



HHS Public Access

Author manuscript

J Am Acad Dermatol. Author manuscript; available in PMC 2020 November 10.

Published in final edited form as:

J Am Acad Dermatol. 2019 June ; 80(6): 1564–1584. doi:10.1016/j.jaad.2018.08.035.

Developing an international standard for classification of surface anatomical location for use in clinical practice and epidemiological research

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Abstract

Background: There is currently no universally adopted terminology for defining human surface anatomical location. The lack of precision, accuracy and reliability of terms used by healthcare providers, in particular dermatologic surgeons, is unsatisfactory both for epidemiological research and for high quality patient care.

Objective: To create a clinically relevant yet concise surface anatomy terminology for international use including the International Classification of Diseases and to map it to existing disparate terminologies.

Methods: Widely used surface anatomy terminology data sets and diagrams were reviewed. A Delphi consensus convened to create a novel surface anatomy terminology. The new terminology was hierarchically mapped to SNOMED terms and NYU Numbers and physically mapped to 2D anatomical diagrams for clarity and reproducibility.

Results: The final terminology data set contains 512 discrete terms arranged in a 9 level hierarchy and has been adopted by the World Health Organization for ICD-11.

Limitations: Terms lack laterality and fine granularity for large sites.

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Conflict of Interest:

Matthew Molenda is the developer and owner of Anatomymapper.com referenced in this manuscript.

Peter Soyer is a Shareholder and Consultant for e-derm GmbH, a Shareholder and Consultant for MoleMap by Dermatologists Pty Ltd. and a Consultant for Canfield Scientific.

Allan Halpern is an Advisory Board Member for Syneos Health.

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Conclusion: Consistent use of precise and accurate surface anatomy terms is crucial to the practice of dermatology, particularly procedural dermatology. The proposed terminology is designed to form the basis for evolution of a universally adoptable terminology set to improve patient care, interprovider communication and epidemiological tracking.

Graphical Abstract

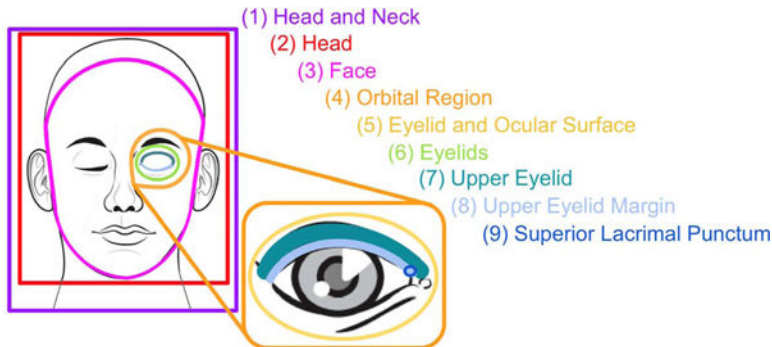


Figure 1. Demonstration of the hierarchical nature of the term set for the face with nine hierarchical levels beginning with Head and Neck and terminating in Superior Lacrimal Punctum. See Table II for corresponding term synonyms and crosslinking to SNOMED terms and NYU Numbers.

Keywords

surface topography; dermatology; surface anatomy; anatomical nomenclature

Introduction

There is currently no internationally accepted set of anatomical terms for use by dermatologists and other health care providers to enable recording of surface anatomy locations on the human body accurately and consistently. This lack of consensus results in errors of accuracy and precision that have clinical and research consequences. Clinically, inconsistent anatomic site terminology can lead to unnecessary biopsies, mistaken clinical/pathologic correlation, and wrong site surgery. These risks grow with the number of providers involved in the care of the patient, the number of biopsies/treatments the patient has had, and the length of follow up. For research purposes, detailed and consistent application of surface anatomy terminology provides a key stratification variable for epidemiology research, quality monitoring, recurrence monitoring, and study of the natural history of cutaneous processes. While digital photography is becoming ubiquitous and presents many advantages for anatomic site documentation, photo-documentation is currently not the norm and the consequences of inconsistent text-based terminology are magnified in the era of electronic medical records and ‘big data’ analyses.

Even if a consistent set of widely accepted terms were available, rising clinical volumes and increasing regulatory and reimbursement demands for documentation contribute to time pressure for clinicians that can undermine the precision and granularity of anatomic labeling. Lengthy free-text descriptions of precise anatomic labels are both inefficient and prone to

errors. As a result, an exhaustive and precise set of anatomical terms would be best applied through automated linkage to anatomic drawings or clinical photographs.

Here we provide a synopsis and comparison of the major extant systems for anatomic labeling along with a proposed system that automatically links a consensus set of terms derived from these systems to a set of anatomic drawings.

Current terminology systems

There are currently a number of readily available surface anatomy maps and term sets, but each has weaknesses for routine application in dermatology practice and research.

The web-based terminology database SNOMED CT (Systematized Nomenclature of Medicine - Clinical Terms) is a detailed and extensive clinical terminology including but not limited to anatomic, pathologic, procedural, event, and demographic terms. It is owned, maintained, and distributed by the International Health Terminology Standards Development Organisation (IHTSDO).¹ SNOMED CT was originally created by the College of American Pathologists and now contains over 320,000 concepts, each with its own SCTID (SNOMED CT Identifier) code. Its weakness, however, lies in its incomplete coverage of detailed surface anatomy, and the large number of options with many overlapping terms for the same location, each with its own SCTID code. Thus, two lesions occurring in exactly the same location could be coded and later analyzed differently. For example, nape of the neck correlates to “Entire posterior portion of neck”, “Entire skin of nuchal region”, “Entire surface region of back of neck” and “Structure of surface region of back of neck”.

The Foundational Model of Anatomy ontology (FMA), created by the Structural Informatics Group at the University of Washington, is a system of internal and surface anatomy which is entirely online.² It was aligned with SNOMED-CT and Galen and adopted by the European Committee for Standardization. Its design is purely ontological (i.e. a conceptual model) with text labels (and associated FMA ID numbers) without a coordinated graphic location, requiring the user to have a fairly detailed anatomical knowledge. Although the system is multi-axial, it is no longer possible to view the full hierarchy satisfactorily since the withdrawal of the Foundational Model Explorer (FME), which previously enabled the hierarchy to be visualized in its entirety through a series of drop-down options. Despite these issues, it is a thorough system and includes laterality.

The third edition of the World Health Organization’s International Classification of Diseases for Oncology (ICD-O-3) is another web-based terminology set with associated codes which has historically been used by tumor and cancer registries.³ It utilizes a dual classification scheme consisting of a morphologic code and a topographic code. Only the morphology component was incorporated into SNOMED. The topography component was derived from the Neoplasms chapter of ICD-10. While the pairing of diagnosis and location, and the integration with other systems is desirable, ICD-O is geared more towards internal malignancies rather than disorders of the skin and the terms and corresponding topography codes are far too broad for finer epidemiological tracking and analysis for dermatologic conditions, for which less than ten locations are available (e.g “skin of trunk” and “skin of upper limb and shoulder”).

Each of these terminologies has its own weaknesses, with most systems being too specific, not specific enough, or too inclusive. While the United States has only recently transitioned to ICD-10, many countries have been using ICD-10 for well over a decade and are now making preparations for the recently released eleventh revision (ICD-11). ICD-11 will enable disorders to be linked to precise anatomical locations including laterality and surface topography, a provisional new classification of which was drawn up and agreed by members of the ICD-11 Dermatology Topic Advisory Group and co-opted experts at an international workshop held in Manchester, UK, in January 2014. This *ad hoc* Dermatology Anatomy Terminology Working Group was informed by existing classifications from the British Association of Dermatologists and the US Anatomy Mapper project.³ An important issue considered at the workshop was the appropriate granularity to be incorporated, with recognition that creating a system that is too finely granular may inhibit adoption. The Group was able to achieve consensus (Table 1). The proposed surface topography classification (ICD-ST) has been accepted by WHO for incorporation into ICD-11 (ICD-ST). It has subsequently been agreed at the International Skin Imaging Collaboration (ISIC) meeting held in 2017 in New York City, USA, that ICD-ST should be used as the foundation for a Delphi Consensus study on classification of surface topography. ICD-ST represents a strong starting point for a future internationally standardized surface anatomy terminology.

To further expand our ICD-ST proposal, we are recommending adoption of the system of post-coordination built into ICD-11, which enables a set of “extensions” including location to be appended to stem concepts. Extensions allow for more specific data to be captured without an explosion in the number of codes required to achieve this, thus promising higher accuracy and precision than is currently available. The hierarchical nature of the proposed system with the facility to qualify enables different levels of anatomic detail to be recorded appropriately, ranging from large areas, for example “Head and Neck”, all the way down to the smallest areas, e.g, “Perionyhcium of the left fifth toe”. Extensions to surface topography terms such as laterality, directional additions, histologic subtype, and Boolean values can transform “squamous cell carcinoma of nose” to “recurrent, previously irradiated, invasive squamous cell carcinoma of the left posterosuperior lateral sidewall of nose,” for example.

Anatomy Mapping

The need for standardized anatomical terms is clear, but accurate use of terms is partly dependent on the user, as knowledge of anatomy is required, particularly in areas with non-discrete borders. A potential solution to this issue is computerized anatomic mapping. With visual maps, an accurate term can be easily generated with a single click. With the increasing sophistication of computer graphics and their incorporation into electronic health record systems via computers, tablets, smartphones, smart cameras enabled with DICOM (Digital Imaging COmmunication in Medicine) functionality or other means, there is opportunity for increasingly precise, accurate and thorough documentation, which may become a requirement for full reimbursement in the future in many countries. With a potential shift to value-based payments, it is important that dermatologists thoroughly document the treatments they perform in order to illustrate the value and extent of the services they provide in a given encounter, a focus of the American Academy of Dermatology’s DataDerm initiative.⁵ An appropriately designed user interface with

standardized clickable body surface graphics incorporated into the electronic health record will enable this to be done in an accurate and reliable manner. In very busy practices or when technical difficulties such as a crashed server occur, historical, established maps or the maps presented on anatomyMapper.com can be printed and sites manually marked by providers for later documentation by medical assistants. In addition to being fast and easy, maps may serve as an educational tool to assist staff and medical trainees learn terminology themselves.

An anatomic numbering system (hereby referred to as “NYU Numbers”) was created under the direction of Dr. Alfred W. Kopf for The New York University Melanoma Cooperative Group in 1972 and has been used at a number of well-respected institutions throughout the years including New York University, Memorial Sloan Kettering Cancer Center, Cleveland Clinic and Mayo Clinic.⁶ The NYU Numbers have distinctly bordered surface regions labeled with numbers rather than text-based terms. This map has sometimes arbitrary borders on areas such as the scalp, which has a single defined area that most would regard as including both the parietal and occipital scalp regions. Furthermore, the NYU Numbers do not have a standardized or widely used legend correlating the numbers with anatomic topography terms and thus it does not assist in the generation of descriptive anatomical terms for documentation.

Anatomy Mapper™ is an easy-to-use web-based interactive map, created by one of the authors, which displays a precise anatomic term on hovering over a specific body location, enabling its text descriptor to be exported with a mouse click.⁷ There are many advantages to this type of system which pairs terms with a map: these include increased accuracy, increased efficiency and improved inter-operator agreement. While this system efficiently generates text-based documentation, it does not yet have a publicly available image markup facility.

Finally, there are commercial dermatology-specific EHR systems with and without maps that enable fast, accurate documentation. Some systems function in 2D while others provide 3D maps for notation of lesions. While 3D maps facilitate precise documentation of lesions on curved body areas, increased time in mouse clicks and model rotations causes decreased overall efficiency. While 2D maps can be printed and notated in times of technology failure or to increase the speed of documentation, the same cannot be said for 3D maps. Therefore, while there are obvious advantages to 3D models they are not without their drawbacks. There are clear advantages to the even more advanced systems that incorporate photo documentation superimposed on a map or assist in coding of location and/or diagnosis. All of these dermatology-specific systems are, however, generally very expensive and unlikely to be accessible to primary care physicians, non-dermatologists or physician extenders, all of whom are performing more and more dermatologic evaluations and biopsies. Additionally, the need for a publicly available standardized terminology set that can be adopted by the international community is not being met by these proprietary systems.

DICOM began as a radiology initiative in 1993 to establish standards for formatting, storage, printing and secure transmission of medical images and has since crossed over into a number of specialties including dermatology.^{8,9} Photographs encoded as DICOM images that can be

uploaded to PACS are becoming increasingly common, especially since the advent of DICOM cameras and smartphone applications. While these photographs are immensely useful for tracking lesions over time and sharing among providers, the “Body Part Examined” DICOM terminology set used to identify the photographed lesion location is very weak, consisting of only 25 location terms, with a laterality notation.⁹ With such a minimal number of surface topography terms available, when photographs are taken close-up it may be difficult to discern the true location of the lesion(s) imaged, particularly if only close-up views are available. Thus, even the gold standard in medical photography has significant room for improvement.

Although we do not claim that we have presented an exhaustive list of available maps and/or topographic term lexicons, we have attempted to illustrate the advantages and pitfalls of each and to propose a system which avoids the dangers we have highlighted by combining standardized terms with detailed anatomic surface maps.

While standardized anatomic maps are promising tools, they should be considered an adjunct to, rather than a replacement for photo-documentation. Photographs are the best way to record the precise location of a lesion in a given individual and are especially important for those occurring at the borders of anatomic regions (e.g., posterior shoulder v. back) where no clear boundaries exist.

Proposal for a Hierarchical Terminology System Cross-linking ICD Topography to SNOMED CT and NYU Numbers

In this paper we have described a new detailed surface anatomy terminology classification which will be a component part of the recently released ICD-11. Terms have been arranged in a hierarchical format for ease of use with 9 levels of granularity. There exist 5 level 1 terms, 20 level 2 terms, 68 level 3 terms, 79 level 4 terms, 170 level 5 terms, 134 level 6 terms, 27 level 7 terms, 7 level 8 terms, and 2 level 9 terms (Table I). Approximately 2000 SNOMED terms with SCTID codes and 310 NYU Numbers were then cross-linked back to the 512 standardized terms. A representation of the hierarchical format of the terms is demonstrated in the graphical abstract and corresponding Table II showing linkage to SNOMED and NYU Numbers. In correlating anatomic locations across systems, a larger standardized data pool is created for retrospective analysis and prospective tracking of topographic data from NYU Numbers and SNOMED. Though not a part of the original 512 terms, we propose the addition of 32 optional qualifiers, such as “posterolateral”, “superomedial”, etc., for optional further subdivision of larger areas. These qualifiers were in some cases included in SNOMED terms but never in NYU Numbers. Our cross-linking of SNOMED/SCTID and NYU Numbers can be accessed online at <http://anatomymapper.com/terms>.¹⁰ Two very important sites for dermatologic oncology are the ear and nose, which are poorly represented in existing classifications. Examples of the granularity of the proposed terminology set crosslinked to SNOMED/SCTID and NYU Numbers for the ear and nose can be seen in Tables III and IV.

To complement our cross-mapping and for historical reference, we have generated an interactive NYU Numbers map with the most precise anatomical terms possible linked to each of the numbered and bordered regions, which can be accessed at <http://>

anatomymapper.com/nyu.¹⁰ Also included on this site are the best match anatomical descriptors for all NYU Numbers: as previously noted, not all NYU Numbers have clearly defined or anatomically correct borders. Terms were generated to best describe the NYU Number regions and thus they are not identical to the proposed 512 proposed terms.

Conclusion

The need for a standardized, widely utilized surface anatomy terminology is evident. None of the currently available terminologies is ideally suited for universal adoption. In creating a more complete, precise, yet concise set of surface anatomy terms, we have sought to create a language to facilitate improved inter-provider communication, generation of a rich dataset which may be used for clinical and epidemiological research, quality monitoring, recurrence monitoring and to assure correct treatment site. The proposed terminology set of 512 non-lateralized terms incorporates the strengths of existing systems while avoiding excessive granularity, a factor which could inhibit adoption. We recognize that this proposed set of terms will require further validation and consensus building to achieve universal adoption. We further anticipate that more granularity, including lateralization, will be added as electronic documentation becomes ubiquitous, making such granularity broadly practical.

The fact that ICD-ST has been accepted by the World Health Organization and is incorporated into the recently released Eleventh Revision of The International Classification of Diseases (ICD-11) should prove a spur to its wider adoption by clinicians. Furthermore, by crosslinking the NYU Numbers map and SNOMED-CT terms to our terminology, we hope to facilitate the transition to ICD-ST for institutions using NYU Numbers and SNOMED-CT-based systems. Finally, the proposed terminology set is freely available for open access online in the public domain in the hopes of promoting adoption and providing a foundation for the generation of increasingly practical systems of accurate, consistent, and precise anatomic labeling.

Acknowledgments

The research presented in this manuscript has not previously been published or presented.

Funding is provided by the P30 Cancer Center Support Grant (CCSG) (P30 CA008748).

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Capsule summary

- There is no standardized universal surface topography term set available.
- We propose a hierarchically arranged set of 512 surface anatomy terms as an initial step toward international adoption.
- It is vital that anatomic sites in dermatology are precise and accurate for correct site treatment, epidemiological tracking and interprovider communication

Table I.

Proposed Hierarchy of 512 Surface Topography Terms

Surface Topography Sorting Index	Hierarchical level	Surface Topography Hierarchical Classification	Surface Topography Sorting Index	Hierarchical level	Surface Topography Hierarchical Classification
1	1	Head and Neck	130	5	Tongue
2	2	Head	131	6	Body of tongue
3	3	Scalp	132	7	Midline of tongue
4	4	Frontal scalp	133	7	Dorsal surface of body of
5	4	Temporal scalp	134	6	Junctional zone of tongue
6	4	Parietal scalp	135	6	Base of tongue
7	4	Occipital scalp	136	7	Dorsal surface of base of
8	4	Vortex of scalp	137	6	Ventral surface of tongue
9	4	Scalp Margin	138	7	Lingual frenulum
10	5	Frontal scalp margin	139	7	Lingual tonsil
11	5	Temporal scalp margin	140	6	Border of tongue
12	5	Parietal scalp margin	141	7	Lateral margin of tongue
13	5	Occipital scalp margin	142	7	Tip of tongue
14	3	External ear	143	5	Floor of mouth
15	4	Pinna	144	6	Alveolingual sulcus
16	5	Helix of pinna	145	6	Mucosa of floor of mouth
17	6	Crus of helix	146	5	Tonsillar region
18	6	Apex of helix	147	6	Glossopalatine arch
19	6	Spine of helix	148	7	Anterior tonsillar pillar
20	6	Tail of helix	149	6	Tonsillar fossa
21	5	Antihelix of pinna	150	7	Palatine tonsil
22	6	Crura of antihelix	151	6	Pharyngopalatine arch
23	6	Scaphoid fossa of pinna	152	7	Posterior tonsillar pillar
24	6	Concha	153	8	Pharyngeal-lymphoid ring
25	6	Cymba conchae	154	7	Oropharynx
26	6	Conchal bowl of pinna	155	8	Lateral wall of oropharynx
27	6	Triangular fossa of pinna	156	8	Posterior wall of
28	5	Tragus of pinna	157	2	Neck
29	5	Intertragic notch of pinna	158	3	Front of neck
30	5	Lobule of pinna	159	4	Anterior triangle of neck
31	5	Anitragus of pinna	160	5	Submental region
32	5	Posterior surface of pinna	161	5	Submandibular region
33	5	Retroauricular sulcus	162	5	Suprasternal notch
34	4	External auditory canal	163	4	Supradavicular region
35	4	External auditory meatus	164	4	Side of neck
36	5	Tympanic membrane	165	4	Posterior triangle of neck
37	3	Face	166	3	Nape of neck
38	4	Forehead	167	1	Trunk
39	5	Central forehead	168	2	Upper trunk
40	5	Paramedian forehead	169	3	Thorax
41	5	Lateral forehead	170	4	Anterior thoracic region
42	5	Glabella	171	5	Upper anterior thoracic region
43	4	Temple	172	6	Clavicular region
44	4	Orbital region	173	6	Infrascapular region
45	5	Periorbital region	174	6	Presternal region
46	6	Supraorbital region	175	6	Lower anterior thoracic region
47	7	Eyebrow	176	4	Lateral thoracic region
48	6	Infrascapular region	177	5	Upper lateral thoracic region
49	5	Eyelid and ocular surface	178	6	Anterolateral upper thoracic region
50	8	Eyelids	179	6	Posterolateral upper thoracic region
51	7	Upper eyelid	180	6	Lower lateral thoracic region
52	8	Upper eyelid margin	181	6	Anterolateral lower thoracic region
53	9	Superior lacrimal punctum	182	6	Posterolateral lower thoracic region
54	8	Superior palpebral sulcus	183	4	Upper back
55	8	Lower eyelid	184	5	Suprascapular region
56	7	Lower eyelid margin	185	5	Scapular region
57	9	Inferior lacrimal punctum	186	5	Interscapular region
58	7	Lateral canthus	187	5	Infrascapular region
59	7	Medial canthus	188	5	Lower thoracic paraspinous region
60	6	Conjunctiva	189	3	Breast
61	7	Palpebral conjunctiva	190	4	Nipple
62	7	Superior conjunctival fornix	191	4	Areola
63	7	Inferior conjunctival fornix	192	4	Upper outer quadrant of breast
64	7	Bulbar conjunctiva	193	4	Upper inner quadrant of breast
65	6	Sclera	194	4	Lower outer quadrant of breast
66	6	Cornea	195	4	Lower inner quadrant of breast
67	4	Limbus of cornea	196	4	Axillary tail of breast
68	4	Cheek	197	4	Inframammary flexure
69	5	Upper cheek	198	2	Lower trunk
70	6	Malar region	199	3	Abdomen
71	5	Central cheek	200	4	Upper abdomen
72	5	Paranasal region	201	5	Epigastrium
73	6	Lateral cheek	202	5	Hypochondrium
74	6	Preauricular region	203	4	Periumbilical region
75	6	Angle of jaw	204	5	Umbilicus
76	6	Mandibular region	205	4	Lateral lumbar region
77	4	Nose	206	4	Lower abdomen
78	5	Root of nose	207	5	Hypogastrium
79	5	Dorsum of nose	208	5	Iliac region
80	5	Supratip of nose	209	3	Lumbosacral region
81	5	Lateral side wall of nose	210	4	Mid back
82	5	Tip of nose	211	5	Posterior lumbar region
83	6	Infratip lobule of nose	212	5	Lumbar paraspinous region
84	6	Ala nasi	213	4	Lower back
85	6	Side wall of ala nasi	214	5	Sacral region
86	6	Alar groove	215	5	Coccygeal area
87	6	Alar rim	216	1	Anogenital region
88	5	Nostril	217	2	Genital region
89	6	Sill of nostril	218	3	Female external genitalia
90	6	Columella	219	4	Vulva
91	4	Oral region	220	5	Labium majus
92	5	Perioral Region	221	5	Labium minus
93	5	Lips	222	5	Clitoris
94	6	Upper lip	223	6	Clitoral prepuce
95	7	Cutaneous upper lip	224	6	Vulval vestibule
96	8	Philtrum	225	6	External urethral meatus
97	7	Vermilion border of upper lip	226	6	Bartholin gland
98	7	Vermilion of upper lip	227	5	Frenulum of labia minora
99	6	Labial commissure	228	4	Vagina
100	6	Lower lip	229	5	Vaginal introitus
101	7	Cutaneous lower lip	230	5	Hymen
102	7	Vermilion border of lower lip	231	3	Male external genitalia
103	7	Vermilion of lower lip	232	3	Penis
104	5	Chin	233	5	Root of penis
105	3	Mouth	234	5	Body of penis
106	4	Vestibule of mouth	235	6	Dorsal surface of penis
107	5	Labial mucosa of upper lip	236	6	Ventral surface of penis
108	5	Superior labial sulcus	237	5	Glans penis
109	5	Superior buccal sulcus	238	6	Penile urethral meatus
110	5	Labial mucosa of lower lip	239	5	Prepuce
111	5	Inferior labial sulcus	240	6	Outer surface of Prepuce
112	5	Inferior buccal sulcus	241	6	Inner surface of Prepuce
113	5	Buccal mucosa	242	5	Coronal sulcus of penis
114	5	Retroalar region	243	6	Frenulum of penis
115	4	Gingivae	244	4	Scrotum
116	5	Upper Gingiva	245	2	Perigenital region
117	6	Upper alveolar mucosa	246	3	Suprapubic area
118	6	Upper alveolar ridge mucosa	247	4	Mons pubis
119	6	Upper alveolus	248	3	Inguinocrural fold
120	5	Lower Gingiva	249	2	Perianal region
121	6	Lower alveolar mucosa	250	3	Anus
122	6	Lower alveolar ridge mucosa	251	3	Perianal skin
123	6	Lower alveolus	252	3	Perineum
124	4	Oral cavity	253	3	Intergluteal cleft
125	5	Palate	254	1	Upper extremity
126	6	Hard palate	255	2	Shoulder
127	6	Soft palate	256	3	Anterior surface of shoulder
128	6	Uvula	257	3	Apex of shoulder
129	6	Palatal mucosa	258	3	Posterior surface of shoulder

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Surface Topography Sorting Index	Hierarchical level	Surface Topography Hierarchical Classification
259	2	Axilla
260	3	Anterior axillary fold
261	3	Apex of axilla
262	3	Posterior axillary fold
263	2	Upper arm
264	3	Anterior surface of upper arm
265	3	Lateral surface of upper arm
266	3	Posterior surface of upper arm
267	3	Medial surface of upper arm
268	2	Elbow
269	3	Antecubital fossa
270	3	Lateral condylar surface of elbow
271	3	Elbow lip
272	3	Medial condylar surface of elbow
273	2	Forearm
274	3	Anterior surface of forearm
275	3	Lateral surface of forearm
276	3	Posterior surface of forearm
277	3	Medial surface of forearm
278	2	Wrist
279	3	Volar surface of wrist
280	3	Lateral surface of wrist
281	3	Dorsal surface of wrist
282	3	Medial surface of wrist
283	2	Hand
284	3	Dorsum of hand
285	4	Knuckles
286	4	First metacarpophalangeal joint
287	4	Second metacarpophalangeal joint
288	4	Third metacarpophalangeal joint
289	4	Fourth metacarpophalangeal joint
290	4	Fifth metacarpophalangeal joint
291	4	Interdigital web spaces of hand
292	4	First interdigital web space of hand
293	4	Second interdigital web space of hand
294	4	Third interdigital web space of hand
295	4	Fourth interdigital web space of hand
296	4	Palm of hand
297	4	Proximal
298	5	Thenar eminence
299	5	Hypothenar eminence
300	4	Central palm
301	4	Distal palm
302	3	Fingers and thumb
303	4	Thumb
304	5	Proximal phalanx of thumb
305	5	Interphalangeal joint of thumb
306	5	Distal phalanx of thumb
307	5	Perionychium of thumb
308	6	Proximal nail fold of thumb
309	6	Eponychium of thumb
310	6	Lateral nail fold of thumb
311	6	Hyponychium of thumb
312	5	Thumbnail
313	6	Lunula of thumb
314	6	Nail bed of thumb
315	6	Nail plate of thumb
316	5	Pad of
317	4	Index finger
318	5	Proximal phalanx of index finger
319	5	Proximal interphalangeal joint of index
320	5	Middle phalanx of index finger
321	5	Distal interphalangeal joint of index finger
322	5	Distal phalanx of index finger
323	5	Perionychium of index finger
324	6	Proximal nail fold of index finger
325	6	Eponychium of index finger
326	6	Lateral nail fold of index finger
327	6	Hyponychium of index finger
328	5	Index
329	6	Lunula of index finger
330	6	Nail bed of index finger
331	6	Nail plate of index finger
332	6	Pad of index finger
333	4	Middle finger
334	5	Proximal phalanx of middle finger
335	5	Proximal interphalangeal joint of middle
336	5	Middle phalanx of middle finger
337	5	Distal interphalangeal joint of middle finger
338	5	Distal phalanx of middle finger
339	5	Perionychium of ring finger
340	6	Proximal nail fold of middle finger
341	6	Eponychium of middle finger
342	6	Lateral nail fold of middle finger
343	6	Hyponychium of middle finger
344	5	Middle finger
345	6	Lunula of middle finger
346	6	Nail bed of middle finger
347	6	Nail plate of middle finger
348	5	Pad of middle finger
349	4	Ring finger
350	5	Proximal phalanx of ring finger
351	5	Proximal interphalangeal joint of ring finger
352	5	Middle phalanx of ring finger
353	5	Distal interphalangeal joint of ring finger
354	5	Distal phalanx of ring finger
355	5	Perionychium of ring finger
356	6	Proximal nail fold of ring finger
357	6	Eponychium of ring finger
358	6	Lateral nail fold of ring finger
359	6	Hyponychium of ring finger
360	5	Ring
361	6	Lunula of ring finger
362	6	Nail bed of ring finger
363	6	Nail plate of ring finger
364	5	Pad of ring finger
365	4	Little finger
366	5	Proximal phalanx of little finger
367	5	Proximal interphalangeal joint of little finger
368	5	Middle phalanx of little finger
369	5	Distal interphalangeal joint of little finger
370	5	Distal phalanx of little finger
371	5	Perionychium of little finger
372	6	Proximal nail fold of little finger
373	6	Eponychium of little finger
374	6	Lateral fold of little finger
375	6	Hyponychium of little finger
376	5	Little
377	6	Lunula of little finger
378	6	Nail bed of little finger
379	6	Nail plate of little finger
380	5	Pad of little finger
381	2	Lower extremity
382	2	Buttock
383	3	Gluteal fold

Surface Topography Sorting Index	Hierarchical level	Surface Topography Hierarchical Classification
384	2	Thigh
385	3	Anterior surface of thigh
386	3	Lateral surface of thigh
387	3	Trochanteric region
388	3	Posterior surface of thigh
389	3	Medial surface of thigh
390	4	Upper medial surface of thigh
391	2	Knee
392	3	Patellar region
393	3	Lateral surface of knee
394	3	Popliteal fossa
395	3	Medial surface of knee
396	2	Lower leg
397	3	Anterior surface of lower leg
398	3	Lateral surface of lower leg
399	3	Posterior surface of lower leg
400	3	Medial surface of lower leg
401	2	Ankle
402	3	Anterior surface of ankle
403	3	Lateral surface of ankle
404	4	Lateral malleolus
405	3	Posterior surface of ankle
406	3	Medial surface of ankle
407	4	Medial malleolus
408	2	Foot
409	3	Dorsum of foot
410	3	Forefoot
411	4	Dorsal surface of forefoot
412	4	Metatarsophalangeal joints
413	5	First metatarsophalangeal joint
414	5	Second metatarsophalangeal joint
415	5	Third metatarsophalangeal joint
416	5	Fourth metatarsophalangeal joint
417	5	Fifth metatarsophalangeal joint
418	5	Interdigital web spaces of foot
419	5	First interdigital web space of foot
420	5	Second interdigital web space of foot
421	5	Third interdigital web space of foot
422	5	Fourth interdigital web space of foot
423	4	Plantar surface of forefoot
424	4	Ball of
425	3	Heel
426	4	Lateral surface of heel
427	4	Posterior surface of heel
428	4	Medial surface of heel
429	4	Plantar surface of heel
430	3	Sole of foot
431	4	Lateral border of sole of foot
432	4	Medial surface of sole of foot
433	4	Arch of foot
434	4	Toes
435	4	Great toe
436	5	Proximal phalanx of great toe
437	5	Interphalangeal joint of great toe
438	5	Distal phalanx of great toe
439	5	Perionychium of great toe
440	6	Proximal nail fold of great toe
441	6	Eponychium of great toe
442	6	Lateral nail fold of great toe
443	6	Hyponychium of great toe
444	5	Great toenail
445	6	Lunula of great toe
446	6	Nail bed of great toe
447	6	Nail plate of great toe
448	6	Pad of great toe
449	5	Second toe
450	6	Proximal phalanx of second toe
451	6	Proximal interphalangeal joint of second
452	6	Middle phalanx of second toe
453	6	Distal interphalangeal joint of second
454	6	Distal phalanx of second toe
455	6	Perionychium of second toe
456	6	Proximal nail fold of second
457	6	Eponychium of second toe
458	6	Lateral nail fold of second toe
459	6	Hyponychium of second toe
460	5	Second toenail
461	6	Lunula of second toe
462	6	Nail bed of second toe
463	6	Nail plate of second toe
464	5	Pad of second toe
465	4	Third toe
466	6	Proximal phalanx of third toe
467	6	Proximal interphalangeal joint of third
468	6	Middle phalanx of third toe
469	6	Distal interphalangeal joint of third toe
470	6	Distal phalanx of third toe
471	6	Perionychium of third toe
472	6	Proximal nail fold of third toe
473	6	Eponychium of third toe
474	6	Lateral nail fold of third toe
475	6	Hyponychium of third toe
476	5	Third toenail
477	6	Lunula of third toe
478	6	Nail bed of third toe
479	6	Nail plate of third toe
480	5	Pad of third toe
481	4	Fourth
482	6	Proximal phalanx of fourth toe
483	6	Proximal interphalangeal joint of fourth
484	6	Middle phalanx of fourth toe
485	6	Distal interphalangeal joint of fourth
486	6	Distal phalanx of fourth toe
487	6	Perionychium of fourth toe
488	6	Proximal nail fold of fourth toe
489	6	Eponychium of fourth toe
490	6	Lateral nail fold of fourth toe
491	6	Hyponychium of fourth toe
492	5	Fourth toenail
493	6	Lunula of fourth toe
494	6	Nail bed of fourth toe
495	6	Nail plate of fourth toe
496	5	Pad of fourth toe
497	4	Fifth toe
498	6	Proximal phalanx of fifth toe
499	6	Proximal interphalangeal joint of fifth
500	6	Middle phalanx of fifth toe
501	6	Distal interphalangeal joint of fifth toe
502	6	Distal phalanx of fifth toe
503	6	Perionychium of fifth toe
504	6	Proximal nail fold of fifth toe
505	6	Eponychium of fifth toe
506	6	Lateral nail fold of fifth toe
507	6	Hyponychium of fifth toe
508	5	Fifth toenail
509	6	Lunula of fifth toe
510	6	Nail bed of fifth toe
511	6	Nail plate of fifth toe
512	5	Pad of fifth toe

Table II.

Demonstrating the hierarchical terminology structure depicted in the graphical abstract with correlated SNOMED terms and associated SCTIDs and NYU numbers. TMTL= too many to list where a single number is not available and aggregate numbers for entire region are too numerous. No matches = no available NYU Number corresponding to the new term.

Surface Topography Sorting Index	Hierarchical level	Surface Topography Hierarchical Classification	Synonym	Closest SNOMED Term Match	Closest SNOMED Match SCTID	Other SNOMED Term Matches	Other SNOMED Match SCTIDs	Left NYU Best Match	Left NYU Overlapping Matches	Right NYU Best Match	Right NYU Overlapping Matches
1	1	Head and Neck	Head and neck	Entire skin of head and neck (body structure)	244067007	Entire head and neck (body structure) Entire skin of head and neck (body structure) Head and neck structure (body structure) Skin structure of head and neck Skin of part of head and neck (body structure)	361355005 774007 5630009 281707000		TMTL		TMTL
2	2	Head	Head	Entire skin of head (body structure)	18144006	Skin structure of head (body structure) Skin of part of head (body structure) Entire skin and subcutaneous tissue of head (body structure) Skin AND subcutaneous tissue structure of head (body structure)	70782009 281708005 731603002 389074000		TMTL		TMTL
37	3	Face	Face	Entire face (body structure)	302549007	Face structure (body structure) Region of face (body structure) Entire skin of face (body structure) Skin structure of face (body structure)	89545001 123853000 361703006 73697004		TMTL		TMTL
44	4	Orbital region	Orbital area	Entire orbital region (body structure)	181143004	Entire orbital margin (body structure) Eye region structure (body structure)	362641009 371986005		TMTL		TMTL
49	5	Eye and ocular surface	Eye and ocular surface	Entire conjunctiva (body structure)	181161008	Eye lid structure (body structure) Eyebrow and/or eyelid structures (body structure) Entire skin of eyelid (body structure) Skin structure of eyelid (body structure) Entire anterior aspect of eyelids (body structure) Structure of anterior aspect of eyelids (body structure) Skin structure of eyelid and periorcular area (body structure) Structure of bulbar conjunctiva (body structure) Structure of tarsal conjunctiva (body structure) Entire tarsal conjunctiva (body structure) Structure of left tarsal conjunctiva (body structure) Structure of right tarsal conjunctiva (body structure) Conjunctival and corneal surface structure (body structure) Corneal structure (body structure) Structure of surface of cornea (body structure) All corneal epithelium (body structure) Conjunctiva and cornea (combined skin) (body structure) Entire anterior surface of cornea (body structure) Conjunctival and/or corneal structures (body structure) Conjunctival and corneal surface structure (body structure)	305083001 80243003 245047005 51360009 368786008 22824006 399996007 1832001 284509009 721962008 721963003 20445007 305090002 363653001 28726007 314483007 368825001 110703002 362659009 305089002 363653001	105 107 113 115 109 111	104 108 112 114 108 110		
50	6	Eyelids	Eye lid	Entire eyelid (body structure)	265782007	Eye lid structure (body structure) Eyebrow and/or eyelid structures (body structure) Entire skin of eyelid (body structure) Skin structure of eyelid (body structure) Entire anterior aspect of eyelids (body structure) Structure of anterior aspect of eyelids (body structure) Skin structure of eyelid and periorcular area (body structure)	305083001 80243003 245047005 51360009 368786008 22824006 399996007	105 107 113 115		104 108 112 114	
51	7	Upper eyelid	Eye lid - upper	Entire upper eyelid (body structure)	244499008	Upper eyelid structure (body structure) Entire skin of upper eyelid (body structure) Skin structure of upper eyelid (body structure) Skin of part of eyelid (body structure) Entire anterior lamella of upper eyelid (body structure)	38934000 245048000 41310005 362676009 363540007	105		104	
52	8	Upper eyelid margin	Eye lid - upper - margin	Entire free margin of eyelid (body structure)	362527007	Entire skin of palpebral margins (body structure) Structure of free margin of eyelid (body structure) Skin structure of palpebral margins (body structure)	368770001 77024004 19701007	107		106	
53	9	Superior lacrimal punctum	Eye lid - superior lacrimal punctum	Entire upper lacrimal punctum (body structure)	728533002	Upper lacrimal punctum (body structure)	263345002		No Matches		No Matches

Table III.

Example of proposed hierarch with correlated SNOMED terms with associated SCTIDs and NYU numbers for the ear. TMTL= too many to list where a single number is not available and aggregate numbers for entire region are too numerous. No matches = no available NYU Number corresponding to the new term.

Surface Topography Sorting Index	Hierarchical level	Surface Topography Hierarchical Classification	Synonym	Closest SNOMED Term Match	Closest SNOMED Match SCTID	Other SNOMED Term Matches	Other SNOMED Match SCTIDs	Left NYU Best Match	Left NYU Overlapping Matches	Right NYU Best Match	Right NYU Overlapping Matches
14	3	External ear	Outer ear	Entire external ear (body structure)	420893000	External ear structure (body structure) Skin structure of ear (body structure)	28347008 1902908		TMTL		TMTL
15	4	Pinna	Auricle	Pinna structure (body structure)	113327001	Entire skin of ear (body structure) Entire pinna (body structure) Skin structure of pinna (body structure)	244073008 421159007 44737009		TMTL		TMTL
16	5	Helix of pinna	External ear - helix	Entire helix of ear (body structure)	279607004	Helix structure (body structure) Entire skin of helix (body structure)	86153000 368602001	119	117 133 135	118	116 132 134
17	6	Crus of helix	External ear - helix - crus	Entire crus of helix (body structure)	362547004	Structure of crus of helix (body structure) Skin structure of crus of helix (body structure) Entire skin of crus of helix (body structure)	78743007 57729007 368602002	117		116	
18	6	Apex of helix	External ear - helix - apex Apex of pinna	No Matches	No Matches	No Matches	No Matches	119	117 133 135	118	116 132 134
19	6	Spine of helix	External ear - helix - spine	Entire spine of helix (body structure)	362535005	Structure of spine of helix (body structure) Skin structure of spine of helix (body structure) Entire skin of spine of helix (body structure)	78389002 29887008 368602004	119	117 133 135	118	116 132 134
20	6	Tail of helix	External ear - helix - tail	Entire tail of helix (body structure)	362536006	Structure of tail of helix (body structure) Skin structure of tail of helix (body structure) Entire skin of tail of helix (body structure)	55418004 86542002 368602009	119	117 133 135	118	116 132 134
21	5	Anthelix of pinna	External ear - anthelix	Entire anthelix (body structure)	279612003	Anthelix structure (body structure) Entire skin of anthelix (body structure) Skin structure of anthelix (body structure)	55861008 368608000 33284007	121	123	120	122
22	6	Crura of anthelix	External ear - anthelix - crura	Entire crura of anthelix (body structure)	362539004	Entire skin of crura of anthelix (body structure) Skin structure of crura of anthelix (body structure)	368607005 113328000	121		120	
23	6	Scaphoid fossa of pinna	External ear - scaphoid fossa	Entire scaphoid fossa (body structure)	362540002	Scaphoid fossa structure (body structure) Entire skin of scaphoid fossa of external ear (body structure) Skin structure of scaphoid fossa of external ear (body structure)	82024001 368810003 20166000	121		120	
24	5	Concha	External ear - concha	Entire skin of concha (body structure)	368615006	Concha of ear structure (body structure) Skin structure of concha (body structure) Entire concha of ear (body structure) Skin of part of concha (body structure)	52678007 21438001 361669004 30590007	125		124	
25	6	Cymba conchae	External ear - cymba conchae	Entire skin of cymba conchae (body structure)	368613001	Cymba conchae structure (body structure) Skin structure of cymba conchae (body structure) Entire cymba conchae (body structure)	86530009 44707003 362545007	125		124	
26	6	Conchal bowl of pinna	External ear - conchal bowl	Entire skin of cavity of concha (body structure)	368614007	Structure of cavity of concha (body structure) Skin structure of cavity of concha (body structure) Entire cymba conchae (body structure) Entire cavity of concha (body structure)	42407000 51099001 362545007 362546008	125		124	
27	5	Triangular fossa of pinna	External ear - triangular fossa	Entire fossa triangularis of ear (body structure)	362538007	Structure of fossa triangularis of ear (body structure) Entire skin of fossa triangularis of ear (body structure) Skin structure of fossa triangularis of ear (body structure)	31136007 368600008 82856008	121		120	
28	5	Tragus of pinna	External ear - tragus	Entire tragus (body structure)	362541003	Tragus structure (body structure) Entire skin of tragus (body structure) Skin structure of tragus (body structure)	59581006 244076000 79502000	127		126	
29	5	Intertragal notch of pinna	External ear - intertragal notch	Entire intertragal incisure (body structure)	362542005	Intertragal incisure structure (body structure) Skin structure of intertragal incisure (body structure) Entire skin of intertragal incisure (body structure)	3362007 45591000 368611004	129		128	
30	5	Lobule of pinna	External ear - lobule Earlobe	Entire ear lobule (body structure)	362544006	Ear lobule structure (body structure) Entire skin of ear lobule (body structure) Skin structure of ear lobule (body structure)	48820003 244077009 2059009	131	141	130	140
31	5	Anitragus of pinna	External ear - anitragus	Entire anitragus (body structure)	362543000	Anitragus structure (body structure) Skin structure of anitragus (body structure) Entire skin of anitragus (body structure)	24284001 36407007 368612006	123		124	
32	5	Posterior surface of pinna	External ear - posterior surface	No Matches	No Matches	Structure of eminentia conchae (body structure) Entire eminentia conchae (body structure)	87786006 368636006	137 139	133 135	136 138	132 134
33	5	Retroauricular sulcus	External ear - retroauricular sulcus postauricular sulcus	Entire postauricular region (body structure)	362623001	Entire skin of postauricular region (body structure) Skin structure of postauricular region (body structure) Postauricular region structure (body structure)	244080005 244080006 81124000	10		9	
34	4	External auditory canal	External ear - auditory canal	Entire external auditory canal (body structure)	181178004	External auditory canal structure (body structure) Skin of external auditory canal (body structure) Entire skin of external auditory canal (body structure)	84301002 86409001 361704000	No Matches		No Matches	
35	5	External auditory meatus	External ear - auditory canal opening Meatus of external auditory canal	Entire external auditory canal opening (body structure) Entire tympanic membrane (body structure)	279654000	Structure of external auditory canal opening (body structure)	67283004	No Matches		No Matches	
36	5	Tympanic membrane	Eardrum	Entire tympanic membrane (body structure)	181180005	Tympanic membrane structure (body structure) Region of tympanic membrane (body structure)	42859004 272649000	No Matches		No Matches	

Table IV.

Example of proposed hierarchy with correlated SNOMED terms with associated SCTIDs and NYU numbers for the nose. TMTL= too many to list where a single NYU Number is not available and aggregate numbers for entire region are too numerous. No matches = no available NYU Number corresponding to the new term.

Surface Topography Sorting Index	Hierarchical level	Surface Topography Hierarchical Classification	Synonym	Closest SNOMED Term Match	Closest SNOMED Match SCTID	Other SNOMED Term Matches	Other SNOMED Match SCTIDs	Left NYU Best Match	Left NYU Overlapping Matches	Right NYU Best Match	Right NYU Overlapping Matches
77	4	Nose	Nose	Entire nose (body structure)	181195007	Entire external nose (body structure) Nose (surface region) (body structure) Nasal structure (body structure) Skin structure of nose (body structure) Entire skin of nose (body structure) External nose structure (body structure) Region of nose (body structure) Skin of external nose (body structure) Region of external nose (body structure)	285785009 182324007 45206002 113179006 244085003 44032009 279542008 245501006 314742005		15 17 19 21 23		16 18 20 22 24
78	5	Root of nose	Nose - root	Entire root of nose (body structure)	1825009	Structure of root of nose (body structure) Entire skin of root of nose (body structure) Skin structure of root of nose (body structure)	368121008 399897007 400033007	19	7	20	8
79	5	Dorsum of nose	Nose - dorsum	Entire dorsum of nose (body structure)	368114008	Structure of dorsum of nose (body structure)	84047001	19		20	
80	6	Supratip of nose	Nose - supratip	Entire supratip of nose (body structure)	399896008	Structure of supratip of nose (body structure) Entire skin of supratip of nose (body structure) Skin structure of supratip of nose (body structure)	400205004 400041007 400203006	21		22	
81	5	Lateral side wall of nose	Nose - lateral side wall	Skin of lateral nose structure (body structure)	314395006	Skin of side of nose (body structure) Skin of lateral nose structure (body structure)	244089006 281714003 314395006	17	15	18	16
82	5	Tip of nose	Nose - tip	Entire apex of nose (body structure)	361926005	Structure of apex of nose (body structure) Skin structure of tip of nose (body structure) Entire skin of tip of nose (body structure)	81091005 79283007 244090002	21		22	
83	6	Infratip lobe of nose	Nose - infratip lobe	No Matches	No Matches	No Matches	No Matches	21	23	22	24
84	5	Ala nasi	Nose - ala	Entire ala nasi (body structure)	361345006	Entire skin of ala nasi (body structure) Alar structure (body structure) Skin structure of ala nasi (body structure)	244087008 61913009 68598004	23		24	
85	6	Side wall of ala nasi	Nose - alar sidewall	No Specific Matches	No Specific Matches	Skin of side of nose (body structure) Skin of part of nose (body structure) Alar structure (body structure)	244089006 281714003 61913009	23		24	
86	6	Alar groove	Nose - alar groove	No Specific Matches	No Specific Matches	Skin of part of nose (body structure) Alar structure (body structure)	281714003 61913009	No Specific Match	23 17 15	No Specific Match	24 18 16
87	6	Alar rim	Nose - alar rim	No Specific Matches	No Specific Matches	Skin of part of nose (body structure) Alar structure (body structure)	281714003 61913009	23		24	
88	5	Nostril	Nare	Both anterior nares (body structure)	244506005	Structure of anterior naris (body structure) Entire left anterior naris (body structure) Entire right anterior naris (body structure)	1797002 421652004 421814002	No Matches		No Matches	
89	6	Sill of nostril	Nose - sill of nostril	No Matches	No Matches	No Matches	No Matches	No Specific Match	23	No Specific Match	24
90	6	Columella	Nose - columella	Entire columella (body structure)	361930008	Columella structure (body structure) Skin structure of lower margin of nasal septum (body structure)	113249009 40021003	No Specific Match	23	No Specific Match	24