Original Article

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Evaluation of error types seen in digital panoramic radiographs

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ABSTRACT

Aims: This study aimed to assess the prevalence of different types of errors in panoramic radiography and explore potential correlations between these errors, age, and gender.

Methods: A total of 2000 panoramic radiographs randomly selected from the patient archives of the Department of Oral, Dental, and Maxillofacial Radiology at Dicle University Faculty of Dentistry, taken in 2023 for various indications, were analyzed. Two experienced radiologists (BK and EK) reviewed the digital panoramic X-ray images. Interobserver agreement was assessed by having both observers re-evaluate 10% of the sample. Patients with developmental anomalies, history of trauma, orthognathic surgery, maxillofacial pathology (e.g., tumors/cysts), and those under 16 years old were excluded. Statistical analyses were conducted using SPSS 20.0 software (IBM Corp., Armonk, NY, USA), with a significance level set at α=5%. Cohen's kappa statistics were utilized to calculate intraobserver agreement.

Results: In the analysis of 2000 panoramic radiographs, it was found that 81.16% exhibited at least one error. The predominant error identified was the misplacement of the tongue against the palate, accounting for 34.75% of cases. A statistically significant association was observed between increasing patient age and higher error rates ($p<0.05$). However, no significant correlation was found between gender and error occurrence ($p>0.05$).

Conclusion: The prevalence of positioning errors in panoramic radiography is considerable. It underscores the importance of providing adequate training to healthcare professionals and technicians to mitigate the risk of misinterpretation and unnecessary exposure to radiation.

Keywords: Patient positioning, diagnostic errors, panoramic radiography

INTRODUCTION

Panoramic radiography is a simple and useful method that shows the maxillomandibular structures and adjacent structures on a single film.[1-4] The technique of panoramic radiography is a curvilinear variant of conventional tomography, which works on the principle of an image receiver with a reciprocally moving x-ray source located around a central point or plane in the image layer. The image layer is a three-dimensional "focal trough" in which the dentition and associated structures must be positioned. Images of structures outside the focal trough are observed as blurred, magnified and distorted.[5,6] Various studies have shown that a significant portion of panoramic radiographs are of non-diagnostic quality.[7-12]

The most important disadvantages of panoramic radiographs are low resolution, low detail, distortion, and unequal magnifications compared to the images obtained from intraoral radiographs, making measurements unreliable and evaluations inaccurate due to superpositions.[3] Low-quality radiographs may lead to misinterpretation and may cause incorrect diagnosis and treatment planning.[7,13-15] Therefore, when obtaining panoramic radiographs, the imaged structure should be of high quality and with minimal distortion.

Errors that frequently occur in the production of panoramic radiographs are technical errors or errors that occur during patient positioning.[16] Some radiopaque and radiolucent images may occur as a result of errors occurring in panoramic radiographs. In addition to the shadows of some soft tissues and anatomical air spaces, foreign body images and ghost images may occur due to errors made during patient positioning and preparation in the examined areas.[17] The use

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of digital imaging leads to the elimination of processing errors, allowing the technician or dentist to focus on patient and technician errors to obtain more accurate and diagnostically acceptable images.[12,17] Dentists need to prevent unnecessary radiation exposure by knowing the errors and their causes.[18]

The aim of this study was to evaluate the distribution of the types of errors encountered in panoramic imaging by age and gender and to evaluate the image quality of panoramic radiographs. We believe that this information will increase the awareness of both physicians and technicians to improve image quality by revealing the common causes of errors.

METHODS

The study was carried out with the permission of the Dicle University Faculty of Dentistry Ethics Committee (Date: 31.01.2024, Decision No: 2024-03). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

In this study, 2000 images randomly selected from the archive of patients who were examined in Dicle University Faculty of Dentistry, Department of Oral and Maxillofacial Radiology in 2023 and whose panoramic radiographs were taken for various reasons were evaluated. All the images obtained using Planmeca ProMax (Planmeca ProMax, Helsinki, Finland) and Midmark Vantage, (Midmark, Ohio, USA) digital panoramic X-ray machines in standard acquisition mode (66 kV, 6 mA, 16 s). All panoramic imaging was conducted by the same eight operators.

The images were examined by two expert radiologists, BK and EK, who had 9 and 12 years of experience, respectively. To determine inter-observer agreement, 10% of the study population was re-evaluated by both observers. Since the agreement between the observers was "very good agreement" for error number 9 and "almost perfect agreement" for the other error types, only one observer's (BK) assessment was used for further statistical evaluations.

Radiographs of patients with developmental anomalies, history of trauma, history of orthognathic surgery or pathology such as tumors/cysts in the maxillofacial region and patients under 16 years of age were not included in the study. Relevant data was supplied by the Metasoft program, which maintains the medical history and radiological information of patients at our clinic. The age and gender of the patients were recorded and the distribution of acquisition errors according to different age groups (16-18, 19-24, 25-34, 35-44, 45-54, 55-64, 65 and over) was analyzed. In line with previous studies, we evaluated the quality of panoramic films into three distinct categories (acceptable, unacceptable, and perfect) based on the number and type of errors.[7,17]

Perfect

There are no errors that affect the radiograph's diagnostic ability.

Acceptable

The radiograph has one or more errors that make it less diagnostic.

Unacceptable

The radiographs are undiagnosable due to errors.

Radiographs were evaluated according to the following 10 general error categories:

- Error 1. The patient tilts his head forward: "V" shaped smile line, incision of the symphysis on radiograph, distortion of the anterior teeth
- Error 2. The patient tilts his head back: Flattened occlusal plane, distortion of the mandible, superposition of the radiopaque image of the hard palate on the upper tooth roots
- Error 3. The patient shifts the head to one side: Reduction in the image on the side the head is turned and enlargement on the opposite side
- Error 4. Patient not standing upright: Superposition of the radiopaque shadow of the cervical vertebrae on the mandibular symphysis
- Error 5. Patient's tongue positioning error: Radiolucent area superimposed on the apex of the maxillary teeth due to palatoglossal airspace caused by the tongue dorsum not touching the palate
- Error 6. Patient movement: Blurred and erroneous image
- Error 7. Foreign bodies: Images that can obscure normal anatomy or pathology, causing both a radiopaque image and a ghost image contralaterally on the panoramic radiograph
- Error 8. Lack of image: Structures such as condyle, mandibular corpus, maxillary sinus not included in the image
- Error 9. The patient tilts the head to one side: The image will be tilted; one angle of the mandible is higher than the other, the condyles are not of equal height.
- Error 10. Lip positioning error: Radiolucent area in the anterior regions due to the patient not keeping the lip closed (Figure 1-9).

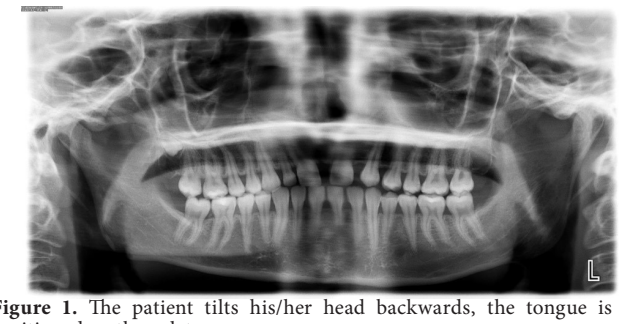

Figure 1. The patient tilts his/her head backwards, the tongue is not positioned on the palate

Figure 2. The patient is not standing upright, the tongue is not positioned correctly

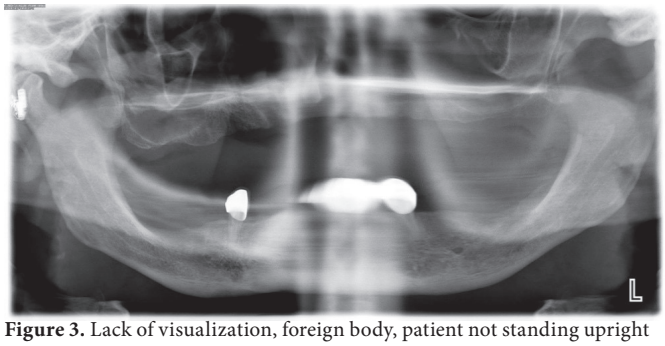

Figure 3. Lack of visualization, foreign body, patient not standing upright

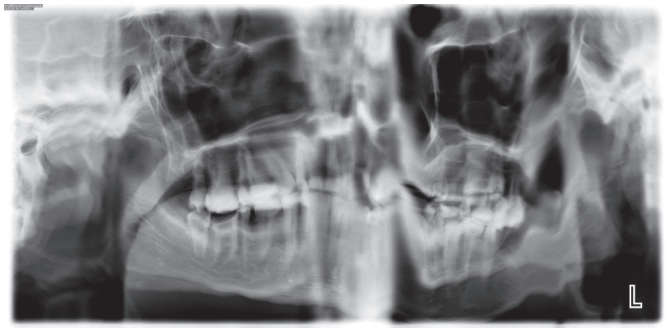

Figure 4. Patient movement

Figure 5. The patient shifts his head to the right side

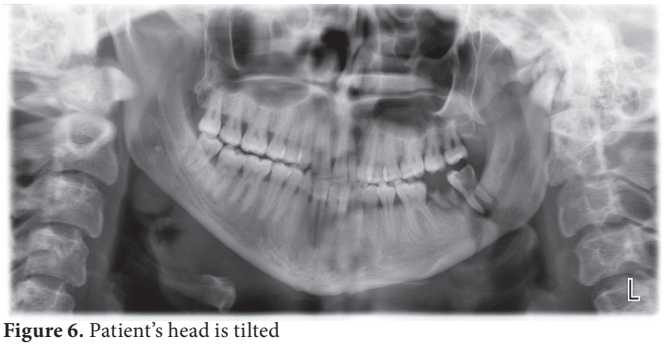

Figure 6. Patient's head is tilted

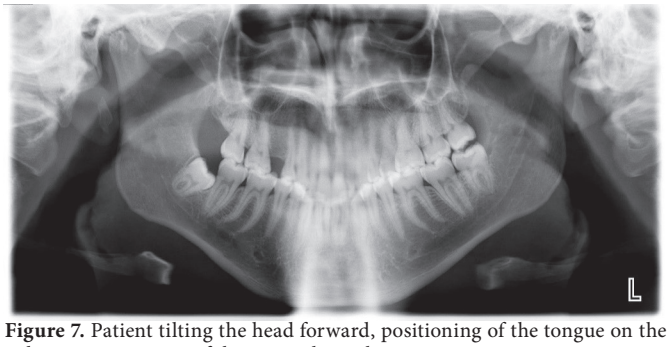

Figure 7. Patient tilting the head forward, positioning of the tongue on the palate, superposition of the cervical vertebrae

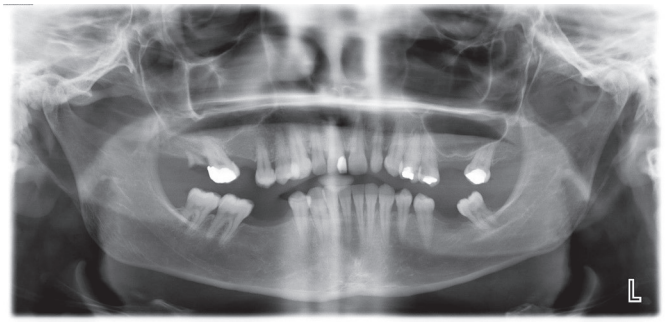

Figure 8. Lip positioning error

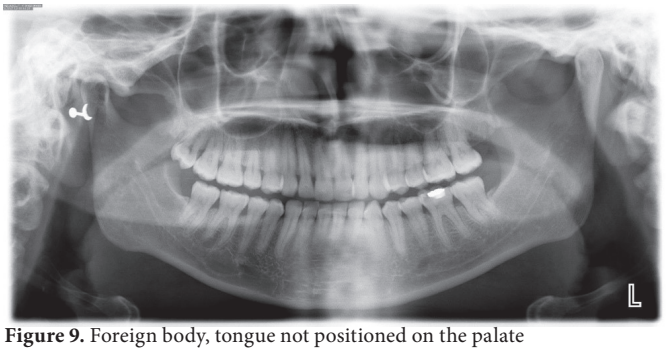

Figure 9. Foreign body, tongue not positioned on the palate

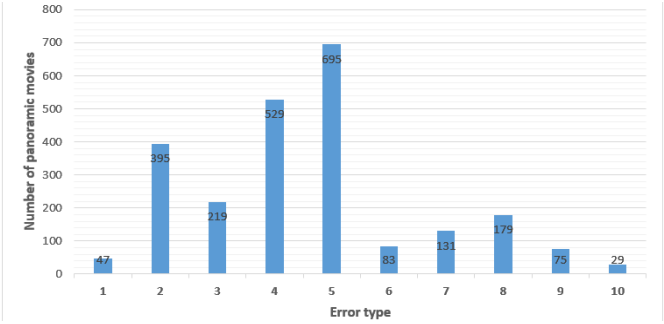

Figure 10. Visualization of the distribution of error types in the presence of errors

Statistical Analysis

Cohen's Kappa test was used to determine the inter-observer agreement. Chi-square test, Cochran-Q test and McNemar test for pairwise comparisons of error types were used to determine whether there were significant differences between error types. Pearson R values were used for correlation analysis. All analyses were performed using SPSS 20.0 software (IBM Corp., Armonk, NY, USA). The significance level was set at α=5%. Intraobserver agreement was calculated using Cohen's Kappa statistics.

RESULTS

A total of 2,000 panoramic X-rays, 881 of which belonged to male patients and 1,119 to female patients, were included in this study. The mean age of the women was 34.70 years, while the mean age of the men was 35.88 years. Kappa test results showed that there was no statistically significant difference in the observed values between the examiners in the scoring of error 1, error 2, error 3, error 4, error 5, error 6, error 7, error 8, error 9, error 10 (Cohen kappa value=1.000, 0.932, 0.834, 0.883, 0.951, 1.000, 0.957, 0.935, 0.793, 1.000).

In Table 1, there is a significant proportional difference between age categories (p<0.001). The error rate in the 45-54 and 65+ age groups was significantly higher than in the 19-24 and 25-34 age groups (p<0.05). There was no difference between the groups in terms of the error rate in panoramic films taken in the 16-18, 35-44 and 55-64 age groups (p>0.05).

Table 1. Distribution of the presence/absence of errors according to ages

	16-18 a, b, c, d	19-24 d, e	25-34 c, e	35-44 b, c, d, e	45-54 a, b	55-64 a, b, c, d, e	>65 a	Total
Error								
No	24 (17.9)	84 (21.2)	131 (20.5)	71 (20.6)	29 (11.4)	27 (16.4)	2 (3)	368 (18.4)
Yes	110 (82.1)	313 (78.8)	507 (79.5)	273 (79.4)	226 (88.6)	138 (83.6)	65 (97)	1632 (81.6)
Total	134 (100)	397 (100)	638 (100)	344 (100)	255 (100)	165 (100)	67 (100)	2000 (100)

*Pearson chi-square test, *There is no significant difference between age groups with the same letter

Table 2 shows the distribution of the acceptability of panoramic films according to the presence/absence of defects. There is a strong negative correlation between the presence of defects and acceptability (pearson r=-0.801). Accordingly, acceptability decreased significantly as the presence of defects increased (p<0.001).

Table 2. Distribution of acceptability by presence/absence of error

	Acceptability			
Eror	**Acceptable**	**Unacceptable**	**Flawless**	**Total**
No	0 (0)	0 (0)	368 (100)	368 (100)
Yes	900 (55.1)	732 (44.9)	0 (0)	1632 (100)
Total	900 (45.0)	732 (36.6)	368 (18.4)	2000 (100)

*Chi-square

Table 3 shows the acceptability of panoramic films according to gender. No correlation was found between gender and acceptability (p>0.05).

Table 3. Acceptability of panoramic films by gender

	Acceptability			
Gender	**Acceptable**		**Flawless**	**Total**
Woman	383 (43.5)	367 (41.7)	131 (14.9)	881 (100)
Male	517 (46.2)	365 (32.6)	237 (21.2)	1119 (100)
Total	900 (45.0)	732 (36.6)	368 (18.4)	2000 (100)

*Chi-square

Figure 10 and Table 4 show the distribution of the number of X-rays according to error types. There is a significant difference according to the distribution of error types (p<0.001). The number of panoramic X-rays with error 5 was the highest, followed by error 4, errors 2 and 3 (p<0.05).

Table 5 shows the distribution of acceptability according to the number of errors. The relationship between the number of errors and acceptability was analyzed and η=0.383 was obtained when acceptability was taken as the dependent variable. The increase in the number of errors has a great effect on acceptability.

Table 4. Distribution of faulty panoramic radiographs according to error types

Error type	n (%)
Error 1	47 (2.35)^{gh}
Error 2	395 (19.75)^{c}
Error 3	219 (10.95)^{d}
Error 4	530 (26.45)^{b}
Error 5	695 (34.75)^{a}
Error 6	83 (4.15)^{fh}
Error 7	132 (6.55)^{ef}
Error 8	179 (8.95)^{de}
Error 9	76 (3.75)^{fgh}
Error 10	29 (1.45)^{h}
Total	2000 (100)

Cochran Q a-h: There is no significant difference between values with the same letter (p>0.05)

Table 5. Distribution of acceptability by number of errors

	Acceptability		
Eror	**Acceptable**	**Unacceptable**	**Total**
One mistake	690 (69.1)	309 (30.9)	999 (100)
Two errors	203 (38.7)	321 (61.3)	524 (100)
Three and four errors	7 (6.4)	102 (93.6)	109 (100)
Total	900 (55.1)	732 (44.9)	1632 (100)

*Chi-square

DISCUSSION

In our study, we aimed to determine the prevalence of ten different errors in panoramic radiographs obtained in our faculty and to classify their image quality as "perfect", "acceptable" and "unacceptable".

Paying attention to some issues while taking radiographs ensures an accurate radiograph. These parameters include bilateral symmetry, occlusal plane with a slight upper concavity, localization of the two mandibular condyles at the same height, clear visualization of the tooth apices of the upper teeth, flat position of the cervical spine, correct adjustment of tube voltage, current and exposure time.[18] In order for the diagnostic quality of panoramic radiography to be adequate, attention should be paid to the correct preparation and positioning of the patient.[2,19] Errors in the radiographic image lead to a decrease in diagnostic benefits, in some cases to repeat imaging and thus to unnecessary radiation exposure of the patient.[20] In this study, only 18.4% of the panoramic radiographs evaluated were free of errors, while 81.16% had at least one error.

Upper jaw periapical tissues cannot be clearly observed due to the radiolucent band formed at the level of the apex of the maxillary teeth as a result of incomplete positioning of the tongue ridge on the palate.[8,21] Due to improper positioning of the cervical vertebrae, the radiopaque shadow of the vertebrae may appear superposed on the mandibular symphysis region. This shadow may prevent clear visualization of the mandibular and maxillary anterior region.[22] Hacıosmanoğlu et al.[10]

examined 186 panoramic images and found at least one error in 93.01%. In their study, the most common error was not positioning the tongue on the palate with 66.12% and the second most common error was the skier position error (27.95%). In our study, the first and second most common errors were not positioning the tongue on the palate (34.75%) and patient not standing upright (26.45%), respectively, similar to the study of Hacıosmanoğlu et al.[10] Although there is a significant difference in the number of images analyzed, the results obtained are consistent. Belgin et al.[8] reported at least one error in 81.6% of 500 panoramic radiographs and the most common error was not positioning the patient upright, while Dhillon et al.[17] reported at least one error in 89% of 1,782 radiographs and the most common error was not positioning the tongue on the palate. When compared in terms of error rates, it is seen that the results of the studies are compatible with our study. Kattimani et al.[1] included 500 panoramic images and found that 17.2% of the radiographs were error-free and 82.8% had at least one error. The most common of these errors (30.8%) were images obtained by turning the head to one side due to incorrect positioning of the midline. Bagherpour et al.[23] reported that 96.7% of 1815 permanent teeth panoramic radiographs and Akarslan et al.[24] reported that 62.39% of 460 panoramic radiographs contained positioning errors, and the most common error in both studies was not placing the tongue correctly on the palate. Costa et al.[25] reported a 68.7% error rate in radiographs, with the tongue not lying on the palate being the most prevalent error. Singh et al.,[26] in contrast to these studies, reported that the head tilting backwards (22.1%) was the most prevalent error in the panoramic radiographs they analyzed. The least common errors observed in our study were failure to close the lips, head tilt forward, head tilt to one side and patient movement. Kattimani,[1] Khator[11] and Dhillon[17] reported that the least common error was patient movement in their study. Belgin et al.[8] reported that the least common error was head rotation to the right side.

There are a limited number of studies in the literature examining the image quality of panoramic radiographs. Belgin et al.[8] found that 18.4% of the images they evaluated were perfect, 50.3% were diagnostically acceptable and 31.3% were unacceptable. Dhillon et al.[17] determined these values as 11%, 64.1% and 24.9%, respectively. In our study, 18.4% of the images in the study population were found to be perfect, 45% acceptable and 36.6% unacceptable. The results were considered to be compatible with our study. Mayil et al.[27] examined 150 panoramic radiographs in a study evaluating the image quality and imaging errors of panoramic radiographs and found that 3.3% of the images were diagnostically unacceptable, 78% were diagnostically acceptable and 18.7% had ideal conditions. When compared with our study, it is seen that the proportion of ideal images is similar, but there is a difference in the proportion of diagnostically acceptable and unacceptable images. This is thought to be due to the large difference in the number of images examined. Kumar et al.[7] reported 22.4% and Lingam et al.[12] reported 32.8% of the radiographs as excellent.

In this study, when we evaluated the acceptability of panoramic radiographs according to gender, no correlation was found between gender and acceptability. Belgin et al.[8] reported in a study that there was no significant difference between gender and the error rate seen in panoramic radiography.

In our study, the relationship between the number of errors and the diagnostic acceptability of panoramic films was examined; it was observed that the acceptability decreased significantly as the presence of errors increased ($p<0.001$). While the acceptability was 69.1% in the presence of a single error, this rate was 6.4% in panoramic images with three or more errors. In the literature review, no study evaluating the correlation between the increase in the number of errors and acceptability was found.

A significant proportional difference was found between age categories and error rate ($p<0.001$). The rate of obtaining error-free images decreased with increasing age. In their study, Marsha et al.[15] classified patients as children, adults, and the elderly. They discovered that the elderly had a higher prevalence of errors than adults (33.6%). In the study by Belgin et al.[8] evaluating the relationship between error types and age, it was reported that positioning errors that may be related to age, such as patient inability to stand upright and patient movement, were frequently seen in elderly patients. Positioning challenges may also arise, particularly in elderly patients with conditions like Parkinson's.[15] The reason for this was thought to be the inability of these patients to remain immobile during the radiography procedure and inadequate communication between the patient and the operator.

Limitations

In our investigation, there are certain limitations. The impact of technician experience could not be assessed due to the lack of information regarding which panoramic radiograph was taken by which technician. Since our hospital is one of the busiest in the region, we are of the opinion that operator density increases the error rate. Therefore, a multicenter study with a larger population would be more advantageous for assessing the prevalence of various types of errors in panoramic radiography.

CONCLUSION

Panoramic radiography offers a wide range of advantages, including a wide field of view and minimal radiation exposure. However, the frequency of errors in preparation and positioning of panoramic radiographs is high. Physicians and technicians should be familiar with the correct panoramic techniques and should make every effort to minimize the patient's radiation dose when taking diagnostic panoramic radiographs. We are of the opinion that operators should receive annual training to provide an explanation of the ideal patient positioning, common errors, and their causes and solutions during panoramic radiography. This will prevent the unnecessary exposure of patients to radiation and prevent the repetition of panoramic imaging. The increasing error rate with advancing age indicates that a special effort is needed for these patients. Better communication with patients and giving them time to position themselves can reduce the number of errors and allow for high-quality panoramic radiographs.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of the Dicle University Faculty of Dentistry Ethics Committee (Date: 31.01.2024, Decision No: 2024-03).

Informed Consent

Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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