Original Article

Mapping Korean Medicinal Material Concepts to UMLS

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Objectives: This pilot study was carried out with the purpose of suggesting a methodology on mapping and registering Korean medicinal material concepts at 2011AB of the UMLS.
Methods: 411 medicinal material concepts were mapped to biomedical terminology within the metathesaurus of the UMLS. Based on the forms of listing on the UMLS and thesauri information, the medicinal material concepts were classified into three groups and mapped.
Results: 76 concepts in Group 1 which English CUIs have Chinese AUIs were mapped considering scientific names and Chinese strings. 259 concepts in Group 2 that have CUIs in the form of 'botanical name/Chinese pinyin' were mapped with the information of Korean and Chinese Pharmacopoeias. Groups 3, 76 concepts of English names in the Korean Pharmacopoeia are matched considering their botanic names and used parts.
Conclusion: This study suggested a methodology to map Korean medicinal material concepts to international standard terminology, which will help ensure interoperability and compatibility between traditional medicine terminology and the UMLS.

Key Words : Korean medicinal material concepts, UMLS, interoperability, traditional medicine terminology

Introduction

A medical terminology system offers systematic organization of various concepts and codes corresponding to diagnoses, symptoms and medicinal substances used in medical treatments. With the development of medical informatics, data are stored as electronic medical records (EMR), and as healthcare infrastructure is being established centering on electronic health record (EHR) and personal health records (PHR), there is a growing need for terminology uniform access consisting of machine-readable and standard biomedical information[1-5].

In western medicine, a variety of biomedical ter-minologies were built for its own purposes, and representative terminologies include Gene Ontology (GO), a genomics database, and the International Classification of Disease (ICD), and Systematic Nomenclature of Medicine (SNOMED), a pathology-centric terminology system, as well as the Medical Subject Headings (MeSH), a controlled vocabulary thesaurus used for indexing articles of Pubmed. The Unified Medical Language System (UMLS) of the National Library of Medicine (NLM) is a language system that integrates such varying databases and structured concepts based on a semantic network.

The UMLS has incorporated over 160 sources and research efforts are being continuously made to unify

concepts in order to ensure interoperability[1-6]. One way to establish connection between disparate biomedical terminologies is to link closely related concepts such as mapping the Gene Ontology to the UMLS[3,4] and mapping the SNOMED CT to MeSH[6]. Along with this, active research has been carried out[7-23] on how accurately a standard terminology system can cover interface terms through linkage between external terminology and the terminologies within the UMLS.

As for traditional medicine (TM), as the need to establish standard TM terminology for the purpose of information sharing and exchange in medical practice increases, studies have been carried out to develop such terminology and to interrelate it with various medical terminologies. X. Zhou et al.[24-26] have reported various developments with a unified traditional Chinese medical language system (UTCMLS) that supports integrated semantic network of concepts and relationships in traditional Chinese medicine (TCM) domain. HC Jang et al.[27] have constructed an ontology for medicinal materials that includes various herbal data and relates clinical concepts in traditional Korean medicine (TKM). Comparative studies[28-30] were performed on WHO international standard terminologies on traditional medicine in the western pacific region (IST)[31] and local terminologies, and efforts were made to analyze UMLS' semantic network and metathesaurus for analysis in relation to local terminology or concepts from TM classics[32,33].

In addition to such efforts, the Information Research Center under KIOM has been carrying out a five-year 'Ontology-based Traditional Korean Medicine Knowledge Framework' project since 2009, and studies to refine and standardize terminology for traditional medicine have been on-going as a specific task under this project. The task mainly involves collecting and refining a total of 30,000 representative conceptual terms for three years from 2009 to 2011, and establishing a concept-centric, UMLS-based management system that can efficiently control and utilize such terms. Currently, KIOM is listing parts of already established terminologies on the UMLS step by step from 2010. This paper introduces the mapping research which is a pilot study for registering the second batch of medicinal terms following the first-batch listing of acupuncture points[34] at 2010AB, and wishes to use it as a basic study to link terminologies of traditional medicine in various fields with the UMLS, in order to enhance interoperability with biomedical terminology.

Materials and Methods

1. Metathesaurus and semantic network in UMLS

The UMLS is a system developed by NLM to consolidate, search and manage various biomedical information, and it offers applications including a metathesaurus browser and a semantic network browser through UMLS Terminology Services (UTS)[34].

Metathesaurus consists of biomedical concepts studied and developed from over 160 various vocabularies (based on 2011AA), as well as thesauri, classification schemas, code sets, and lists of controlled terms. Each concept within the metathesaurus has one semantic type (STY) or more within the UMLS semantic network. The semantic network is comprised of 135 semantic types and 54 relationships, offering a consistent framework among different vocabularies forming the metathesaurus[32].

2. Medicinal material concepts in UMLS

The concepts unique identifiers (CUIs) for medicinal names listed in the UMLS are divided largely into three types: first is the botanical name, second is when 'botanical name/Chinese pinyin' is written, and third is when botanical name and the used parts are written together[32].

In the case of ginseng, for example, a total of five ginseng-related CUIs were found, including the three aforementioned types (Table 1). Ginseng has two

Table 1. The Metathesaurus of Several Ginseng Concepts in the Unified Medical Language System

Concept	Panax ginseng	Panax	Ginseng/ren shen/ xi yan she	KOREAN GINSENG ROOT	ginseng root
CUI code	C0949314	C0086767	C0696787	C0874065	C0873046
Semantic Type	- Plant	- Plant	- Plant	- Organic Chemical - Pharmacologic Substance	- Organic Chemical - Pharmacologic Substance
Atoms A-code vocabulary	- ginseng A8256442 CRISP Thesaurus - ninjin A8256849 CRISP Thesaurus - renshen A8257056 CRISP Thesaurus - panax ginseng A8257007 CRISP Thesaurus - Panax ginsengs A17008128 MeSH - ginseng, Panax A17010862 MeSH - Panax ginseng A13058133 MeSH Czech - Panax-ginseng A8214966 MeSH Dutch - Panax ginseng A13104422 MeSH Portuguese - Panax ginseng A13393887 MeSH Spanish - Panax ginseng A2038790 Metathesaurus Names - ginseng A7102093 NCBI Taxonomy - ninjin A7139479 NCBI Taxonomy - Korean ginseng A7104153 NCBI Taxonomy - Chinese ginseng A7146330 NCBI Taxonomy - hong shen A7139048 NCBI Taxonomy - insam A7139062 NCBI Taxonomy	- shinseng A8257070 CRISP Thesaurus -jen shen A8256899 CRISP Thesaurus - Ginseng A0063292 Library of Congress Subject Headings - Ninjin A0092350 MeSH - Panax A0097034 MeSH - Schinsengs A17008127 MeSH - Shen, Jen A17002629 MeSH - Renshen A17010861 MeSH - radix ginseng A13062272 MeSH Czech -Panax japonicum A15693583 MeSH Japanese - Ginsem A9114594 MeSH Portuguese - ZHEN`SHEN` A13489846 MeSH Russian - Ginseng A9192821 MeSH Spanish - Panax A0097035 Metathesaurus Names - Panax A0097036 NCBI Taxonomy	- Ginseng/ ren shen/ xi yan she A8586335 Alternative Billing Concepts - ginseng/ ren shen/ xi yan she A8591270 Alternative Billing Concepts	- Korean Ginseng Root A10099116 National Drug Data File - KOREAN GINSENG ROOT A10380046 RXNORM	-Ginseng Root A10093747 National Drug Data File -GINSENG ROOT A10379884 RXNORM

plant names registered as CUIs, which are *Panax* (C0086767) and *Panax ginseng* (C0949314). Although they are registered as CUIs with different codes and concepts, they are still classified as 'Plant' as the same STY, and atoms under it are nearly the same.

As for *Panax ginseng* (C0949314) and its atoms, it has various vocabularies including CRISP Thesaurus, MeSH, MeSH Czech, MeSH Dutch, MeSH Portuguese, MeSH Spanish and NIBI Taxonomy, and Korean reading sounds *insam* and Chinese sounds *renshen,* as well as Japanese reading sound *ninjin* and *hong shen*, which is steamed ginseng, are listed as lexical unique identifiers (LUIs). In concepts of *Panax* (C0086767), it has multiple vocabularies including CRISP Thesaurus, Library of Congress Subject Headings, MeSH, MeSH Japanese, MeSH Russian, MeSH Portuguese and MeSH Spanish, and the concepts for ginseng in several languages including the Latin name of *radix ginseng* as well as *shinseng* and *jen shen* are listed as the same concepts.

Ginseng/ren shen/xi yan she (C0696787) that has the CUI form of 'the botanical name/Chinese pinyin' is sourced from a vocabulary called Alternative Billing Concepts (ABC), which is a compilation of medical concepts aiming to classify codes of traditional medicinal terminologies to secure compatibility of medical information systems between countries[35]. Within the ABC framework, the definition of *Ginseng/ ren shen/xi yan she* (C0696787) is listed as '*ren shen/ xi yan she'* as Chinese pinyin, with 'Plant' being its STY. In ABC, there are a total of 306 medicinal material concepts that belong to the classification of oriental herbs and natural substances including *Ginseng/ ren shen/xi yan she* (C0696787).

Lastly, *ginseng root* (C0873046) and *KOREAN GINSENG ROOT* (C0874065) are the CUIs that list ginseng's plant name and used parts, and they have two STYs, 'Pharmacologic Substance' and 'Organic Chemical' at once.

In this study, concepts corresponding to 'Plant', 'Pharmacologic Substance' and 'Organic Chemical',

which are STYs of medicinal material concepts were collected by using UMLS databases in order to use them in mapping to KIOM terms, and English preferred concepts, CUI codes, STYs, definitions, and atoms that are provided through thesauri were extracted.

3. Korean medicinal material concepts in KIOM terms

The KIOM terms whose refinement research was completed in 2011 are a collection of about 90,000 terms in total, including 30,000 representative concepts. Among these, 685 medicinal material concepts include such information as representative concepts in Chinese-Korean, synonyms, herbs, used parts, definitions and sources. However, collection of information on the names of medicinal materials in English was additionally required in order to map to their corresponding concepts in the UMLS. Although oriental medicine-related concepts are written in English based on the International Standard Terminologies (IST), names of medicinal materials vary from one country's pharm-acopoeia to another, and thus they were excluded from mapping due to the difficulty of standardization[36]. Therefore, as an alternative to IST, the Korean and Chinese pharmacopoeias[37-38] were used instead in order to collect English names of medicinal materials.

For this study, among the KIOM terms, such information as representative concepts in Chinese and Korean, synonyms and herbs, and used parts was extracted from 685 terms whose STY is medicinal material, and English names and Chinese pinyins mapped to such Chinese concepts were extracted from the Korean and Chinese pharmacopoeias.

4. Mapping of Korean Medicinal Material to UMLS

Medicinal material concepts of the UMLS collected for mapping were divided largely into three groups according to their information.

Group 1 is where an English CUI has names of

Chinese AUI medicinal materials, and when a given KIOM term and Chinese string match, and when the English botanic or scientific name is identical, it was mapped as the same concept. For instance, 甘草 (A15681634), an MSHJPN concept among AUIs, is listed for *Glycyrrhiza uralensis* (C0696940: plant: MSH/MH | A plant species of the family FABACEAE). Because its Chinese string matches the KIOM concept 甘草 *(감초)* and *Glycyrrhiza uralensis* is the same as scientific name of *licorice root*, it was mapped as the same concept.

Group 2 involves medicinal material names of ABC that have a CUI in the form of 'botanical name/ Chinese pinyin.' By using the Chinese Pharmacopoeia which contains Chinese pinyins, information such as their Chinese letters, herb and used parts was collected and then mapped to the Chinese medicinal material names of matching KIOM terms. For example, for *Aloe vera / lu hui* (C0696654 : plant : ALT/PT | lu hui), plant: *Aloe barbadensis Miller*, Part used: juice, which is the Chinese pinyin of luhui[38], was collected from the Chinese Pharmacopoeia, and because it matches the information of KIOM's medicinal material name, 노회 *(蘆薈),* it was mapped as the same concept.

In Group 3, terms whose form of English preferred concept was noted as 'herb name with used parts' were found and then mapping was attempted for those that match the English names in the Korean Pharmacopoeia. For instance, while *Schisandra Fruit* (C1365523: Pharmacologic Substance) does not have AUIs like 五味子 or *Wuweizi*, its English name is listed as *Schisandra Fruit* in the Korean Pharmacopoeia, and thus it was considered as the same concept and mapped accordingly.

Results

Of 685 medicinal material concepts from KIOM terms, 76 concepts in Group 1, 259 cases in Group 2 and 76 cases in Group 3 were mapped to UMLS concepts (Table 2).

All Chinese AUIs in Group 1 are MSHJPN concepts, and they included hiragana and katagana in addition to Chinese characters. For Chinese characters, the traditional Chinese writing system adopted in Korea and Japan was used, and simplified Chinese of China was rarely used. Of 87 medicinal material concepts that match the Chinese concepts listed in the Korean Pharmacopoeia, 76 concepts with matching English herbs name were extracted. Semantic type was 'plant,' excluding *Betel Nut* (C0684282: Pharmacologic Substance, Organic Chemmical), *Psyllium* (C0033979: Pharmacologic Substance, Organic Chemical, Biologically Active Substance) and *Ipecac* (C0022046: Pharmacologic Substance, Organic Chemical).

Of 306 medicinal material concepts in ABC, 259 concepts that are listed in KIOM and whose pinyins could be obtained from the Chinese Pharmacopoeia were mapped for Group 2. Of these, 252 concepts exclusive of *Huang Qi* (C0696679), *Trichosanthis* (C0696979), *Chai Hu* (C0696694), *Ephedra sinica* (C0696758), *Dang Shen* (C0696723), *Salvia miltiorrhiza* (C0696940), *huzhang* (C2314887) were all specified using the form of 'name of herb/Chinese pinyin' The semantic types were mostly 'plant,' and Chinese pinyins were quoted for definition. Moreover, when a concept has the same herb but different medicinal material names depending on the used parts, as in the case of *Puerariae/ge gen/ge hua* (C0696916: Plant: ALT/PT | ge gen/ge hua), *Lycium chinense/di gu pi/ gou qi zi* (C0696837 : Plant : ALT/PT | di gu pi/ gou qi zi), *Mori albae/sang bai pi/sang shen/sang ye/ sang zhi* (C0696859 : Plant : ALT/PT | sang bai pi/sang shen/ sang ye/sang zhi), it was considered as the same concept within the UMLS. In this case, they were mapped to '갈근/갈화, 지골피/구기자, 상백피/ 상심/상엽/상지' which are the same forms of UMLS definitions.

For Group 3, 76 concepts that match English names in the Korean Pharmacopoeia and note their herbs and used parts at the same time were collected.

Table 2. Examples of Group 1, 2 and 3

Group	Group 1		Group 2		Group 3	
English Preferred concept	**Glycyrrhiza uralensis**	**Sinomenium acutum**	**Aloe vera / lu hui**	**Clematidis / wei ling xiang**	**Schisandra Fruit**	**Sophora flavescens Root**
CUI code	C0936179	C1072870	C0696654	C0696722	C1365523	C2699491
Semantic Type	plant	plant	plant	plant	Pharmacologic Substance	Pharmacologic Substance Organic Chemmical
Definition	MSH/MH | A plant species of the family FABACEAE.		ALT/PT | lu hui	ALT/PT | wei ling xiang		
Atoms A-code vocabulary	- 甘草 A15681634 MSHJPN - カンゾウ A15672989 MSHJPN - Chinese Licorice A2029814 MSH -cao, Gan A17003236 MSH	- 防己 A15690760 MSHJPN - ボウイ(生薬) A15734863 MSHJPN - acutum, Sinomenium A17000728 MSH - Feng Teng, Qing A16995198 MSH	- aloe vera / lu hui A8590035 ALT	- clematidis / wei ling xiang A8590642 ALT	- Schisandra Fruit A10117769 NDDF	- Sophora Root A16760751 NCI -Ku Shen Root A16765294 NCI - SOPHORA FLAVESCENS ROOT A16765293 NCI - Sophorae Radix A16753995 NCI
Chinese pinyin in CP	Gancao	Fangji	Luhui	Weilingxiang	Wuweizi	Kushen
English names in KP	Licorice	Sinomenium Stem and Rhizome	Aloe	Clematidis Radix	Schisandra Fruit	Sophora Root
Scientific names in KP	- Glycyrrhiza uralensis Fischer - Glycyrrhiza glabra Linne - Glycyrrhiza inflata Batal.	- Sinomenium acutum Rehder et Wilson	- Aloe ferox Miller - Aloe africona Miller - Aloe spicata Baker	-Clematis mandshurica Maximowicz	- Schisandra chinensis Baillon	- Sophorae flavescens Solander ex Aiton
Mapped KIOM terms	감초 (甘草)	방기 (防己)	노회 (蘆薈)	위령선 (威靈仙)	오미자 (五味子)	고삼 (苦蔘)

As for the semantic type, 37 cases were pharmacologic substances, 22 cases were organic chemical, and some other terms including plant, food and substance, were included. Moreover, 8 cases where the English names of AUI, rather than of CUI, matched those in the Korean Pharmacopoeia. For instance, *Sophora Root*, which is the English name of 고삼 (苦蔘) in the Korean Pharmacopoeia is registered in the UMLS as the AUI A16760751/NCI/SY/C71831 of *Sophora lavescens*

Root (C2699491: Organic Chemical, Pharmacologic Substance). Thus, 고삼 (苦蔘) of KIOM and *Sophora flavescens Root* of CUI's UMLS were linked.

Discussion and Conclusions

This study is meaningful in that it investigated how medicinal material-related concepts, among other traditional medicine concepts, are listed in the

UMLS while suggesting a methodology to map them to standard medicinal material-related concepts, thereby serving as a starting point of concept-mapping research, which will help ensure interoperability and compatibility between traditional medicine terminology and the UMLS.

Of KIOM terminology, the study examined how 685 medicinal material concepts were listed in UMLS, and then classified them into three cases-firstly, when a concept is a name of the herb of a given medicinal material, secondly, when a concept is described in the form of 'the botanic name/Chinese pinyin,' and thirdly, when a name of the herb and used parts are noted at the same time. The concepts that correspond to their STYs, 'Plant', 'Pharmacologic Substance' and 'Organic Chemical', were collected by using UMLS databases, and the information provided by thesauri, such as English Preferred concept, CUI code, STY, definitions and atoms, were extracted to determine their concordance. The medicinal material concepts of the UMLS collected for mapping were divided into three groups largely based on their respective forms of CUIs and information. Group 1 is where an English CUI has names of Chinese AUI medicinal materials, and 76 medicinal material concepts were mapped to their KIOMs counterparts. Group 2 involves medicinal material names of ABC that have a CUI in the form of 'botanical name/Chinese pinyin'. Information on the Chinese pinyins, Chinese letters and herbs and used parts was collected by using the Chinese Pharmacopoeia and the concepts in this group were then mapped to the Chinese medicinal material names of 252 matching KIOM terms. In Group 3, concepts whose form of English preferred concept was noted as 'herb name with used parts' were found and then mapped 76 concepts that match the English names in the Korean Pharmacopoeia.

Medicinal material concepts in Group 1 and Group 2 are outcomes of mapping studied in Japan and China, respectively, and they were often defined and named as concepts originating from Traditional Chinese Medicine (TCM) or Kampo. The fact that medicinal material concepts using Chinese characters or using Chinese pinyins are listed in the UMLS, which represents international medical terminologies, can be attributable to China's efforts and policies to establish international standards centering on TCM. This indicates the urgency of research to standardize Korea's own traditional medicinal terminologies and to map them to the UMLS in order to address TCM's offensive to make its own terminologies international standards in an effort to dominate traditional medicine through terminologies.

Moreover, when mapping the medicinal material concepts, there exist conceptual differences among the outcomes of Groups 1 and 2, and those of Group 3. However, their distinction was quite vague when they are noted in Korean. As shown in the example of ginseng in Table 1 above, the UMLS has five CUIs with ginseng-related concepts, with ginseng in Groups 1 and 2 denoting a plant for medicinal purposes and the one in Group 3 referring to the root of a plant for medicinal purposes that has medicinal effect. Even the Korean Pharmacopoeia, which was used as a reference for this study as Korea's national standard for medicinal material names, was found to contain mixed descriptions in English without consistent standards and format. For instance, some medicinal materials are noted in the form of 'herb with used parts', as in the case of *Sophora Root* and *Schisandra Fruit*, whereas some other medicinal materials have no notation of used parts, like in the case of *licorice* and *ginseng*. Therefore, a new set of standards is needed to denote medicinal materials in English that considers 'herb with used parts' based not only on the definitions in the Korean Pharmacopoeia but also information on herbs that are used in actual clinical settings.

Studies on terminologies to explain basic concepts of traditional medicine are a foundation to advance it as an academic field as well as to globalize its practice. However, research on traditional medicine-

related concepts and ways to map them to international standard medical systems has not been actively carried out in the Korean traditional medicine community. For efficient management of information in the field of traditional medicine as well as for its globalization, continuous and systematic research is needed to establish essential standard terminologies for traditional medicine and to link them to international standard terminologies.

Acknowledgements

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