multicultural society where legal and illegal immigration is rising and also to determine the quantum of punishment delivered to the accused wherein minority/majority status hinges, thus age calculation has become increasingly important in forensic sciences[3,4,5] . The use of dentition for age assessment appears to date back to the early years of the nineteenth century[6]. A dental implication in age assessment was first published by Saunders by presenting a pamphlet "Teeth a Test of Age"[7].

First scientific method for age determination using teeth was given by Gustafson in 1950[8] and first radiographic method of age determination based on the formation of dentin was given by Philipas[9]. Because of its less variability, teeth can be inspected clinically in living individuals and are less susceptible to nutritional changes, dental age estimation has gained importance compared to other maturity indicators like skeletal and sexual[10]. Radiographic methods of age estimation are non-invasive and hence they gained more attention compared to other methods like morphological, histological and biochemical methods, since some of these methods require extraction, time-consuming and expensive [8,11,12,13]. In 1994 Kvaal and Solheim presented a method of age estimation which combined radiological and morphological measurements, but dental extraction was required hence Kvaal et al in 1995 developed a new method for age estimation based on the relationship between age and the pulp size [14,15] .

Various features used in the radiographic age determination includes jaw bone pre- natally, appearance of tooth germs, degree of crown completion, eruption of the crown in the oral cavity, degree of root completion of erupted and unerupted teeth, degree of resorption of deciduous teeth, volume of pulp chamber and root canals/formation of physical secondary dentin etc[15,16,17,18]. Age estimation is grouped into three phases[19,20,21]

1. Pre-natal, neonatal and post-natal,
2. Children and adolescent
3. Adults.

Method of age estimation in adults include

Volume assessment of teeth – pulp/tooth ratio method by Kvaal

Coronal pulp cavity index

Development of third molar- Harris and Nortje method

Van Heerden system[22,23,24,25]

In Kvaal's method pulp/tooth ratio of monoradicular teeth like maxillary central incisor, lateral incisor, second premolar and mandibular lateral incisor, canine, first premolar were selected and from each tooth pulp-root length(R), pulp-tooth length(P), tooth-root length(T), pulp-root width at cemento-enamel junction(A), pulp-root width at mid-root level(C), pulp-root width at midpoint between levels C and A(8) .

The aim of this Systematic review is to determine the reliability of Kvaal's method in dental age estimation in adult population.

MATERIALS AND METHODS

An electronic data search was carried out in PUBMED(Advanced) using the key words " human, adult, adolescents, middle aged, geriatrics, dental , teeth, tooth, age determination , age assessment , age estimation , age identification, radiographic methods, radiological methods, pulp/tooth area ratio , Kvaal's method. Other search include Science Direct, Cochrane, Ingenta connect and hand search. The article search included only those listed in English literature published between 1995 to 2014.The search results were short listed using preset inclusion and exclusion criteria. The articles were screened on the basis of title and abstract. Full text was then procured for the relevant articles which fulfilled the inclusion criteria like studies on age estimation in human adults using Kvaal's method, studies which included only those teeth considered in original Kvaal's method[maxillary- central incisor, lateral incisor, second premolar and mandibular- lateral incisor, canine, first premolar]. Studies which used other radiological methods of age estimation were excluded.

RESULTS

The search methodology used in this review revealed 531 publications of which 12 articles were included and the remaining articles were excluded from the review. The general information of selected articles are tabulated based on the population, imaging technique, teeth used, standard error of estimate(table1) and the results of the included studies in table 2 respectively. The tooth/ teeth which were found to be reliable in each study, sample size of included studies and the imaging modalities used in various studies are shown in graph1, 2 and 3 respectively.

DISCUSSION

Total of 531 studies were found in electronic and manual searches, of which 514 studies were excluded based on inappropriate title and content of the abstract. For further evaluation 17 studies were retrived and further of 3 studies were excluded going through full text which is found to be irrelevant to the study and 2 studies were repeated in pubmed and Science direct searches. Excluding all these total of 12 studies were finally included in this systematic review.

The 12 included studies have compared Chronological Age and the Estimated Age and the result was mentioned as either Standard Error of Estimate (SEE) or given as a value of R^2. In few studies specific tooth is given as a good predictor of age and in few studies the ratios were specified as a reliable predictor. The included studies were done in different population including Norwegian, Spanish, Turkish, Australian, and Indian and with age range of 15-87 years. The sample size in each included studies were 100 and above, except in three studies done by Ridhima Sharma et al , Nitin

Agarwal et al, Neelampari Parikh et al where the sample size was 50, 50, 30 respectively. The various imaging modalities like conventional IOPA, Digital IOPA, OPG, Digital OPG were used in different studies and in the first study done by Kvaal et al conventional IOPA was used. Of the 12 included studies Digital OPG was used in maximum of 5 studies, followed by Digital IOPA in 3 studies, OPG in 2 studies and conventional IOPA in 2 studies. In 9 out of 12 included studies 6 teeth were used for age estimation, in two studies central incisor was used and one study has used 3 mandibular teeth.

CONCLUSION

In this systematic review all included articles showed the feasibility of Kvaal's method for dental age estimation in various population worldwide. In most of the studies 6 teeth were used for age estimation as done in original Kvaal's method except few studies were maxillary central incisor and 3 mandibular teeth alone were used. The results of the included studies showed the difference between chronological and estimated age with a minimum range of ± 5.49 years in a study done by Neelampari Parikh, Gunjan Dave to a maximum of ± 11-14years in a study done by Preeti kanchan Talreja, Ashith B.Acharya. Out of 12 studies maxillary central incisor and lower first premolar (in 3 studies each) was proved to be a better indicator of age.

Since the rate of secondary dentin deposition is influenced by environmental and genetic factors, the regression formula derived for one population sample does not fit the other, hence the population specific formula should be derived for each population. It was noted that from the included studies that most of them were carried out after 2010. To find out the accuracy of each radiographic methods of age estimation, systematic review on each method has to be carried out. From the review of included studies it can be considered that Kvaal's method can be considered as one of the radiographic methods of age estimation and not the reliable one.

SUMMARY

Age estimation is at most important as it gives an identity of the individuals in situations like mass disaster, in medico legal cases for commencement of judgment, where the victim tries to escape saying juvenile. In recent times the focus on age estimation is markedly increasing worldwide because of the increase in crime rate and mass disasters, hence looking for the accurate method of age estimation.

So far Kvaal's method has been done using various two dimensional imaging modalities, future research using three dimensional imaging modalities like CBCT is recommended hoping for further better result.

GENERAL INFORMATION OF SELECTED ARTICLES [TABLE 1]

S.no	Journal	Author	Year	population	Imaging tech	Sample & Age range	Tee
1	Forensic science international	Sigrid I. Kvaal, Kristin M.Kollveit et al[11]	1995	Norwegian	IOPA (paralleling technique)	100(20-87)	All
2	Forensic science international	Nathalie Bosmans et al[3]	2005	Belgian	OPG	197(19-75)	All
3	Int J Legal Med	M.I. Landa, P. M.Garamendi[26]	2009	Spanish	digitalOPG	100(14-60)	mar
4	Journal of Forensic Dental Sciences	Ridhima Sharma, Srivastava A[27]	2013	Indian	Digital IOPA(RVG)	50(15-60)	All
5	Dentistry	Rupa chandramala[28]	2012	Indian	Digital OPG	100(20-70)	All
6	Forensic science international	Humeyra Ozge Erbudak et al[29]	2012	Turkish	Digital OPG	123 (14-57)	All
7	Archives of oral biology	Preeti kanchan Talreja,Ashith B.Acharya[30]	2012	Indian	Digital IOPA (Group A-paralleling technique and Group B-bisecting angle technique)	100(25-77) Group A-47, Group B-53)	All
8	Journal of Forensic Dental Sciences	Nitin Agarwal et al[31]	2013	Indian	IOPA	50 (20-70)	Ma c i
9	Journal of Forensic Dental Sciences	Piyush G.Limdiwala[32]	2013	Indian	Digital OPG	150(20-55) Group A-Kvaal's criteria, Group B- without Kvaal's criteria	All
10	BUJOD	Neelampari Parikh, Gunjan Dave[33]	2013	Indian	Digital OPG	30(15-60)	6

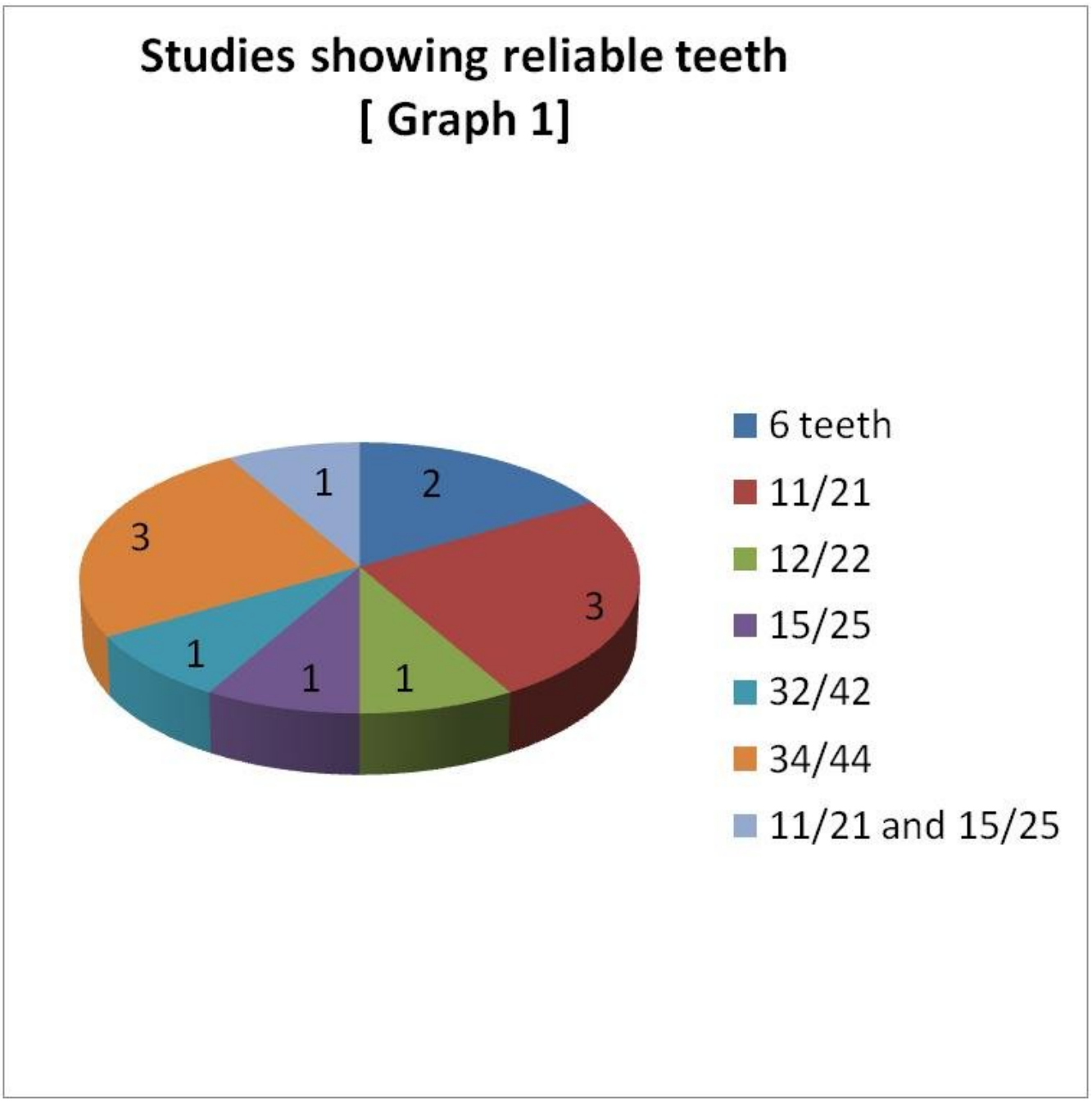
S.no	Journal	Author	Year	population	Imaging tech	Sample & Age range	Tee
11	Forensic science international	Shalmira Karkhanis,Peter Mack,Daniel Franklin[34]	2014	Australian	OPG	279(males-136,females-143). Age range:males-20-62,females-20-73	All
12	Journal of Forensic Dental Sciences	Shruthi K.Patil et al[35]	2014	Indian	Digital IOPA	200(20-50)	Ma c i

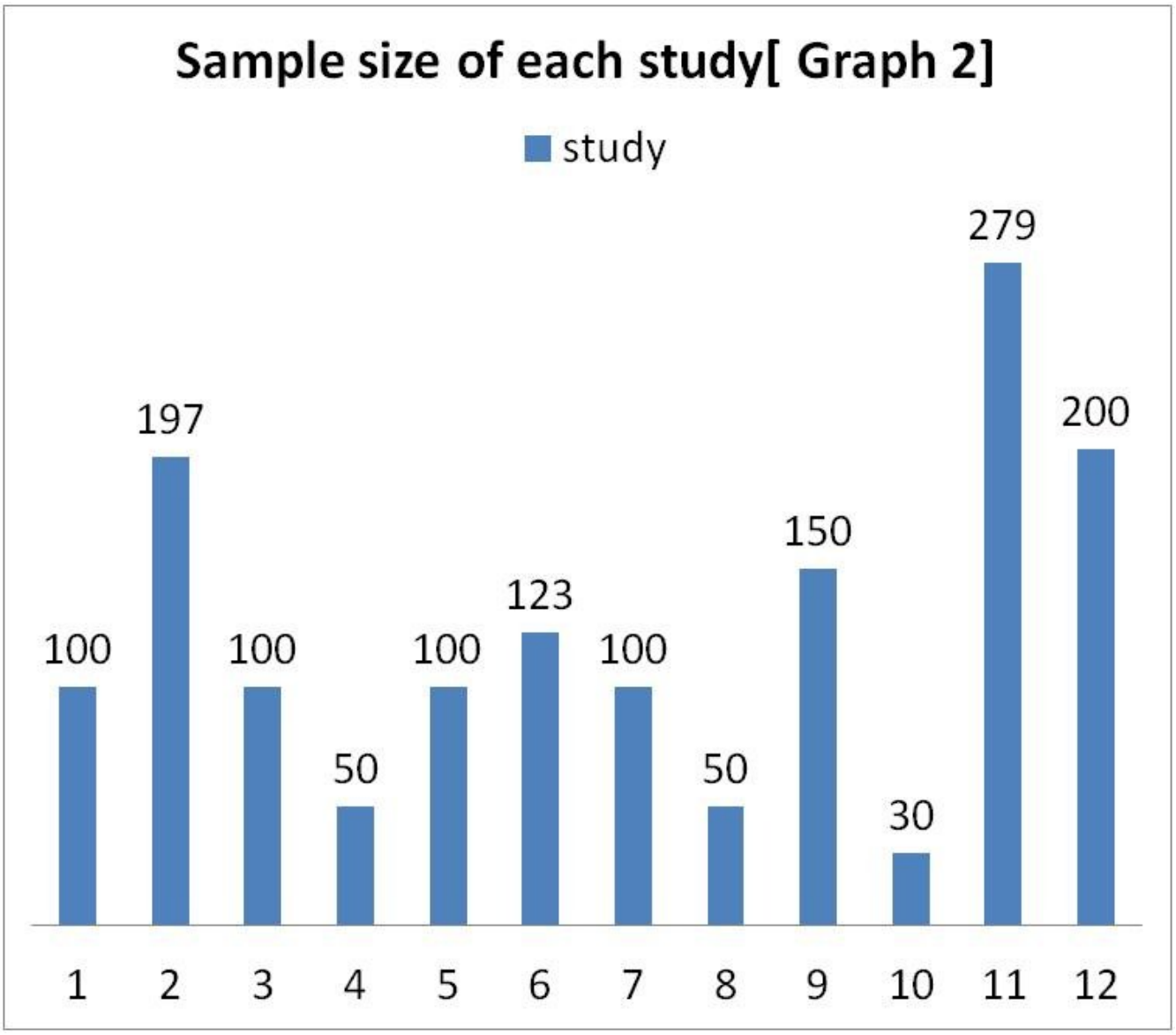
RESULTS OF INCLUDED STUDIES [TABLE 2]

S.no	Author	Results
1	Sigrid I. Kvaal, Kristin M.Kollveit et al	Tooth length and root length are not significantly correlated with age. Correlation between age and most of all the ratios for each type of tooth was stronger (r^2-0.76) than correlation between age and each ratio separately
2	Nathalie Bosmans et a	Correlation between chronological age and ratio T were not significant and correlation of the difference between W and L were also not significant. S.E.E was lower for mandibular first premolar(8.1 years)
3	M.I. Landa, P. M.Garamendi	Best Correlation was observed for ratio B(ratio between width of pulp an root at level B)from lower first premolar teeth.
4	Ridhima Sharma, Anurag Srivastava	R^2 was strongest (0.198) for lower first premolar indicating that the age can be estimated better with this particular tooth.
5	Rupa chandramala	Upper second premolar is a better indicator of age with r^2(0.385), followed by upper central incisor r^2(0.289)
6	Humeyra Ozge Erbudak et al	R^2 was strongest (0.345) for lower lateral incisor indicating this tooth as a better predictor of age.
7	Preeti kanchan Talreja,Ashith B.Acharya	Group A- R^2 was strongest(0.34) for Upper second premolar Group B- R^2 was strongest(0.44) for Upper central incisor. Under estimation of age was noted in both the groups of this study .
8	Nitin Agarwal et al	Except for length variables, all other morphological parameters showed a significant correlation with age. Upper central incisor is predicted as a better indicator of age.
9	Piyush G.Limdiwala	Group A- r^2 was strongest(0.29) when using all 6 teeth Group B- r^2 was strongest(0.12) when using all 6 teeth
10	Neelampari Parikh, Gunjan Dave	R^2 was strongest for upper lateral incisor (0.522), indicating this tooth as a better predictor of age in population of Gujarat.
11	Shalmira Karkhanis,Peter Mack,Daniel Franklin	R^2 was higher for upper central incisor(0.135) followed by upper second premolar
12	Shruthi K.Patil et al	S.E.E was ± 6.5years

Abbreviation: S.E.E - Standard Error of the Estimate

Titles and Legends of figures




Sample size of each study[Graph 2]
study
100
197
100
50
100
123
100
50
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279
200
1
2
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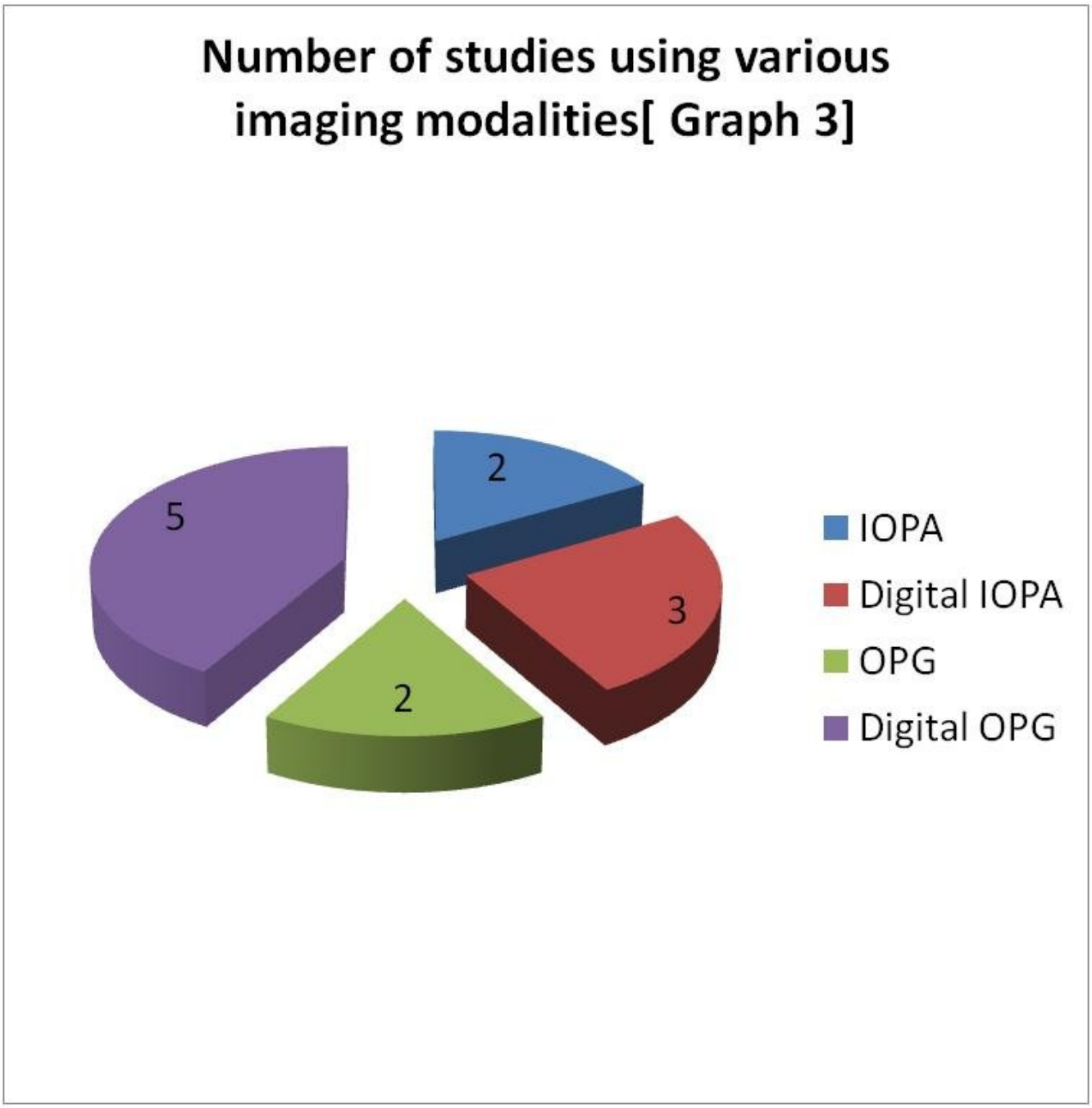

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