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Exploring Turkish equivalents of terms for musculoskeletal radiology: insights for a standardized terminology

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ABSTRACT

Aims: This study aimed to provide an analysis of Turkish equivalents of English terms for musculoskeletal radiology.

Methods: The present study focuses on a global endorsement of English terms in musculoskeletal radiology, and explores how their Turkish equivalents are used in reference books (Turkish translation of the books, Diagnostic Imaging: Musculoskeletal: Trauma and Diagnostic Imaging: Musculoskeletal: Non-Traumatic Disease). Furthermore, the study attempts to provide a picture of how AI-based tools (i.e. neural machine translation tools such as DeepL, Google Translate and an AI Chatbot, ChatGPT) vary in the translation of these terms.

Results: The study found that the most common translation strategies for musculoskeletal radiology terms were borrowing and literal translation, with several combined strategies used for complex terms. AI-based tools like DeepL, Google Translate, and ChatGPT showed a high similarity to human translations, but differences were observed in word choice, strategy use, and orthographic variations. These differences, though minor, highlight the challenges of achieving consistency and accuracy in AI-generated medical translations.

Conclusion: The present study provides a list of Turkish equivalents for musculoskeletal terminology in English, and presents an analysis of translations by radiology specialists and AI-based tools. Careful evaluation of AI translations is essential to ensure accuracy and consistency in the translation of medical terminology, particularly in subspecialities such as musculoskeletal radiology.

Keywords: Radiology, musculoskeletal radiology, AI-based translation tools, terminology

INTRODUCTION

In the relevant literature, there have been several studies investigating how terminology is used in radiology, particularly in radiological reports. Radiologists and the referring physicians might use different lexicons, which will result in confusion with radiology reporting.[1] With the technological advancements, this is also crucial today for automatic radiology report generation.[2] A survey was conducted with radiologists and primary care physicians to understand their interpretation of the presence of metastatic disease based on the terminology used in a fictitious report.[1] The results demonstrated an agreement between the two groups, yet radiologists gave a higher likelihood for several phrases when compared to the primary care physicians. In an earlier study, a group of researchers investigated the extent of the agreement between radiologists and non-radiologists in terms of the use of terms to convey diagnostic certainty in radiology reports[3]. To this end, they administered an interview with 12 randomly selected radiologists from 6 different subspecialties, and identified the 15 most frequently used words and phrases. The researchers prepared a questionnaire including these words and phrases in a random order and asked radiologists and other physicians to rank these terms in order of the diagnostic certainty. The results revealed that there was poor agreement, thereby suggesting the need for a standardization of terminology. The radiology community has recognized that a standard terminology is essential to improve the clarity of radiology reports, to decrease variation, to facilitate access to imaging data, and to enhance the quality of practice. To this end, there have been attempts to develop a controlled terminology for radiology. For instance, Radiological Society of North America (RSNA) has built RadLex to provide a standardized and comprehensive set of terms for radiology reporting, teaching and conducting research.[4] Furthermore, there have been attempts to enhance RadLex[5] and converting it into a structured hierarchical text report.[6] Additionally, researchers have provided lists of standardized terms for particular topics. To illustrate, a recent study attempted to present a consensus glossary for thoracic

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radiology in Portuguese.[7] The experts from Brazil and Portugal presented a consensus statement for reporting chest images. The list included 60 terms in total including acinus, air trapping, fungus ball, broncholith, etc. In another study, researchers aimed to provide a standardized terminology for liver imaging for research, education and clinical care of patients.[8] The aim of the present study is to focus on a global endorsement for musculoskeletal radiology terminology,[9] their Turkish equivalents and how AI-based tools translate these terms.

Terminology for Musculoskeletal Radiology

Over the past 100 years, musculoskeletal radiology has evolved into a major imaging subspecialty.[10] Along with the developments in the field, there have been few studies on the terms of musculoskeletal radiology across the world. For instance, a recent study addressed the need for a standardized terminology in MRI descriptions of musculoskeletal inflections.[11] To this end, the Society of Skeletal Radiology developed a consensus on nomenclatures and identified the definition, diagnosis as well as controversies and rationale for each term through discussions and endorsements. They presented a list of 19 terms related to the categories including soft tissue, joints/tendon sheaths, bone surface, medullary space, and necrosis. The challenges posed by inconsistent terminology in describing musculoskeletal findings on MRI were also discussed.[12] It was emphasized that ambiguous terms such as meniscal tears, bone bruises, joint subluxation, etc. might lead to miscommunication among radiologists and clinicians, and thus influencing patient care. More recent and comprehensive study was administered by Palmer et al.[9] The researchers compiled a list of terms for musculoskeletal radiology. The authors included members of the International Skeletal Society, representing Asia, Australia, Europe and the USA. They selected 101 terms for inclusion and obtained consensus agreement from 19 musculoskeletal radiology societies worldwide.

The anatomical structures, disease processes, and syndromes that are essential to the musculoskeletal lexicon are the main topics of the glossary. The researchers reported that they prioritized the terms that potentially have problematic meaning, and due to the prevalence of musculoskeletal disorders and derangement, many terms related to neoplasm, spine, intervention, and pediatrics were excluded from the glossary. The final list of terms was formed with the global endorsement of the 19 societies. Due to the significant consensus and large terminology included in Palmer et al.,[9] the present study attempted to provide a general picture of how Turkish equivalences of these terms are used in books and journal articles by radiologists in Turkiye. Furthermore, the present study will also present a discussion of how AI-based translation tools (DeepL, Google Translate and ChatGPT within the scope of this study) translated these terms.

Translation of Medical Terminology

Medical translation has always remained an important topic throughout the human history. Medical translation "is the most universal and the oldest field of scientific translation.[13]Mombasa and Manila It is often regarded to be limited to extremely specialist materials and complex medical terminology.[14] Nevertheless, medical translation is of great importance for clinical practice, physician-patient communication, education and research, particularly in today's world. Medical terminology has a special place from a translation perspective. The level of formality, technicality, and the means of communication in medical language varies depending on the genre and context.[15] Medical language has a large number of Greek and/or Latin-derived terms that frequently have equivalents in ordinary everyday language (e.g. hemorrhage vs. bleeding).[16] There might also be multiple equivalents for the same term (e.g. adhesive capsulitis vs. frozen shoulder or scapulohumeral periarthritis) in formal settings. Neologisms are a reflection of the ever-evolving field of medical research and ongoing discoveries and developments. Every year, the World Health Organization (WHO) reports that thousands of new terms are coined as a consequence of new research, theoretical shifts, or duplications of existing medical concepts.[14] This level of varieties in medical terminology might be challenging for translation, and thus communicative situations in healthcare. In a recent study, for instance, researchers explored the elements of medical terminology which are particularly challenging for translation, the examples of which included acronyms, culture-specific items, terminological variations, and neologisms.[14]

In the relevant literature, even though there have been some attempts to present standardized terminologies for various subspecialities and topics, there have been very few studies addressing the translation strategies used to cope with medical terminology. There is a thorough summary of the primary translation issues, the varied definitions of fidelity in translation, and potential translation procedures pointed out in the relevant literature such as exoticism, cultural borrowing, calque, transliteration, cultural transplantation, etc.[16] In another study, researchers analyzed the strategies for translating medical terminology about COVID-19 from English into Macedonian.[14] They examined a corpus of 130 terms, highlighting challenges in conveying accurate and consistent terminology for diverse audiences including medical professional and the public. Relying on Vinay and Darbelnet's model,[17] the study identified methods for structured terminology, ensuring clarity and effective communication. More recently, the English translation strategies for Mongolian medical terminology were explored, emphasizing specificity, scientific basis, and cultural distinctiveness.[18] The study underscored the challenges in translating the terms into English, given their strong ties to Mongolian cultural heritage and their technical complexity. It outlined four key translation strategies: literal translation, transliteration, free translation, and a combined approach, which are used to preserve the cultural and professional essence while ensuring accessibility and comprehensibility for audiences.

Due to the dynamic and varied nature of translation strategies for medical terminology, the present study relied on Vinay and Darbelnet's model, which presents a clear picture of the translation categories and strategies, and widely used

to ensure effective and context-dependent translation. The model outlines 7 translation strategies divided into two categories, namely direct translation and oblique translation.[17] Direct translation is used when it is possible to transpose a source language element by element into a target language. The translation strategies in this category include borrowing (using the same word for the source language, e.g. 'aspirin'), calque (a literal translation of expressions or phrases, e.g. 'skyscraper' in English becomes 'gökdelen' in Turkish, structurally similar, as well), and literal translation (word-for-word translation from one language to another). On the other hand, oblique translation is employed when greater linguistic or cultural differences and it consist of the following strategies; transposition (alteration of word class, e.g. verb to noun), modulation (shifting perspectives or viewpoints, e.g. 'negative test result' becomes 'test sonucu temiz'), equivalence (expression of the same idea with culturally appropriate terms), and adaptation (modifying concepts to suit cultural norms, e.g. translating 'pediatrician' to 'çocuk doktoru' for cultural relevance).

AI-based Tools in Musculoskeletal Radiology and Terminology

Artificial intelligence (AI) has gained major attention in musculoskeletal radiology. There have many studies highlighting how AI might be utilized throughout the entire imaging workflow.[19,20] A current study examined the diagnostic performance of ChatGPT based on textual vs. visual information in musculoskeletal radiology and they provided a comparison with the radiologists' diagnostic performance.[21] To this end, they provided medical history and imaging findings input into GPT-4- based ChatGPT and GPT-4V-based ChatGPT. Furthermore, two radiologists, including a radiology resident and a board-certified radiologist, provided diagnoses for all cases. GPT-4-based ChatGPT (accuracy rate: 43%) demonstrated a comparable performance to the radiology resident (41%), yet lower than that of the board-certified radiologist (53%). GPT-4V-based ChatGPT had the lowest performance (accuracy rate: 8%). In another study, it was explored how AI might shape the entire imaging workflow in musculoskeletal radiology.[22] More precisely, they attempted to show the transformative potential of AI in both interpretive tasks (e.g., image analysis and diagnosis) and noninterpretive tasks (e.g., scheduling and reporting). A group of researchers sought to test how AI algorithm performed against experienced radiologist in musculoskeletal radiology.[23] They used four datasets of conventional hand, wrist, and scaphoid radiographs for training and diagnosing scaphoid fractures. Furthermore, the AI algorithm was compared with the analysis of 5 experienced musculoskeletal radiologists. The results revealed that the algorithm detected the fractures at the level of experienced radiologists and might be utilized in order to shorten their reading time.

Research has indicated that ChatGPT has the potential to revolutionize radiology reporting by ensuring precision and standardization.[24,25] Given that recent studies have argued the role and performance of AI on various applications such as diagnosis, classification, and radiology report generation,[26] it might be notable to explore how AI-based tools such as DeepL, Google Translate and ChatGPT translate these terms into other languages. AI-based translation tools have a great potential and contribution especially in terms of translation accuracy and speed.[27] Exploring the performance of NMT tools, DeepL and Google Translate, the researchers found that these tools provided accurate results in informative texts,[28] yet had challenges in narrative and functional texts. In another study, the performance of ChatGPT was examined and it was reported that the AI tool produced publishable texts with human post-editing.[29] Therefore, the present study seeks to explore how AI-based translation tools performed at translating musculoskeletal terminology. This study focuses on the translation of English terms into Turkish, and provides a comparison between the results of these tools and the translations by the radiology specialists.

METHODS

The study was carried out without involvement of any animate beings. Hence, an ethics committee approval was not required. All steps were carried out in accordance with the ethical rules and the principles.

Materials

The materials for exploring the Turkish equivalents of the terms included the reference books for musculoskeletal radiology translated into Turkish and AI-based translation tools, namely DeepL, Google Translate and ChatGPT. There were two reference books examined in detail for the Turkish equivalents. These included the Turkish translations of the books entitled "musculoskeletal: trauma" and "musculoskeletal: non-traumatic disease" from diagnostic imaging series. The former was authored by Sonin, Manaster, Andrews, Crim, and Tuite, and the 1st edition was published in 2010. The latter was authored by Manaster, Roberts, Petersilge, Moore, Hanrahan, and Christopher, and the 1st edition was published in 2012.

The books were translated from English into Turkish under the leadership of Prof. Dr. Remide Arkun and with contributions of several other radiology specialists in the field of musculoskeletal radiology. The first book entitled "diagnostic imaging, musculoskeletal: trauma" was translated as "diagnostic imaging, kas-iskelet: travma". The book consisted of 7 chapters including an introduction, shoulder and humerus, elbow, wrist and hand, hip and pelvis, knee, and ankle and foot. The second book entitled "diagnostic imaging, musculoskeletal: non-traumatic disease" was translated as "diagnostic imaging, kas-iskelet: travma dışı hastalıklar" and it comprised 12 chapters. These chapters were arthritis, osseous tumors and tumor-like conditions, soft tissue tumors, congenital and developmental abnormalities, dysplasias, systemic diseases with MSK involvement, orthopedic implants or arthrodesis, infection, bone marrow, bone marrow edema and necrosis, metabolic bone disease, and drug-induced and nutritional MSK conditions.

Palmer et al.[28] selected and received consensus on a list of 101 terms for musculoskeletal radiology. The same list was checked in the Diagnostic Imaging reference books for musculoskeletal radiology. There were only 5 terms which were not found

either in the English source texts or in the Turkish translation texts. Therefore, there were 96 terms examined in the present study. Furthermore, the same list of 96 terms were translated by using the well-known neural machine translation tools, namely DeepL and Google Translate, and ChatGPT, which is frequently employed in AI-based research on radiology.

RESULTS

The present study, thus, attempted to provide an analysis of the Turkish equivalents of the terms which previously received a global endorsement for musculoskeletal radiology, how they were translated into Turkish. To this end, the reference books translated from English into Turkish were examined. There were 96 terms identified in the English source texts and its Turkish translations. Furthermore, given that AI-based technology has also started to be used in image processing, diagnosis and report generation in radiology, the present study aimed to explore how AI-based tools translated these terms in Turkish, as well. Therefore, the result part presents an analysis of how English terms were used by Turkish radiology specialists in the translation of the reference books for musculoskeletal radiology. Afterwards, the translation suggestions by AI-based tools (DeepL, Google Translate and ChatGPT within the scope of this study) are explored and further discussed.

Turkish Equivalents of Terms for Musculoskeletal Radiology

The Turkish translations of the terms for musculoskeletal radiology were examined based on the translation strategies suggested by Vinay and Darbelnet's model. When all the terms and the translation strategies were considered, the most frequently used strategy were borrowing (n: 83), e.g. translating 'adhesive capsulitis' into Turkish as 'adeziv kapsülit' and literal translation (n: 53), e.g. translating 'groin pain' into Turkish as 'kasık ağrısı'. Given that some terms included multiple words, there were also more than one strategy used in the translations of each term, as well. The translation strategies employed included 10 different patterns in general as follows: adaptation+borrowing (n: 1), borrowing+literal translation (n: 23), borrowing (n: 41), borrowing+literal translation+addition (n: 2), borrowing+equivalence (n: 2), literal translation+equivalence (n: 1), literal translation (n: 11), literal translation+borrowing (n: 14), borrowing+addition+literal translation (n: 1), and calque+literal translation (n: 2). In the translation of medical terms for musculoskeletal terminology, thus the most frequent patterns were borrowing, borrowing+literal translation, literal translation+borrowing, and literal translation respectively (see appendix for **Table 1 and 2** illustrating the Turkish equivalents of the English terms for musculoskeletal radiology: an analysis of how the terms were used in the reference books).

Adaptation+borrowing: There is only 1 example for this pattern, which is for the translation of 'boutonniere deformity'. Boutonniere means 'yaka çiçeği' in Turkish, another name for Boutonniere deformity in English is button hole deformity. Due to this difference, the Turkish preference was adapted as translation for this term. Nevertheless, the word 'deformity' is received only with minor orthographic changes in transliteration (i.e. spelling the term according to the alphabetical characters of the target language). Thus, a combination of both adaptation and borrowing is observed.

Borrowing+literal translation: This patter in observed in 23 examples. For the terms which comprises more than one words, a combination of borrowing and literal translation strategies is quite frequently preferred. For instance, 'atypical femoral fracture' is translated as 'atipik femur kırığı', where the first two words are borrowed, yet the last word 'fracture' is translated into Turkish as 'kırığı".

Borrowing: For the terms which consist of only one word or two words, employing merely 'borrowing' strategy was observed in 41 cases. To illustrate, 'chondromalacia' was used as 'kondromalazi', merely with minor orthographic changes in transliteration.

Borrowing+literal translation+addition: In 2 examples, there were also additions to the term in the Turkish translation. The terms were 'ankle, anterior (anteromedial, anterolateral) impingement' and 'ankle, posterior (posteromedial) impingement'. In the Turkish translations, the word 'sendromu' was also added, so the translation ended, for instance, as 'anterior (anteromedial, anterolateral) sıkışma sendromu, ayak bileği'.

Borrowing+equivalence: In 2 cases, the pattern of borrowing and equivalence was observed. For instance, 'carpal boss' was translated as 'karpal kemik' where the Turkish equivalence for boss was used, and for 'cyclops syndrome', the word 'lezyon' was preferred and the term was translated as 'siklops lezyonu', where the word 'siklops' was borrowed, yet an equivalent word was used for syndrome.

Literal translation+equivalence: There was only 1 case of literal translation and equivalence. For 'bone bruise', the translation choice was 'kemik kontüzyonu'. Bone is translated as 'kemik', which is a word-to-word translation. Bruise, on the other hand, has a literal translation, which is 'çürük', yet it is translated as 'contusion'.

Literal translation: The mere use of literal translation as a translation strategy was observed in 11 examples. For instance, 'bone island' was translated word-to-word as 'kemik adası', and 'sprain' was translated as 'burulma'. The translation of 'O'Donoughe's triad' was also accepted as an example of literal translation. The full term in English is 'O'Donoughe's unhappy triad'. However, the full term is not found in the original English source text, nor in the Turkish translations. In the English text, only 'unhappy triad' is used, which is literally translated into Turkish as 'mutsuz üçlü'. Therefore, instead of excluding the term from the analysis, the word was accepted as an example of literal translation within the scope of the present study.

Literal translation+borrowing: The pattern of literal translation and borrowing was also quite frequent with 14 cases. Although the same strategies with the pattern of 'borrowing and literal translation' was employed, this pattern was also categorized additionally to underline that the literal translation was first employed for initial words

Table 1. Turkish equivalents of the English terms for musculoskeletal radiology: an analysis of how the terms were used in the reference books

Nr.	English term	Turkish equivalent [reference books]	Translation strategies
1	Acetabular labral tear	Asetabular labrum yırtığı	Borrowing+literal translation
2	Acetabular retroversion	Asetabular retroversiyon	Borrowing
3	Adhesive capsulitis	Adeziv kapsülit (other usages: donum omuz/ scapulohumeral periartrit)	Borrowing
4	Ankle, anterior (anteromedial, anterolateral) impingement	Anterior (anteromedial, anterolateral) sıkışma sendromu, ayak bileği	Borrowing+ literal translation+addition
5	Ankle, posterior (posteromedial) impingement	Posterior (posteromedial) sıkışma sendromu, ayak bileği	Borrowing+ literal translation+addition
6	Anterolateral ligament of the knee	Anterolateral bağ	Borrowing+literal translation
7	Atypical femoral fracture	Atipik femur kırığı	Borrowing+literal translation
8	Avulsion fracture	Avülziv yaralanma/avülziyon kırığı	Borrowing+literal translation
9	Bone bruise	Kemik kontüzyonu	Literal translation+equivalence
10	Bone island	Kemik adası	Literal translation
11	Bone marrow edema	Kemik iliği ödemi	Literal translation
12	Bone mineral density	Kemik mineral yoğunluğu	Literal translation
13	Boutonniere deformity	Düğme iliği deformitesi	Adaptation+borrowing
14	Brodie's abscess	Brodie absesi	Borrowing
15	Buford complex	Buford kompleks	Borrowing
16	Cancellous bone	Sesamoid kemik/süngerimsi kemik	Literal translation
17	Carpal boss	Karpal kemik	Borrowing+equivalence
18	Carpet lesion		
19	Chondromalacia	Kondromalazi	Borrowing
20	Compartment syndrome	Kompartman sendromu	Borrowing
21	Coracoacromial arch	Korokoakromiyak ark	Borrowing
22	Cortical bone	Kortikal kemik	Borrowing+literal translation
23	Crescent sign of osteonecrosis	Kresent işareti	Borrowing+literal translation
24	Cyclops syndrome	Siklops lezyon	Borrowing+equivalence
25	Denervation myopathy	Denervasyon miyopati	Borrowing
26	Double line sign in osteonecrosis	Osteonekrozu çift çizgi işareti	Literal translation+borrowing
27	Enthesopathy	Entesopati	Borrowing
28	Epicondylitis	Epikondilit	Borrowing
29	Femoral diaphyseal stress injury	Femur diyafiz stres hasarı	Borrowing+literal translation
30	Friction syndrome	Sürtünme sendromu	Literal translation+borrowing
31	Geyser sign	Geyser işareti	Borrowing+literal translation
32	Glenoid retroversion	Glenoid retroversiyon	Borrowing
33	Groin pain	Kasık ağrısı	Literal translation
34	Haglund's syndrome	Haglund sendromu	Borrowing
35	Heterotopic ossification	Heterotopic osifikasyon	Borrowing
36	Hill-Sachs defect	Hill-Sachs defekt	Borrowing
37	Hip impingement, cam deformity	Kalça sıkışma sendromu, cam deformitesi	Literal translation+borrowing, borrowing
38	Hip impingement, femoroacetabular	Femoral asetabular sıkışma	Borrowing+literal translation
39	Hip impingement, ischiofemoral	Iskifemoral sıkışma	Borrowing+literal translation
40	Hip impingement, pincer deformity	Kıskaç/pincer tip sıkışma	Literal translation/borrowing+addition+literal translation
41	Iliotibial band friction syndrome	İliotibiyal bant sürtünme sendromu	Borrowing+literal translation
42	Impingement syndrome	Sıkışma sendromu	Literal translation+borrowing
43	Intersection syndrome	Kavşak sendromu	Literal translation+borrowing
44	Ivory vertebra	Fildişi vertebra	Literal translation+borrowing
45	Lisfranc joint	Linsfrank eklemi	Borrowing+literal translation
46	Looser zone	Looser hatları/milkman kırıkları/yalancı kırıklar	Borrowing+literal translation
47	Medial tibial stress syndrome	Medial tibial stres sendromu	Borrowing
48	Metallosis	Metalozis	Borrowing
49	Mucoid change	Mukoid değişiklik	Borrowing+literal translation
50	Muscle injury	Kas yaralanması	Literal translation
51	Myonecrosis	Kas enfarktı	Literal translation+borrowing (muscle infarction, alternative to myonecrosis)
52	Myopathy	Miyopati	Borrowing
53	Myositis	Miyozit	Borrowing
54	Myositis ossificans	Miyozitis osifikans	Borrowing
55	Myotendinous junction	Kas-tendon bileşkesi	Calque+literal translation
56	Myotendinous unit	Kas-tendon ünitesi	Calque+literal translation
57	Necrotizing fasciitis	Nekrozitan fasiit	Borrowing

Table 1. Turkish equivalents of the English terms for musculoskeletal radiology: an analysis of how the terms were used in the reference books (continues)

Nr.	English term	Turkish equivalent [reference books]	Translation strategies
58	O'Donoghue's triad	Mutsuz üçlü	Literal translation (O'Donoghue's unhappy triad; "O'Donoghue" is omitted both in English source text and in Turkish text).
59	Osteitis condensans ilii	Osteitis kondensans ilii	Borrowing
60	Osteochondral defect	Osteokondral defekt	Borrowing
61	Osteochondritis dissecans	Osteokondritis disekans	Borrowing
62	Osteonecrosis	Osteonekroz	Borrowing
63	Osteoporosis	Osteoporoz	Borrowing
64	Paratenonitis	Tenosinovit	Borrowing
65	Pathologic fracture	Patolojik kırık	Borrowing+literal translation
66	Periosteal reaction	Periost reaksiyonu	Literal translation
67	Plantar plate	Plantar fasya	Borrowing+literal translation
68	Pseudarthrosis	Psödoartroz	Borrowing
69	Quadrilateral space syndrome	Kuadrilateral mesafe sendromu	Borrowing+literal translation
70	Ramp lesion		
71	Reaction to metal		
72	Reactive arthritis	Reaktif artrit	Borrowing
73	Rice bodies	Pirinç cisimleri	Literal translation
74	SAPHO syndrome	SAPHO	Borrowing
75	Sarcopenia		
76	Serous atrophy of bone marrow	Seröz atrofi, kemik iliği	Borrowing+literal translation
77	Shoulder, glenohumeral instability	Omuz, glenohumeral instabilite	Literal translation+borrowing
78	Shoulder, posterosuperior impingement	Omuz, posterosuperior sıkışma	Literal translation+borrowing
79	Shoulder, rotator cuff tear (full thickness)	Omuz, rotator cuff/kılıf yırtığı (tam kat)	Literal translation+borrowing
80	Shoulder, rotator cuff tear (overview)	Omuz, rotator cuff/kılıf yırtığı (tam kata yakın)	Literal translation+borrowing
81	Shoulder, rotator cuff tear (partial thickness)	Omuz, rotator cuff/kılıf yırtığı (kısmi)	Literal translation+borrowing
82	Shoulder, SLAP tear (superior labrum anterior-to-posterior	SLAP yırtık	Borrowing+literal translation
83	Shoulder, subacromial impingement	Omuz, subakromiyal sıkışma	Literal translation+borrowing
84	Skier's thumb	Kayakçı başparmağı	Literal translation
85	Sprain	Gerilme/burkulma	Literal translation
86	Stress fracture	Stres kırığı	Borrowing+literal translation
87	Stress response	Stres cevabı	Borrowing+literal translation
88	Subchondral insufficiency fracture	Subkondral yetmezlik kırığı	Borrowing+literal translation
89	Subluxation	Subluksasyon	Borrowing
90	Swan neck deformity	Kuğu boynu deformitesi	Literal translation+borrowing
91	Synovitis	Sinovit	Borrowing
92	Tendinopathy	Tendinopati	Borrowing
93	Tophus	Tofüs	Borrowing
94	Torsion	Torsiyon	Borrowing
95	Transient osteoporosis	Transiyet kemik iliği ödem sendromu	Borrowing+literal translation
96	Trochanteric syndrome	Trokanterik sendrom	Borrowing
97	Tubulation	Tubulasyon	Borrowing
98	Tunnel syndrome	Tünel sendromu	Borrowing
99	Ulnar impaction syndrome	Ulnar impaksiyon sendromu	Borrowing
100	Version	Retroversiyon (bileşik halde kullanılıyor)	Borrowing
101	Wolff's law		

and later word(s) was kept and borrowing strategy was preferred. Otherwise, in terms of the usage of strategies, both patterns might be considered similar. An example of literal translation+borrowing was the translation of 'swan neck deformity', which was 'kuğu boynu deformitesi'. The first two words 'kuğu boynu' are the examples of literal translation, whereas 'deformitesi' is an example of borrowing strategy. Additionally, the translation of 'myonecrosis' was also accepted as an example of 'literal translation+borrowing'. An alternative term for myonecrosis in the literature is muscle infarction, for the Turkish translation, 'kas enfarktı' is preferred, where 'kas' is an example of literal translation and 'enfarktı' is an example of borrowing.

Borrowing+addition+literal translation: There was also 1 example of borrowing+addition+literal translation, where 'hip impingement, pincer deformity' was translated as 'pincer tip sıkışma'. This term defines one subtype of hip impingements. Even though the word 'tip (i.e. type in English) is not in the English term, it is also included in the Turkish translation to highlight the type of impingement.

Calque+literal translation: The last example of the pattern for translation strategies included calque and literal translation. There were 2 cases, including the word 'myontendinous' where myo means 'related to muscle' and tendinous refers to 'related to tendon'. The word was translated into Turkish

Table 2. Turkish translations of the English terms for musculoskeletal radiology: an analysis of how NMT and AI-based tools translate medical terms

Nr.	English Term	DeepL	Google Translate	ChatCPT
1	Acetabular labral tear	Asetabular labral yırtık	Asetabular labral yırtığı	Asetabular labrum yırtığı
2	Acetabular retroversion	Asetabular retroversiyon	Asetabular retroversiyon	Asetabular retroversiyon
3	Adhesive capsulitis	Yapışkan kapsülit	Adhesif kapsülit	Adeziv kapsülit
4	Ankle, anterior (anteromedial, anterolateral) impingement	Ayak bileği, anterior (anteromedial, anterolateral) sıkışma	Ayak bileği, anterior (anteromedial, anterolateral) sıkışma	Ayak bileği, ön (anteromedial, anterolateral) sıkışma
5	Ankle, posterior (posteromedial) impingement	Ayak bileği, posterior (posteromedial) sıkışma	Ayak bileği, posterior (posteromedial) sıkışma	Ayak bileği, arka (posteromedial) sıkışma
6	Anterolateral ligament of the knee	Dizin anterolateral bağı	Diz anterolateral bağı	Diz anterolateral bağ
7	Atypical femoral fracture	Atipik femur kırığı	Atipik femoral kırık	Atipik femur kırığı
8	Avulsion fracture	Avülsiyon kırığı	Avulsiyon kırığı	Avulsiyon kırığı
9	Bone bruise	Kemik çürüğü	Kemik çürüğü	Kemik kontüzyonu
10	Bone island	Kemik adası	Kemik adası	Kemik adacığı
11	Bone marrow edema	Kemik iliği ödemi	Kemik iliği ödemi	Kemik iliği ödemi
12	Bone mineral density	Kemik mineral yoğunluğu	Kemik mineral yoğunluğu	Kemik mineral yoğunluğu
13	Boutonniere deformity	Yaka çiçeği deformitesi	Boutonniere deformitesi	Boutonniere deformitesi
14	Brodie's abscess	Brodie'nin apsesi	Brodie apsesi	Brodie apsesi
15	Buford complex	Buford kompleksi	Buford kompleksi	Buford kompleksi
16	Cancellous bone	Kansellöz kemik	Süngersi kemik	Spongiyöz kemik
17	Carpal boss	Karpal patron	Karpal çıkıntı	Karpal kemik çıkıntısı
18	Carpet lesion	Halı lezyonu	Halı lezyonu	Halı lezyonu
19	Chondromalacia	Kondromalazi	Kondromalazi	Kondromalazi
20	Compartment syndrome	Kompartman sendromu	Komppartman sendromu	Kompartman sendromu
21	Coracoacromial arch	Korakoakromiyal kemer	Korakoakromial ark	Korakoakromial ark
22	Cortical bone	Kortikal kemik	Kortikal kemik	Kortikal kemik
23	Crescent sign of osteonecrosis	Osteonekrozun hilal işareti	Osteonekrozun hilal işareti	Osteonekrozun hilal belirtisi
24	Cyclops syndrome	Cyclops sendromu	Siklops sendromu	Cyclops sendromu
25	Denervation myopathy	Denervasyon miyopatisi	Denervasyon miyopatisi	Denervasyon miyopatisi
26	Double line sign in osteonecrosis	Osteonekrozda çift çizgi işareti	Osteonekrozda çift çizgi işareti	Osteonekrozda çift çizgi belirtisi
27	Enthesopathy	Entesopati	Entesopati	Entezopati
28	Epicondylitis	Epikondilit	Epikondilit	Epikondilit
29	Femoral diaphyseal stress injury	Femoral diyafiz stres yaralanması	Femoral diafiz stres yaralanması	Femur diyafiz stres yaralanması
30	Friction syndrome	Sürtünme sendromu	Sürtünme sendromu	Sürtünme sendromu
31	Geyser sign	Gayzer işareti	Gayzer işareti	Geyser belirtisi
32	Glenoid retroversion	Glenoid retroversiyonu	Glenoid retroversiyon	Glenoid retroversiyon
33	Groin pain	Kasık ağrısı	Kasık ağrısı	Kasık ağrısı
34	Haglund's syndrome	Haglund sendromu	Haglund sendromu	Haglund sendromu
35	Heterotopic ossification	Heterotopik kemikleşme	Heterotopik kemikleşme	Heterotopik ossifikasyon
36	Hill-Sachs defect	Hill-Sachs defekti	Hill-Sachs defekti	Hill-Sachs defekti
37	Hip impingement, cam deformity	Kalça sıkışması, kam deformitesi	Kalça sıkışması, kam deformitesi	Kalça sıkışması, cam deformitesi
38	Hip impingement, femoroacetabular	Kalça sıkışması, femoroasetabular	Kalça sıkışması, femoroasetabular	Kalça sıkışması, femorosatabular
39	Hip impingement, ischiofemoral	Kalça sıkışması, iskiyofemoral	Kalça sıkışması, iskiofemoral	Kalça sıkışması, ischiofemoral
40	Hip impingement, pincer deformity	Kalça sıkışması, kıskaç deformitesi	Kalça sıkışması, pens deformitesi	Kalça sıkışması, pincer deformitesi
41	Iliotibial band friction syndrome	İliotibial bant sürtünme sendromu	İliotibial bant sürtünme sendromu	İliotibial bant sürtünme sendromu
42	Impingement syndrome	Sıkışma sendromu	Çarpışma sendromu	Sıkışma sendromu
43	Intersection syndrome	Kesişme sendromu	Kesişim sendromu	İnterseksiyon sendromu
44	Ivory vertebra	Fildişi omur	Fildişi omur	Fildişi vertebra
45	Lisfranc joint	Lisfranc eklemi	Lisfranc eklemi	Lisfranc eklemi
46	Looser zone	Daha gevşek bölge	Daha gevşek bölge	Looser zonu
47	Medial tibial stress syndrome	Medial tibial stres sendromu	Medial tibial stres sendromu	Medial tibial stress sendromu
48	Metallosis	Metallosis	Metalozis	Metallozis
49	Mucoid change	Mukoid değişim	Mukoid değişim	Mukoid değişim
50	Muscle injury	Kas yaralanması	Kas yaralanması	Kas yaralanması
51	Myonecrosis	Miyonekroz	Myonekroz	Miyonekroz
52	Myopathy	Miyopati	Miyopati	Miyopati
53	Myositis	Miyozit	Miyozit	Miyozit
54	Myositis ossificans	Miyozit ossifikans	Miyozit ossifikans	Miyozitis ossifikans
55	Myotendinous junction	Miyotendinöz kavşak	Miyotendinöz kavşak	Miyotendinöz bileşke
56	Myotendinous unit	Miyotendinöz ünite	Miyotendinöz ünite	Miyotendinöz ünite
57	Necrotizing fasciitis	Nekrotizan fasiit	Nekrotizan fasiit	Nekrotizan fasiit
58	O'Donoghue's triad	O'Donoghue'nun üçlüsü	O'Donoghue triadı	O'Donoghue triadı

Table 2. Turkish translations of the English terms for musculoskeletal radiology: an analysis of how NMT and AI-based tools translate medical terms (continues)

Nr.	English Term	DeepL	Google Translate	ChatCPT
59	Osteitis condensans ilii	Osteitis condensans ilii	Osteitis condensans ilii	Osteitis kondensans ilii
60	Osteochondral defect	Osteokondral defekt	Osteokondral defekt	Osteokondral defekt
61	Osteochondritis dissecans	Osteokondritis dissekans	Osteokondritis dissekans	Osteokondritis dissekans
62	Osteonecrosis	Osteonekroz	Osteonekroz	Osteonekroz
63	Osteoporosis	Osteoporoz	Osteoporoz	Osteoporoz
64	Paratenonitis	Paratenonit	Paratenonit	Paratenonit
65	Pathologic fracture	Patolojik kırık	Patolojik kırık	Patolojik kırık
66	Periosteal reaction	Periosteal reaksiyon	Periosteal reaksiyon	Periosteal reaksiyon
67	Plantar plate	Plantar plaka	Plantar plak	Plantar plak
68	Pseudarthrosis	Psödartroz	Psödartroz	Psödoartroz
69	Quadrilateral space syndrome	Dörtgen boşluk sendromu	Dörtgensel boşluk sendromu	Dörtgen boşluk sendromu
70	Ramp lesion	Rampa lezyonu	Rampa lezyonu	Ramp lezyonu
71	Reaction to metal	Metale karşı reaksiyon	Metale reaksiyon	Metale reaksiyon
72	Reactive arthritis	Reaktif artrit	Reaktif artrit	Reaktif artrit
73	Rice bodies	Pirinç gövdeleri	Pirinç cisimleri	Pirinç cisimcikleri
74	SAPHO syndrome	SAPHO sendromu	SAPHO sendromu	SAPHO sendromu
75	Sarcopenia	Sarkopeni	Sarkopeni	Sarkopeni
76	Serous atrophy of bone marrow	Kemik iliğinde seröz atrofi	Kemik iliğinin seröz atrofisi	Kemik iliği seröz atrofi
77	Shoulder, glenohumeral instability	Omuz, glenohumeral instabilite	Omuz, glenohumeral instabilite	Omuz, glenohumeral instabilite
78	Shoulder, posterosuperior impingement	Omuz, posterosuperior sıkışma	Omuz, posterosuperior sıkışma	Omuz, posteriyosuperior sıkışma
79	Shoulder, rotator cuff tear (full thickness)	Omuz, rotator manşet yırtığı (tam kalınlık)	Omuz, rotator manşet yırtığı (tam kalınlık)	Omuz, rotator manşet yırtığı (tam kalınlık)
80	Shoulder, rotator cuff tear (overview)	Omuz, rotator manşet yırtığı (genel bakış)	Omuz, rotator manşet yırtığı (genel bakış)	Omuz, rotator manşet yırtığı (genel bakış)
81	Shoulder, rotator cuff tear (partial thickness)	Omuz, rotator manşet yırtığı (kısmi kalınlık)	Omuz, rotator manşet yırtığı (kısmi kalınlık)	Omuz, rotator manşet yırtığı (kısmi kalınlık)
82	Shoulder, SLAP tear (superior labrum anterior-to-posterior	Omuz, SLAP yırtığı (superior labrum anterior-posterior)	Omuz, SLAP yırtığı (üst labrum ön-arka)	Omuz, SLAP yırtığı (üst labrum ön-arka)
83	Shoulder, subacromial impingement	Omuz, subakromiyal sıkışma	Omuz, subakromial sıkışma	Omuz, subakromial sıkışma
84	Skier's thumb	Kayakçının başparmağı	Kayakçının baş parmağı	Kayakçı başparmağı
85	Sprain	Burkulma	Burkulma	Burkulma
86	Stress fracture	Stres kırığı	Stres kırığı	Stres kırığı
87	Stress response	Stres tepkisi	Stres tepkisi	Stres yanıtı
88	Subchondral insufficiency fracture	Subkondral yetmezlik kırığı	Subkondral yetersizlik kırığı	Subkondral yetmezlik kırığı
89	Subluxation	Subluksasyon	Subluksasyon	Subluksasyon
90	Swan neck deformity	Kuğu boynu deformitesi	Kuğu boynu deformitesi	Kuğu boynu deformitesi
91	Synovitis	Sinovit	Sinovit	Sinovit
92	Tendinopathy	Tendinopati	Tendinopati	Tendinopati
93	Tophus	Tophus	Tophus	Tofüs
94	Torsion	Burulma	Torsiyon	Torsiyon
95	Transient osteoporosis	Geçici osteoporoz	Geçici osteoporoz	Geçici osteoporoz
96	Trochanteric syndrome	Trokanterik sendrom	Trokanterik sendrom	Trokanterik sendrom
97	Tubulation	Tübülasyon	Tübülasyon	Tübülasyon
98	Tunnel syndrome	Tünel sendromu	Tünel sendromu	Tünel sendromu
99	Ulnar impaction syndrome	Ulnar impaksiyon sendromu	Ulnar impaksiyon sendromu	Ulnar çarpma sendromu
100	Version	Versiyon	Sürüm	Versiyon
101	Wolff's law	Wolff yasası	Wolff yasası	Wolff yasası

as 'kas-tendon'. For instance, 'myontendinous junction' was translated into Turkish as 'kas-tendon bileşkesi', where 'kas-tendon' is an example of calque in the same structure and 'bileşkesi' is an example of literal translation, where it is translated word-to-word in an appropriate form.

To sum up, the study explored the Turkish translations of musculoskeletal radiology terms, focusing on the strategies proposed by Vinay and Darbelnet's model. Borrowing and literal translation emerged as the most frequently employed strategies, reflecting the technical and precise nature of medical terminology. Multi-word terms often required combining strategies, resulting in ten distinct patterns such as borrowing+literal translation. While the borrowing strategy dominated single-word or straightforward terms, more complex phrases demanded nuanced combinations including adaptation+borrowing or calque+literal translation. Thus, the analysis emphasizes the also highlighted the need for translators to reconcile the linguistic fidelity with the functional clarity of medical terms in the target language. This comprehensive investigation underscores the complexity of achieving accurate, culturally relevant translations in specialized fields, as in musculoskeletal radiology.

AI-based Tools and Translation of Medical Terms

The terms for musculoskeletal radiology were also translated through neural machine translation tools such as DeepL and Google Translate and an AI chatbot, namely ChatGPT. There were differences identified between the Turkish translations by radiology specialists in the reference books and the translations by AI-based tools. Nevertheless, the percentage of similarity was quite high. It was 55.20% for DeepL and likewise 55.20% for Google Translate, whereas the similarity was even higher for Chat GPT with 59.37% (see Appendix for the Turkish translations of the English terms for musculoskeletal radiology: An analysis of how NMT and AI-based tools translate medical terms). Even though the differences were due to minor alterations and alternative usages in the field, which does not heavily influence understanding, these variations should be avoided for ensuring standardized and accurate usage. The sources of differences included three major categories, namely word choice, choice of strategy use (e.g. using literal translation and borrowing instead of otherwise around), and variations in orthographic writing. For instance, for the term 'acetabular labral tear', the reference book used the translation 'asetabular labrum yırtığı' by employing borrowing and literal translation strategies. However, DeepL and Google Translate translated the term with a difference choice of borrowed word and gave the output of 'asetabular labral yırtık' (DeepL) and 'asetabular labral yırtığı' (Google Translate).

The choice of translation strategy use also leads to differences in the output. For instance, for 'bone bruise', the reference book used 'kemik kontüzyonu'by employing literal translation (for 'bone', 'kemik') and equivalence (for 'bruise', 'kontüzyonu') strategies, yet both DeepL and Google Translate translated the term word to word as 'kemik çürüğü', whilst ChatGPT suggested 'kemik kontüzyonu'. Another example is the translations of 'heterotopic ossification'. In the reference book, the borrowing strategy was used and the term was translated as 'heterotopik osifikasyon'. DeepL and Google Translate, on the other hand, translated the term as 'heteropik kemikleşme', suggesting a literal translation for the word 'ossification'.

The last type of source of differences included variations in orthographic writing. For instance, for 'heterotopic ossification', ChatGPT also followed the borrowing strategy, yet suggested the Turkish equivalent with double 's', 'heterotopik ossifikasyon'. How to write the word where borrowing strategy was used leads to the question of orthographic writing in several other ways, as well. The examples of these terms include Pseudarthrosis, Tophus, Osteitis condensans ilii, etc., where the challenge is to decide which letters to keep or change in accordance with the Turkish writing rules.

The distribution of the types of differences for DeepL can be listed as strategy use in translation (43.47%), word choice (28.26%), and orthographic writing (28.26%) respectively. The leading reason behind the difference between the translation of the radiology specialists and DeepL emerges to be strategy use. In other words, while the radiology specialist preferred to use literal translation, for instance, 'kas-tendon ünitesi' for myotendinous unit, DeepL suggested 'miyotendinöz ünite'. For Google Translate, it is word choice (45.23%), orthographic writing (33.33%), and strategy use (21.42%). In other words, word choice is the leading factor when it comes to Google Translate. For instance, Google Translate suggested 'kesişim sendromu' for 'intersection syndrome while the radiology specialist used 'kavşak sendromu' in the reference book. Lastly, for Chat GPT, the distribution is more consistent, strategy use (36.58%), word choice (31.70%) and orthographic writing (31.70%).

All in all, the present study compared the Turkish translations of musculoskeletal radiology terms from the reference books by the radiology specialists to those generated by neural machine translation (NMT) tools, DeepL and Google Translate, as well as AI-based tools, ChatGPT. While the AI tools exhibited a high percentage of similarity with the specialist translations-55.20% for DeepL and Google Translate, and 59.37% for ChatGPT-key differences were noted in word choice, translation strategy, and orthographic conventions. These differences, though minor, highlight the challenges of achieving standardization in medical translations. The findings emphasize the need for careful evaluation of AI-generated translations to ensure accuracy and consistency in specialized medical contexts.

DISCUSSION

The results of the present study align with and extend the findings of previous research in the field of medical terminology translation. Palmer et al.[9] emphasized the importance of achieving global consensus on musculoskeletal radiology terminology. Nevertheless, it is important to acknowledge the challenges posed by translating these terms into various languages. The Turkish translations analyzed in this study reveal that borrowing and literal translation were the most frequently used strategies, reflecting a similar tendency toward linguistic fidelity and technical precision observed in international studies. This adherence to established translation strategies underscores the universal difficulty in reconciling linguistic and functional equivalence in specialized fields like radiology.

Consistent with findings of some researchers, who highlighted the role of borrowing in medical terminology to preserve technical accuracy,[30] this study found that borrowing was predominantly employed, especially for single-word terms such as 'chondromalacia' ('kondromalazi'). However, the analysis also revealed nuanced patterns, such as the combined use of borrowing and literal translation for multi-word terms, highlighting the flexibility required in translating complex terms. These results point to a broader insight in medical translation, where standardization is crucial yet challenging due to linguistic and cultural variability.

The role of AI-based tools in medical translation was also explored, adding a novel dimension to the discussion. Consistent with the findings of a study, which demonstrated the potential of AI-based tools, the present study found a high degree of similarity (55.20%-59.37%) between translations by AI-based tools and those in the reference books. However, differences in strategy use, word choice, and orthographic conventions highlight limitations in the AI tools' ability to achieve standardized translations. For instance, the term

'acetabular labral tear' was translated differently by DeepL, Google Translate and ChatGPT, revealing variability in borrowing strategy implementation. These inconsistencies resonate with the concerns about the lack of contextual and domain-specific sensitivity in machine translations.

The study also sheds light on the challenges posed by orthographic variations, which were a significant source of differences in AI-generated translations. Orthographic consistency is critical for standardizing medical terminology. For instance, terms such as 'pseudarthrosis' require careful adaptation to Turkish orthography without compromising technical accuracy. The study's detailed categorization of translation strategies provides valuable insights into how AI tools might be improved to better align with the nuanced strategies employed by human specialists.

The present study focused on a recent study conducted by Palmer et al.,[9] which presented a consensus agreement globally on the English terms in the field of musculoskeletal radiology, and sought to provide an analysis of their Turkish equivalents so that a standardized terminology might be achieved for the use of radiology specialists and referring physicians.

Limitations

Furthermore, this study examined how AI-based tools translated the same terms into Turkish, as well, and discussed their similarities and differences. Nevertheless, the present study only relied on two reference books which were translated from English into Turkish. Even though, the translations were managed under the supervision of a radiology expert and with contributions of several other radiology specialists, the use of Turkish equivalents of these terms might vary in radiology reports as well as in academic publications. Future research might examine how these terms are used in the samples of radiology reports in Turkiye or in academic publications in Turkish, and gather comments and suggestions of the radiologists. Furthermore, radiology specialists might also show variance depending on individual differences such as their age range. Thus, future research might provide a comparison between terminology use of different age groups in radiology reports. Lastly, this study only focused on the Turkish translations of the English terms for musculoskeletal radiology, researchers might also explore the terminology equivalents in various language pairs as well as in other medical fields and subspecialties.

CONCLUSION

Overall, the results emphasize the need for standardized guidelines in the translation of medical terminology, particularly in specialized fields such as musculoskeletal radiology. While borrowing remains the dominant strategy, the use of hybrid strategies reflects the complexity of achieving functional clarity alongside linguistic fidelity. AI tools demonstrate potential but require refinement to address contextual and orthographic challenges more effectively. This study contributes to the growing body of literature on medical translation by highlighting the interplay between traditional human strategies and emerging AI capabilities.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out without involvement of any animate beings. Hence, an ethics committee approval was not required.

Informed Consent

Since the study was conducted without the participation of any living being, no written consent form was obtained.

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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