J Surg Med. 2023;7(2):151-155.
DOI: 10.28982/josam.7709

Research article

Journal of Surgery and Medicine
e-ISSN: 2602-2079
https://jsurgmed.com/

Orthopedic surgeons' attitudes and expectations toward artificial intelligence: A national survey study

Ertuğrul Şahin [1], Haluk Berk [2]

[1] Kafkas University, Faculty of Medicine, Department of Orthopedics and Traumatology, Kars, Turkey
[2] Dokuz Eylul University, Faculty of Medicine, Department of Orthopedics and Traumatology, Izmir, Turkey

ORCID ID of the author(s)

EŞ: 0000-0002-8509-3570
HB: 0000-0003-0402-3608

Corresponding Author
Ertuğrul Şahin
Kafkas University, Faculty of Medicine, Department of Orthopedics and Traumatology, Kars, Turkey
E-mail: ertugrulsahinn@hotmail.com

Ethics Committee Approval
The study was approved by Dokuz Eylul University Non-interventional Clinical Research Ethics Board with protocol number 2021/16-01 on May 27, 2021.
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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

Published
2023 February 13

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Abstract

Background/Aim: There is a lack of understanding of artificial intelligence (AI) among orthopedic surgeons regarding how it can be used in their clinical practices. This study aimed to evaluate the attitudes of orthopedic surgeons regarding the application of AI in their practices.
Methods: A cross-sectional study was conducted in Turkey among 189 orthopedic surgeons between November 2021 and February 2022. An electronic survey was designed using the SurveyMonkey platform. The questionnaire included six subsections related to AI usefulness in clinical practice and participants' knowledge about the topic. It also surveyed their acceptance level of learning, concerns about the potential risks of AI, and implementation of this technology into their daily practice
Results: A total of 33.9% of the participants indicated that they were familiar with the concept of AI, while 82.5% planned to learn about artificial intelligence in the coming years. Most of the surgeons (68.3%) reported not using AI in their daily practice. The activities of orthopedic associations focused on AI were insufficient according to 77.2% of participants. Orthopedic surgeons expressed concern over AI involvement in the future regarding an insensitive and nonempathic attitude toward the patient (53.5%). A majority of respondents (80.4%) indicated that AI was most feasible in extremity reconstruction. Pelvis fractures were found in the region where the AI system is most needed in the fracture classification (68.7%).
Conclusion: Most of the respondents did not use AI in their daily clinical practice; however, almost all surgeons had plans to learn about artificial intelligence in the future. There was a need to improve orthopedic associations' activities focusing on artificial intelligence. Furthermore, new research including the medical ethics issues of the field will be needed to allay the surgeons' worries. The classification system of pelvic fractures and sub-branches of orthopedic extremity reconstruction were the most feasible areas for AI systems. We believe that this study will serve as a guide for all branches of orthopedic medicine.

Keywords: artificial intelligence, attitudes, orthopedic surgeons, survey

How to cite: Şahin E, Berk H. Orthopedic surgeons' attitudes and expectations toward artificial intelligence: A national survey study. J Surg Med. 2023;7(2):151-155.

Introduction

The use of artificial intelligence (AI) in health care has gained interest in recent years [1]. AI represents health-related research and clinical care with enhanced qualities and abilities that exceed those naturally found in clinicians. AI has been applied in a wide range of fields in medicine including cardiology, radiology, dermatology, and mental health [1,2].

The application of AI systems has high potential in orthopedics. Digital imaging and documentation are steadily increasing, resulting in a large database for algorithms. Therefore, the use of AI is inevitable in improving the quality of patient care through management, research, and diagnosis [3].

There is a lack of AI understanding among orthopedic surgeons as to how it can be utilized in their clinical practice [4]. AI in the orthopedic area is still in its infancy compared to other areas of medicine [1]. Orthopedic surgery has recently begun adopting AI systems, and in the literature it is possible to see the increase in research for AI applications in recent years. Hip fractures [5,6], and pediatric elbow fractures [7] have been diagnosed with image-based algorithms. Radiographic measurements, such as acetabular component position [8] and coronal knee alignment [9] can also be performed with AI systems. These programs have been used for the pre-operative templating total knee arthroplasty to improve the accuracy and efficiency of surgery [10-12].

In addition, we believe that new projects and research are still needed to figure out the potential and logic of AI systems. With this need in mind, we designed a national multicenter survey to evaluate the views and attitudes of orthopedic surgeons regarding the application of AI in their practices.

Materials and methods

This questionnaire was approved by the Dokuz Eylul University Non-interventional Clinical Research Ethics Board with protocol number 2021/16-01 on May 27, 2021. The research was carried out as a descriptive observational study among orthopedic surgeons in Turkey. A search of the Council of Higher Education Theses Center database [https://tez.yok.gov.tr/UlusalTezMerkezi/] was performed. In conducting a detailed search, the subject division was filtered using "orthopedics and traumatology," and the time was limited between 1980 and 2020. The list of surgeons was numbered one by one, starting with the number one. The participants of the survey were randomly selected by generating random numbers in Microsoft Excel.

An electronic survey was designed using the SurveyMonkey platform. Between November 2021 and February 2022, an electronic survey was distributed via email to 650 orthopedic surgeons. The invitation email included the aim of the study and a link to participate in the survey. The email was sent three times, one week apart. Data collection was completed anonymously. Informed consent including the nature and aim of the survey was provided, and participants were notified that it was always possible to withdraw from the survey.

The survey included six subsections. The first subsection aimed to gather general demographic data including age, gender, title/degree, the institution of residency training, years of experience, and the institution where currently working. The second subsection evaluated the level of awareness of artificial intelligence. Answers were scored using two types of five-point Likert scales (strongly disagree, disagree, undecided, agree, strongly agree; and never, slightly, moderately, adequately, and completely). The third subsection aimed to analyze the preference of treatment steps in which AI would be used. The fourth subsection assessed surgeons' concerns about the potential risks of AI involvement in daily practice. The fifth subsection explored the sub-branches of orthopedics in which AI would be useful. The last subsection included the surgeons' preference level of AI usage according to the classification of fracture type.

Statistical analysis

The distributions of data were checked using the Kolmogorov-Smirnov normality test. Categorical data were analyzed with the chi-square test and represented as numbers and percentages. The differences in the questionnaire responses according to working places and daily practices were analyzed using the Mann-Whitney test. All analyses were done on SPSS for Windows (version 22.0; IBM Corp, Armonk, NY, USA). A *P*-value below 0.05 was accepted as a statistical difference.

Results

The demographic data including age, gender, title/degree, the institution of residency training, years of experience, and the institution where currently working is shown in Table 1. A total of 650 registrants and 189 surgeons filled out the questionnaire (response rate: 29.1%).

Table 1: Descriptive characteristics of the participants

Characteristics	n(%)
1) Gender	
Male	186 (98.4)
Female	3 (1.6)
2) Age (years)	
25 – 29	1 (0.5)
30 – 34	41 (21.7)
35 – 39	61 (32.3)
40 – 50	66 (34.9)
>50	20 (10.6)
3) Title/Degree	
Specialist	81 (42.9)
Chief resident	6 (3.2)
Assistant professor	28 (14.8)
Associate professor	48 (25.4)
Professor	26 (13.8)
4) The institution of orthopedics and traumatology residency training	
Training and research hospital	75 (39.7)
University hospital	104 (55)
Foundation university hospital	10 (5.3)
Abroad	0 (0.0)
5) Experience in orthopedic surgery (years)	
<5	53 (28)
5 – 9	51 (27)
10 – 14	38 (20.1)
15 – 20	24 (12.7)
>20	23 (12.2)
6) The institution of current working for	
State Hospital	26 (13.8)
Training and research hospital	55 (29.1)
University hospital	44 (23.3)
Foundation university hospital	16 (8.5)
Private hospital	34 (18)
Specialty hospital	0 (0.0)
Private clinic	14 (7.4)

The results of evaluating the level of awareness of artificial intelligence are indicated in Table 2. This table shows 33.9% of participants thought that they were adequately or completely familiar with the concept of AI. On the other hand, 82.5% of participants planned to learn about artificial

Table 2: Responses rate to questions about the level of awareness of AI (n, [%])

Evaluating the level of awareness of artificial intelligence that orthopedists have					
Question	**Never**	**Slightly**	**Moderately**	**Adequately**	**Completely**
▪ **How familiar do you think you are with the concept of artificial intelligence?**	6 (3.2)	41 (21.7)	78 (41.3)	48 (25.4)	16 (8.5)
▪ **How much information are you planning to learn about artificial intelligence in the coming years?**	2 (1.1)	1 (0.5)	30 (15.9)	93 (49.2)	63 (33.3)
▪ **To what extent do you use AI in your day-to-day clinical practices?**	68 (36)	61 (32.3)	48 (25.4)	7 (3.7)	4 (2.1)
	Strongly disagree	**Disagree**	**Undecided**	**Agree**	**Strongly agree**
▪ **I think, compared to clinical experience, AI will be better at making accurate and rapid diagnoses.**	6 (3.2)	44 (23.3)	62 (32.8)	62 (32.8)	15 (7.9)
▪ **I think I will be out of a job in the future because of the widespread use of artificial intelligence.**	61 (32.3)	113 (59.8)	8 (4.2)	5 (2.6)	2 (1.1)
▪ **I think that the activities that orthopedic associations conduct focusing on information technologies, such as artificial intelligence, are sufficient.**	39 (20.6)	107 (56.6)	33 (17.5)	7 (3.7)	3 (1.6)
▪ **I think the subject of artificial intelligence should be included in the curriculum of orthopedic specialty training.**	2 (1.1)	13 (6.9)	39 (20.6)	94 (49.7)	41 (21.7)

Table 3: Participants' consideration of using AI in which treatment steps (n, [%])

To what extent would you consider using the AI in the treatment steps mentioned below?					
Question	**Never**	**Slightly**	**Moderately**	**Adequately**	**Completely**
▪ **Diagnosis**	8 (4.2)	14 (7.4)	61 (32.8)	65 (32.3)	39 (20.7)
▪ **Radiographic evaluation**	2 (1.1)	4 (2.1)	31 (16.4)	81 (42.9)	71 (37.6)
▪ **Surgical planning (Templating)**	2 (1.1)	0 (0.0)	32 (16.9)	94 (49.7)	60 (31.7)
▪ **Prognostic management**	5 (2.6)	16 (8.5)	59 (31.2)	76 (40.2)	32 (16.9)
▪ **Evaluation of treatment success**	5 (2.6)	9 (4.8)	46 (24.3)	84 (44.4)	44 (23.3)
▪ **Literature review**	0 (0.0)	3 (1.6)	10 (5.3)	54 (29.6)	121 (64.0)

Table 4: Distribution of participants' concerns about potential situations when AI will be involved in many fields of their daily practice in the future (n, [%])

With the likelihood/possibility/probability of AI involvement in many fields of our daily practice in the future, to what extent are you concerned about the following potential situations?					
Question	**Never**	**Slightly**	**Moderately**	**Adequately**	**Completely**
▪ **Who will be responsible in the case of AI-related malpractice**	19 (10.1)	31 (16.4)	55 (29.1)	42 (22.2)	40 (21.2)
▪ **Cognitive dissonance**	5 (2.6)	25 (13.2)	83 (43.9)	54 (28.6)	20 (10.6)
▪ **Inability to adapt to real-world practice**	8 (4.2)	30 (15.9)	83 (43.9)	48 (25.4)	17 (9)
▪ **Having an insensitive and nonempathic attitude toward the patient and not being able to evaluate the patient's thoughts and expectations**	11 (5.8)	24 (12.7)	50 (26.5)	44 (23.3)	57 (30.2)
▪ **Going beyond serving just as a complementary component in diagnosis and treatment and becoming the decision-maker of the entire process**	20 (10.6)	33 (17.5)	63 (33.3)	38 (20.1)	32 (16.9)

Table 5: Relationship between sub-branches of orthopedics and feasibility of AI (n, [%])

To what extent do you think that AI is useful and feasible in the sub-branches mentioned below?					
Question	**Never**	**Slightly**	**Moderately**	**Adequately**	**Completely**
▪ **Arthroplasty**	2 (1.1)	1 (0.5)	45 (23.8)	79 (41.8)	60 (31.7)
▪ **Foot and Ankle**	4 (2.1)	25 (13.2)	76 (40.2)	64 (33.9)	19 (10.1)
▪ **Hand and Microsurgery**	26 (13.8)	62 (32.8)	55 (29.1)	30 (15.9)	15 (7.9)
▪ **Extremity Reconstruction and the Ilizarov**	2 (1.1)	6 (3.2)	28 (14.8)	66 (34.9)	86 (45.5)
▪ **Shoulder and Elbow**	7 (3.7)	31 (16.4)	87 (46)	43 (22.8)	19 (10.1)
▪ **Spine**	3 (1.6)	10 (5.3)	36 (19)	80 (42.3)	59 (31.2)
▪ **Pediatric**	7 (3.7)	61 (32.3)	73 (38.6)	32 (16.9)	15 (7.9)
▪ **Sports Injury – Arthroscopic Surgery**	6 (3.2)	39 (20.6)	81 (42.9)	45 (23.8)	17 (9)
▪ **Trauma**	7 (3.7)	27 (14.3)	64 (33.9)	56 (29.6)	34 (18)
▪ **Tumor**	6 (3.2)	27 (14.3)	56 (29.6)	47 (24.9)	52 (27.5)

Table 6: Participants' opinions how AI system is needed for fracture classification according to region (n, [%])

To what extent do you think you need an AI system to classify the fracture type of the following regions?					
Question	**Never**	**Slightly**	**Moderately**	**Adequately**	**Completely**
Vertebrae	9 (4.8)	21 (11.1)	60 (31.7)	60 (31.7)	39 (20.6)
Humerus	23 (12.2)	48 (25.4)	71 (37.6)	30 (15.9)	15 (7.9)
Radius	23 (12.2)	36 (19)	77 (40.7)	39 (20.6)	14 (7.4)
Ulna	26 (13.8)	50 (26.5)	71 (37.6)	27 (14.3)	15 (7.9)
Carpal	18 (9.5)	39 (20.6)	59 (31.2)	46 (24.3)	27 (14.3)
Pelvis	7 (3.7)	11 (5.8)	41 (21.7)	67 (35.4)	63 (33.3)
Femur	20 (10.6)	30 (15.9)	93 (49.2)	28 (14.8)	16 (8.5)
Tibia	20 (10.6)	33 (17.5)	85 (45)	31 (16.4)	19 (10.1)
Fibula	23 (12.2)	52 (27.5)	72 (38.1)	26 (13.8)	15 (7.9)
Tarsal	18 (9.5)	36 (19)	74 (39.2)	36 (19)	25 (13.2)

intelligence in the coming years. The majority (68.3%) of surgeons expressed that they did not use AI in their daily clinical practices. Additionally, participants who were working in training hospitals (training and research hospitals, university hospitals, foundation university hospitals) were more likely to use AI in their daily clinical practice than other center workers (P=0.045).

A total of 40.7% of participants thought that AI would be better than clinical experience in making accurate and rapid diagnoses. Surgeons in non-academic positions (34.6%) and those in academic positions (45.4%) agreed that AI has a superior diagnostic ability for clinical experiences. The majority of surgeons (92.3%, n=174) did not believe that their jobs would be replaced by AI in the future. The activities that orthopedic associations conduct focusing on AI were not believed to be sufficient according to 77.2% of participants. In addition, 71.4% of surgeons expressed the need for AI in the curriculum of orthopedic specialty training.

Participants' consideration of using AI in relation to treatment steps is shown in Table 3. Most surgeons would consider using AI in the treatment steps of diagnosis, radiographic evaluation, surgical planning (templating), prognostic management, evaluation of treatment success, and literature review. Among all the treatment steps mentioned, the literature review had the highest agreement with 93.6%, followed by surgical planning (81.4%) and radiographic evaluation (80.5%). The diagnosis had the least agreement with 53%.

The distribution of participants' concerns about potential situations in which AI will be involved in their daily practice in the future can be seen in Table 4. The most possible situation of AI involvement in the future that concerned orthopedists were having an insensitive and nonempathic attitude

toward the patient and not being able to evaluate the patients' thoughts and expectations (53.5%) followed by who will be responsible in the case of AI-related malpractice (43.3%) and cognitive dissonance (39.2%).

The relationship between sub-branches of orthopedics and the feasibility of AI is revealed in Table 5. Of all respondents, 80.4% thought that AI was the most useful and feasible in extremity reconstruction and in the Ilizarov procedure followed by arthroplasty and spine with rates of 73.5%. Hand and microsurgery had the lowest rate (23.8%). In sports injury–arthroscopic surgery—there was a statistical difference between the participants who employed at least a moderate use of AI in their day-to-day clinical practices and those who used it slightly or not at all (P=0.043).

Participants' opinions on how an AI system is needed for fracture classification according to the region is seen in Table 6. Pelvis fractures were found in the region where the AI system is most needed in the fracture classification (68.7%), followed by vertebrae (52.3%) and carpal (38.6%) fractures. Fibula fractures were reported as having the least need for an AI system (21.7%).

Discussion

Our study has shown that less than half of our participants are familiar with AI systems. Nevertheless, the majority would like to learn about artificial intelligence in the coming years. Furthermore, only almost 30% use AI in their daily clinical practices. Nearly all of the participants believe that they will not be replaced by AI.

In this study, we assessed whether AI is superior to clinical experience in diagnosis. Less than half of the participants thought that AI would be better at diagnosis. Doctors in non-academic positions were less likely than surgeons in academic positions to agree that AI has superior diagnostic capacity. On the other hand, Oh et al. [13] showed that academicians were less likely than medical students and training physicians to agree that AI is diagnostically superior. We found that doctors in academic positions were more knowledgeable about AI technology in the orthopedic area, thus making them more aware that AI systems had great potential and could perform tasks that could not be done by humans.

There are some important aspects of the doctor-patient relationship. Doctors can interact with patients to gain their trust, reassure them, and have an empathic attitude toward them [14]. AI systems can collect important information to facilitate diagnoses and treatment plans; furthermore, there is always a need to integrate interaction between the doctor and patient, collect the medical history, perform a physical exam, and help further discussion [15]. Our results supported that more than half of the participants believe that AI cannot take the doctors' place in the doctor-patient relationship.

Almost half of the orthopedists believed that the future involvement of AI in many fields will bring about some problems. The most likely concerns who would be responsible in the case of AI-related malpractice in the future. These results are consistent with a study by Sarwar et al. [16] that the legal implications of AI in medicine, both from a regulator and malpractice standpoint, were a common theme among pathologists. Hence, regulatory authorities and principles should be defined to prevent ethical and legal problems in medicine caused by AI.

The alignment of extremities is quantified by defining several anatomic landmarks [17]. Traditionally, the plan of extremity reconstruction is done with the radiographic evaluation of extremities, and this method takes a great deal of time, whereas AI can process data very quickly. When we combine these two pieces of information, it is not surprising that most of the participants believe that AI is useful and feasible in extremity reconstruction and the Ilizarov procedure.

The literature review process includes both creative and mechanical issues, which are useful areas for AI systems. By avoiding time-consuming and repetitive tasks, researchers can dedicate more time to other issues [18]. In the current study, most of the respondents preferred using AI in the literature review followed by surgical planning and radiographic evaluation. These results were not surprising, considering the large volume of digital imaging data that AI models can interpret. Federer et al. [19] reported in a review study that almost half of the publications related to AI and orthopedics were interpreted using diagnostic imaging modalities.

During the last decades, there have been several studies reported on AI for fracture recognition with very promising results [20-23]. However, its applications and limitations are still large and unsolved questions [24]. We asked the participants about the classification of which region fractures have superiority for the use of AI systems. Pelvis fractures had the highest agreement that AI systems would be the most useful. These responses could suggest that the classification of severe pelvic ring fractures is extremely difficult, partly due to their complexity and the absence of imaging in important patient subgroups. Therefore, the industry must pay attention to integrating AI systems in the classification of pelvis ring fractures.

A large majority of participants expressed an interest in integrating AI into residency training. They supported the belief that the orthopedics community must, in fact, extend a greater effort to ensure AI's future role in this field. Training and education programs should be planned to teach orthopedic surgeons how to use AI-based applications in their daily clinical practice. This was also mentioned by most participants in previous studies [25,26].

Orthopedic surgeons were extremely confident about their future. On the statement: "I think I will be out of a job in the future because of the widespread use of artificial intelligence," 92.1% of orthopedic surgeons responded with strongly disagree or disagree. However, these results were not consistent with previous studies. Abdullah et al. [27] indicated that most respondents were concerned that their jobs would be replaced by AI. In another study, 48.3% of participants reported that they believed certain specialties would be replaced by AI [28]. However, the study by Oh et al. [13] reported that doctors did not believe they would be replaced.

Limitations

This study, of course, has some limitations. Firstly, we only included a fraction of Turkish orthopedic surgeons, and not all surgeons worldwide are represented in our cohort. We did not evaluate the participants' technical level of AI technology, which

might cause different AI conceptualizations. The nature of survey-based studies is that there is always the possibility of recall bias. The response rate is low, and the sample size is small. Therefore, an increase in the risk of selection bias can be expected. However, the distribution of participants' age, years of experience, and current working places were homogenous.

Conclusion

In conclusion**,** most of the respondents did not use AI in their daily clinical practice, but almost all surgeons had plans to learn about artificial intelligence in the coming years and there was a need to improve the activities that orthopedic associations conduct focusing on artificial intelligence. Furthermore, new research including medical ethics issues will be needed to overcome the orthopedic surgeons' worries. The classification system of pelvic fractures and sub-branches of orthopedic extremity reconstruction were the most feasible areas for AI systems. We believe that the results we determined will serve as a guide in all branches of orthopedic medicine.

References

1. Cabitza F, Locoro A, Banfi G. Machine learning in orthopedics: A literature review. Front Bioeng Biotechnol. 2018;6:75.
2. Choy G, Khalilzadeh O, Michalski M, Do S, Samir AE, Piankh OS, et al. Current applications and future impact of machine learning in radiology. Radiology. 2018;288(2):318–28.
3. Panchmatia JR, Visenio MR, Panch T. The role of artificial intelligence in orthopedic surgery. Br J Hosp Med. 2018;79(12):676–81.
4. Federer SJ, Jones GG. Artificial intelligence in orthopedics: A scoping review. PLoS ONE. 2021;16(11):e0260471. doi: 10.1371/journal.pone.0260471.
5. Urakawa T, Tanaka Y, Goto S, Matsuzawa H, Watanabe K, Endo N. Detecting intertrochanteric hip fractures with orthopedist-level accuracy using a deep convolutional neural network. Skelet Radiol. 2019;48:239–44.
6. Yamada Y, Maki S, Kishida S, Nagai H, Arima J, Yamakawa N, et al. Automated classification of hip fractures using deep convolutional neural networks with orthopedic surgeon-level accuracy: ensemble decision-making with antero-posterior and lateral radiographs. Acta Orthop. 2020;91:699–704.
7. Choi JW, Cho YJ, Lee S, Lee J, Lee S, Choi YH, et al. Using a dual-input convolutional neural network for automated detection of pediatric supracondylar fracture on conventional radiography. Investig Radiol. 2020;55:101–10.
8. Rouzrokh P, Wyles CC, Philbrick KA, Ramazanian T, Weston AD, Cai JC, et al. A deep learning tool for automated radiographic measurement of acetabular component inclination and version after total hip arthroplasty. J Arthroplasty. 2021;36(7):2510–7.e6. doi: 10.1016/j.arth.2021.02.026
9. Schock J, Truhn D, Abrar DB, Merhof D, Conrad S, Post M, et al. Automated analysis of alignment in long-leg radiographs by using a fully automated support system based on artificial intelligence. Radiol Artif Intell. 2021;3(2):e200198.
10. Lambrechts A, Ganapathi M, Wirix-Speetjens R. Clinical Evaluation of Artificial Intelligence-based Preoperative Plans for Total Knee Arthroplasty. CAOS 2020 - The 20th Annual Meeting of the International Society for Computer Assisted Orthopedic Surgery: EasyChair; 2020;169–73.
11. Li Z, Zhang X, Ding L, Du K, Yan J, Chan MTV, et al. Deep learning approach for guiding three-dimensional computed tomography reconstruction of lower limbs for robotically-assisted total knee arthroplasty. Int J Med Robot. 2021;17(5):e2300. doi: 10.1002/rcs.2300.
12. Jacofsky DJ, Allen M. Robotics in Arthroplasty: A Comprehensive Review. J Arthroplasty. 2016;31(10):2353–63. doi: 10.1016/j.arth.2016.05.026
13. Oh S, Kim JH, Choi SW, Lee HJ, Hong J, Kwon SH. Physician Confidence in Artificial Intelligence: An Online Mobile Survey J Med Internet Res. 2019;21(3):e12422.
14. Inkster B, Sarda S, Subramanian V. An empathy-driven, conversational artificial intelligence agent (Wysa) for digital mental well-being: real-world data evaluation mixed-methods study. JMIR Mhealth Uhealth. 2018;23;6(11):e12106. doi: 10.2196/12106
15. Krittanawong C. The rise of artificial intelligence and the uncertain future for physicians. Eur J Intern Med. 2018;48:e13-4. doi: 10.1016/j.ejim.2017.06.017
16. Sarwar S, Dent A, Faust K, Richer M, Djuric U, Ommeren RV, et al. Physician perspectives on integration of artificial intelligence into diagnostic pathology. NPJ Digit Med. 2019;2:28. doi: 10.1038/s41746-019-0106-0
17. Paley D, Herzenberg JE, Tetsworth K, McKie J, Bhave A. Deformity planning for frontal and sagittal plane corrective osteotomies. Orthop Clin North Am. 1994;25(3):425-65.
18. Tsafnat G, Glasziou P, Choong MK, Dunn A, Galgani F, Coiera E. Systematic review automation technologies. Systematic Reviews. 2014;3:1–15.
19. Federer SJ, Jones GG. Artificial intelligence in orthopedics: A scoping review. PLoS ONE. 2021;16(11): e0260471. doi: 10.1371/journal.pone.0260471
20. Kim DH, MacKinnon T. Artificial intelligence in fracture detection: transfer learning from deep convolutional neural networks. Clin Radiol. 2018;73(5):439–45. doi: 10.1016/j.crad.2017.11.015
21. Olczak J, Fahlberg N, Maki A, Razavian AS, Jilert A, Stark A, et al. Artificial intelligence for analyzing orthopedic trauma radiographs Deep learning algorithms-are they on par with humans for diagnosing fractures? Acta Orthopedica. 2017;88(6):581–6. doi: 10.1080/17453674.2017.1344459
22. Chung SW, Han SS, Lee JW, Oh KS, Kim NR, Yoon JP, et al. Automated detection and classification of the proximal humerus fracture by using deep learning algorithm. Acta Orthop. 2018;89(4):468–73. doi: 10.1080/17453674.2018.1453714
23. Gan KF, Xu DL, Lin YM, Shen Y, Zhang T, Hu K, et al. Artificial intelligence detection of distal radius fractures: a comparison between the convolutional neural network and professional assessments. Acta Orthopedica. 2019;90(4):394–400. doi: 10.1080/17453674.2019.1600125
24. Langerhuizen DWG, Janssen SJ, Mallee WH, Van Den Bekerom MPJ, Ring D, Karkhoffs GMMJ, et al. What Are the Applications and Limitations of Artificial Intelligence for Fracture Detection and Classification in Orthopedic Trauma Imaging? A Systematic Review. Clin Orthop Relat Res. 2019; 477(11):2482-91. doi: 10.1097/CORR.0000000000000848
25. Liang S, Tang F, Huang X, Yang K, Zhong T, Hu R, et al. Deep-learning-based detection and segmentation of organs at risk in nasopharyngeal carcinoma computed tomographic images for radiotherapy planning. Eur Radiol. 2019;29(4):1961–7. doi: 10.1007/s00330-018-5748-9
26. Wong K, Gallant F, Szumacher E. Perceptions of Canadian radiation oncologists, radiation physicists, radiation therapists and radiation trainees about the impact of artificial intelligence in radiation oncology–national survey. J Med Imaging Radiat Sci. 2021;52(1):44–8. doi: 10.1016/j.jmir.2020.11.013
27. Abdullah R, Fakieh B. Health Care Employees' Perceptions of the Use of Artificial Intelligence Applications: Survey Study. J Med Internet Res. 2020;22(5):e17620. doi: 10.2196/17620
28. Sit C, Srinivasan R, Amlani A, Muthuswamy K, Azam A, Monzon L, et al. Attitudes and perceptions of UK medical students towards artificial intelligence and radiology: a multicentre survey. Insights Imaging. 2020;11:14. doi: 10.1186/s13244-019-0830-7

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