Background: Many smartphone applications are currently available for neurosurgeons to use in integrating with their clinical practice, complementing with aids for patients, diagnosis tools and education in both neuroanatomy and neuropathology.

Purpose: To provide a comprehensive review and comparison of apps available to neurosurgeons in the United States and Australia.

Methods: Searches were made on Apple Inc App Store on both the United States and Australian stores and described in detail according to the website.

Results: 42 apps were found and compared in costs, ratings, functionality and app size. The majority of apps had no reviews, and there were only 2 apps that were not available on both the United States and Australian App Stores.

Conclusion: While there are no significant differences between the United States and Australian App Stores for neurosurgical apps, there remains a shortage of high quality apps for use in clinical practice. However, there is ongoing improvement with the quality of apps for neurosurgeons.
surgeons, trainees and residents which this review aims to do.

Neurosurgical apps are currently available to complement clinical practice. These include the numerous guideline apps to aid diagnosis and treatment options, patient information apps that help patients understand in more detail neurosurgical procedures and education apps which help with the learning of neuroanatomy, neuropathology and neurosurgical operations.

Due to the having different App Stores in the US and Australia, there were searches for neurosurgical apps on both the US and Australian App Stores. Apps are able to be downloaded from the US and Australian App Stores provided the user has access to an US or Australian credit card respectively. As such, comparisons were made between two different App Stores to assess if there were any differences for clinicians based in different countries.

The apps were compared across the board in regards to the type of app, ratings, costs and the differences between the US and Australian store according to description pages. Many apps were also downloaded onto an iPhone to see review the app design and functionality.

Methods

Searches were done for neurosurgical apps using the phrase “Neurosurgery”, “Neuro surgery” and “Neurological Surgery” in the iTunes App Store on 1st October, 2012. These were obvious terms one would use to search for neurosurgical apps. These apps were reviewed according to the app detail page, costs, app size and ratings, both in the United States and Australian App Store.

While many other apps are used by neurosurgeons for education (e.g. Epocrates), remote radiology (e.g. Citrix) or communication, these were omitted from this review as these were not specific to neurosurgery alone.

The apps were reviewed in the context of being helpful in clinical practice. As such, the apps were reviewed not only with the app description pages, but also in real life on the iPhone 4S to see whether the apps had the same functionality as described on their app pages. The selection of apps was performed from selecting the top 5 most popular apps by ranking in each of the US and Australian App Stores.

Functionality or the primary purpose of apps was verified according to the description page in iTunes.

Results

Following the search for neurosurgical apps, 39 iPhone apps were found following the search for “Neurosurgery” while a further 3 apps were found using the search term “Neuro surgery”, which were Pocket Brain, Neurology Psychiatry OSCEs and Neurointensive Care Guide. All apps are listed in the appendix 1. Not all apps were relevant to neurosurgery, with eight apps not being directly relevant to neurosurgery.

These apps varied in sizes, from 100 KB to 1.71 GB shown in Figure 1. Majority of apps were quite small, with simple calculators being the smallest. In general, the larger apps had a large number of images or 3D diagrams, such as iSpineCare with many radiological and computer generated imagery.
Pricing also varied, with *iSpineOperations* priced at USD $89.99 while 19 apps were free. In fact, the majority of apps were free or 99 cents in USD. The different prices of apps have been charted in Figure 2. The mean costs of the apps in the US store was USD $8.02 including the free apps, and USD $14.29 excluding. The Australian store prices were marginally higher due to AUD pricing.

Each neurosurgical app were given a category, corresponding to the type of app they were. This has been graphically represented in Figure 3. The variety of apps available were categorised into guidelines, calculators, exam related apps, reference guides, journals, educational apps, and apps specifically relating to neurosurgical conferences. The educational apps were then further divided into the specific areas of interest, being anatomy, pathology, surgery, anatomy and patient directed.

The timing of updates also varied among the apps. Shown in Figure 4, only 12 apps were recently updated within a month, while 24 apps were not updated for at least 6 months. This shows apps trended towards less frequent updates, though further investigation is needed on whether this affects the clinical data in the apps and whether there is a bias among the apps that are updated less frequently.
Table 1: Top 5 Neurosurgical apps in iTunes App Store

<table>
<thead>
<tr>
<th>US App Store</th>
<th>Australian App Store</th>
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<tbody>
<tr>
<td>1. Neurosurgery Survival Guide (4.5 stars, 15 reviews)</td>
<td>1. iSpineCare (5 stars, 6 reviews)</td>
</tr>
<tr>
<td>2. Pocket Brain (4.5 stars, 8 reviews)</td>
<td>2. iSpineOperations (5 stars, 5 reviews)</td>
</tr>
<tr>
<td>3. Helsinki Microneurosurgery Basics and Tricks (4.5 stars, 5 reviews)</td>
<td>3. Neuro Board Review (3.5 stars, 5 reviews)</td>
</tr>
<tr>
<td>4. iSpineCare (4 stars, 28 reviews)</td>
<td>4. Neumind (2 stars, 20 reviews)</td>
</tr>
<tr>
<td>5. Neuro Toolkit (4 stars, 27 reviews)</td>
<td>5. N/A</td>
</tr>
</tbody>
</table>

Some of the apps also had ratings from end users. These were from the app description pages, and were mean scores of all reviews, scored out of a Likert scale of 5 and a different rating in each of the US or Australian stores. The top 5 rated apps from each App Store are listed in Table 1. The majority of apps did not have a rating due to not having enough reviews. The number of ratings recorded for each app were also documented. Figure 5 showed the number of ratings available for the apps within each different App Store. Seven apps in the US store had over 10 reviews, while only 1 app had over 10 reviews in the Australian store.

Discussion

There were limited high quality apps available. Many apps had minimal information (e.g. SLIC, Simpli Glasgow) or were not suited for neurosurgeons (e.g. Neurology Psychiatry OSCEs). In comparison to orthopaedic apps, with 61 apps in total and 17 apps with over ten reviews, there were far fewer neurosurgical apps available. Given the number of ratings were given for the neurosurgical apps, these were likely also less popular.

Categories

There was no obvious bias in terms of the type of app, as each category was relatively equal in number of apps. These ranged from 2 to 6 apps in each category.

Ratings

Overall, there were few ratings of apps in the US store, with only 10 apps having a rating. The Australian store had even fewer reviews, with only 4 apps having ratings. It is likely that the Australian App Store suffered from a small sample of reviewers, possibly due to population differences in neurosurgeons in US and Australia, and also possibly due to the Australian App Store having less input from users. iSpineCare was the only app present in both the US and Australian lists. However, given the small number of apps in the Australian store, it is not possible to make meaningful conclusions about the differences in the two lists.
The most rated app with 299 reviews was Neuromind, a comprehensive guideline app that included many different calculators for assessing neurosurgical patients. This app allows one to scroll through a list of calculators and guidelines, and allows one to use current evidence to decide on a management plan. The app lists the reference clearly for each decision being made. A screenshot of this app is shown in Figure 6.

One of the most highly rated apps was iSpineCare, appearing in the top 5 for both US and Australian listings. This is a large app (1.71 GB) which contains many videos of 3D animations and descriptions of spinal pathology. It has been produced with view of explaining pathology to patients. Figure 7 shows a screenshot from the app, which allows patients to see a disc herniation with a 3D animation. It likely has a high rating due to being suitable for patients as the app is visually attractive and describes pathologies in detailed animations. There are many comments¹⁰, though unverified, on the app description page detailing doctors using the iSpineCare to show to patients.

Costs

In comparing these apps, it was found that the costs of app were often not relative to its functionality. For example, Simplic Glasgow costs $0.99 USD but only has one function in calculating the Glasgow Coma Scale (GCS) of patients. Neuromind however, includes many different calculators and references including assessments of acute subdural haematoma (SDH) and cervical spine injuries using the sub-axial cervical spine injury classification system (SLIC).¹¹ This app has been written by a neurosurgical trainee in Netherlands, Pieter Kubben and is based on currently available guidelines for neurosurgery. There were also many apps that were over $10, though these were textbooks that often included many diagrams and imaging (e.g. Oxford Handbook of Neurology, iSpineOperations). There was only one app, Neuro Board Review, that utilised the function of in-app purchases. This was a free app to download but all content had to be further downloaded by paying through the app.

Foreign Languages

Apps in other languages were also available (e.g. Turkish Neurosurgery), though quite rare. This is likely due to searches being done on US and Australian App Stores, which are predominantly English apps. There are likely more apps in other languages in their relevant country’s App Stores.

Of note though, there was three apps that were multilingual. i-Neurochirurgie/i-Neurosurgery was written in both French and English, and the user had to decide before further use of the app while Neuroradiology Multilingual and Neurology multilingual described neurological pathologies and neuroanatomy respectively in English, German, French, Japanese, and Chinese. These could
potentially be used in a clinical setting to explain medical concepts to patients who speak a different language.

**Patient Information apps**

Other apps that could be used for explaining concepts to patients include mLumbarPosteriorInterbodyFusionCage, mLumbarLaminectomy and mLumbarMicroDiscectomy. These are apps with simplified language and patient orientated information for patients undergoing these operations. In fact, the apps are marketed as an information resource for patients. These apps could potentially replace or supplement traditional brochures for such patients. The issues with these apps include the fact that they are not free ($2.99 USD) which many patients may not be willing to pay, differing terminologies being used due to this app being US orientated and does not allow for clinicians to explain variations in specific cases for patients.

Patient orientated apps were often less detailed using less medical terminology and included more diagrams and photos to explain the concepts more easily. There were also apps for nurses (Nursing & Surgery) which were more orientated to describing basic terminology.

**Conference Adjunct apps**

Lastly, there are many apps used in conjunction with their respective conferences (e.g. CNS 2012 Annual Meeting Guide, SNIS 2012). These often provide schedules of talks and further information of speakers and topics for attendees. As of 2012, there is currently no such app available for the Neurosurgical Society of Australasia Annual Scientific Meeting.

**Conclusion**

There are various apps currently available for neurosurgeons, with many able to be used to complement clinical practice by providing further information for patients or having guidelines convenient on the iPhone. However, there is scope for improvement in the quality of neurosurgical apps compared to other fields of medicine.

The major differences between the Australian and US App Store the fewer ratings in the Australian store and missing apps in each store, though overall there were very similar, and clinicians would not notice any difference in using either stores. Given the small sample sizes in each App Store, the differences between the two stores are not reliably conclusive.

Future directions in view of neurosurgical apps will be to look at comparisons with other smartphone systems, such as Android and looking at the effectiveness of neurosurgical apps in the clinical practice. There should also be comparisons of apps over time, to show the differences and improvements of neurosurgical apps in the App Store. Lastly, there should also be reviews incorporating non-specific neurosurgical apps that may still be helpful in clinical practice.

**Appendices**


**References**


