Title: Clear Aligner Innovations Since 2000: Keyword-Based Patent Landscape Analysis.

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Abstract

From Harold D. Kesling's positioners in 1945 to Invisalign in 1998, technology has evolved by leaps and bounds, thereby pioneering the fundamental concepts of modern CAT. Since the 1980s, US-focused research has consistently found that patents are relatively more important to research & development than other forms of intellectual property protection. Patent landscape analysis, sometimes known as "patent mapping," is a tried-and-tested multi-step procedure that makes use of artificial intelligence (AI) and computer software to sort through, compile, and extract data from patents. The primary objective of this study was to perform a landscape analysis of patents filed with respect to clear aligners since 2000. The analysis accumulates data regarding innovations spanning more than two decades. This landscape analysis depicts that code A61C7/08 has the maximum potential and hence shares the major chunk of patents filed in relation to clear aligners. With the help of such data, it enables researchers involved in the field of clear aligners to proactively work on inventing novel concepts related to clear aligners which in turn will benefit users of clear aligners. The present study gives us an insight into the patents not only granted but filed or even modified on a global level.

Keywords: Clear aligners, landscape analysis, Patents, Innovations

1. Introduction

From Harold D. Kesling's positioners [1] in 1945, to Invisalign in 1998 technology has evolved by leaps and bounds, thereby pioneering the fundamental concepts of modern CAT. The process of digital image acquisition to digital treatment planning followed by 3D printing of models to aligner fabrication involves numerous steps which are continuously evolving thus the need for innovations and patents.The number of patents for clear aligners has been growing significantly in recent years. In this study, we set out to examine the global patent landscape for the clear aligner technology.

Since the 1980s, US-focused research has consistently found that patents are relatively more important to research &development than other forms of intellectual property protection, such as trade secrets, trademarks, and copyrights, as well as strategic complementary assets, such as lead time, sales and service advantages, and manufacturing advantages.

They are already laying the groundwork for the cutting-edge technological society of the future. It is improper to argue against patents that aren't instantly converted into commercial goods. The act of invention is akin to advancing a well-thought-out idea that might one day be tested empirically. Even if a theory isn't immediately applied, it's still important to have it to advance our overall grasp of a topic and to keep progressing. A broad portfolio of scientific developments always ends up influencing waves of innovation, and having patents aimed at products of the future is just as vital as

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having those focused at products of today.
Companies invest billions of dollars in research and development because a patent guarantees the protection of inventions. This leads to scientists and engineers at various organisations looking for the best, most unique answers to the problems facing the world, which opens the door for new and improved products.
Patent landscape analysis[2], sometimes known as "patent mapping," is a tried-and-tested multi-step procedure that makes use of artificial intelligence (AI) and computer software to sort through, compile, and extract data from patents. In order to avoid litigation or to avoid wasting time and resources on developing technology that has already been developed and may be on the market, an organisation may use the information obtained from a patent landscape analysis to develop novel technology, identify potential businesses or technologies to licence or acquire, or design around technological information into simple language structures.

2. Material and Methods

The Tool

It takes a lot of time and knowledge to analyse or map patents. Table 1 provides an illustration of a typical scenario for a patent analysis based on the training materials created for patent analysts, such as those in Chen (1999). It is clear from the foregoing that these procedures call for analysts to possess a particular level of skill in information retrieval, domain-specific technologies, and business intelligence.
Table 1 3, 7 A Typical scenario for Patent Analysis
1. Task identification: specify the analytical task's objectives, concepts, and scope.
2. Searching, filtering, and downloading associated patents iteratively
3. Segmentation: Separate, tidy, and standardise the components that are structured and unstructured.
4. Analyzing the substance of the patent to condense its claims, subjects, functions, or technologies
5. Clustering: classify or group examined patents according to some extracted attributes.
6. Visualization: develop topic maps or technology-effect matrices
7. Interpretation: foresee business or technological relationships.
The graphical outcomes of patent analysis are known as patent maps for unstructured texts and patent graphs for structured data, respectively. Such maps require a great deal of manual labour to create and maintain; these tasks do in fact involve text mining techniques including text segmentation, summary extraction, keyword identification, topic detection, taxonomy development, term clustering, and document categorization.
Text mining4,8, sometimes referred to as knowledge discovery or data mining (Fayyad, Piatetsky-Shapiro, Smyth, & Uthurasamy, 1996), is frequently seen as a method for uncovering implicit, little-known, and possibly beneficial patterns in a big text archive. In order to search the repository for these patterns, the text mining procedure in practise entails a number of user interactions with the text mining tools. The text mining methods used in patent analysis are generally NLP-based.
To evaluate and present textual data in electronic documents, natural language processing (NLP)1,2 uses computer methods. It has been used to convert technology information into straightforward linguistic forms. In this study, NLP used a keyword-based methodology. Using keywords or phrases that are pertinent to the issue is known as a keyword-based strategy. For patent mapping, we also employ Boolean operators in addition to keywords.
Any reliable literature search relies on Boolean operators10. A database can combine search terms using these operators, often known as linking words. They help researchers set up their searches to produce more exact and pertinent results. It makes all the difference between a difficult and a positive searching experience to know how to use them properly. The three major Boolean operators for creating searches are AND, OR, and NOT.
The patent search analysis5,6 was done using website – lens.org. The patent search was made using boolean operator and a combination of three "AND" "OR" "NOT" for the word's clear aligner, invisalign, clear aligner therapy was used as the keywords. The search results were then categorized under six categories – Applicants, Publications over time, Legal Status, Jurisdictions, Inventors, Document Types. The data was analysed and the following results were drawn.

3. Result

In this study our primary objective was to employ visualization technique to represent patent information and result analysis. Since the year 2000 till date the no of patents documented are shown in fig 1. Number of patents applied was found to be maximum9 in 2021.The patents documented over time in the previous decade are sparse and from 2010 onwards there is a gradual but steady rise not only in the no of applied patents but also in the number of amended applied patents. However in the past one year although the no of patients opting for CAT is steadily rising but the no of patents filed show a declining trend which points to the fact that there is a dire need for research in this field.
Figure 2 shows that the highest no of patents filed was in the year 2019, the number of patents granted was highest in 2020 and the number of patents published was the highest in 2021.
People with technical backgrounds who are licenced and authorised to handle any and all things relating to the writing and filing of a patent with the United States Patent and Trademark Office are known as patent agents and attorneys[11] (USPTO). Figure 4 shows that the principal agent or attorney. Figure 4 elicits that the top agent/attorney is Wilson Sonsini

Goodrich & Rossati followed by Pabst Patent Group Llp. While the number of applied patents is more then 931 but the number of granted patents is barely 574 and design right is 8 as depicted in figure 4. The highest number of applied patents were 750 by Align Technology INC as depicted by figure 6 and 7 followed by Kyo Eric and others. Total number of publications were 213,205,170 in the year 2020, 2021 and 2022 respectively. Figure 5 shows that in legal status of the patents, 819 active and 386 pending patents were found with maximum jurisdiction of United States. The inventor with highest number of patents war Kuo Eric with 138 patents as shown in figure 8.

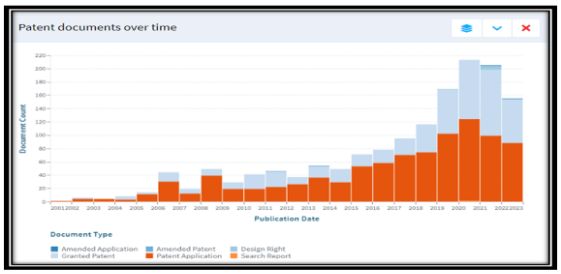

Figure -1. Patent documents over time

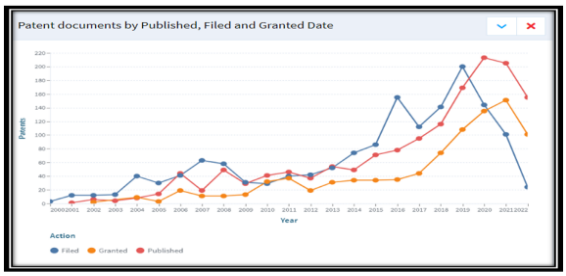

Figure 2. Patent documents by Published, Filed and Granted Date

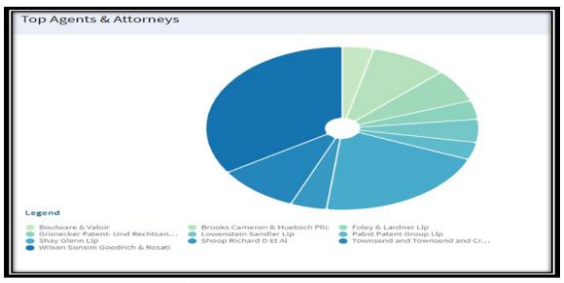

Figure 3. Top Agents & Attorneys

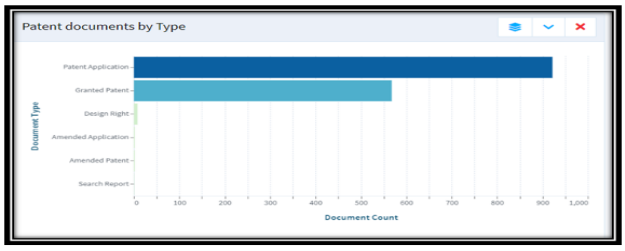

Figure 4. Patent documents by Type.

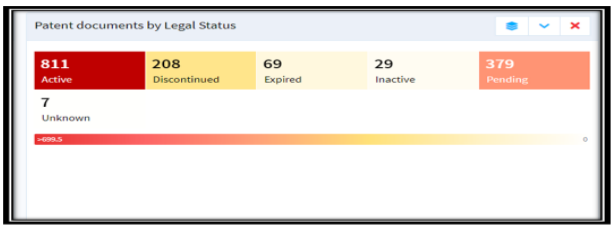

Figure 5. Patent documents by legal status.

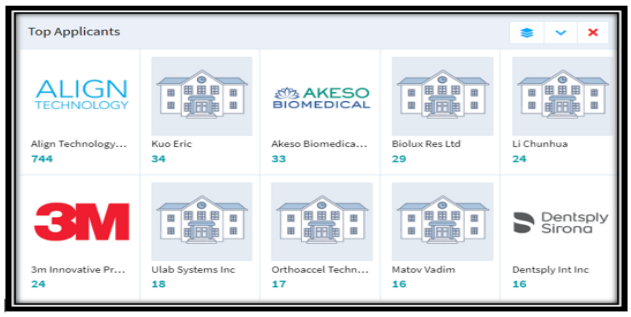

Figure 6. Top applicants

Figure 7. Top Owners

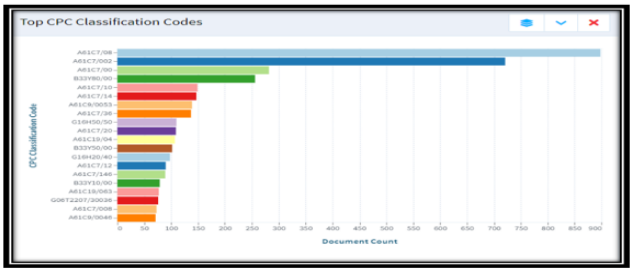

Figure 8. Top CPC Classification Codes.

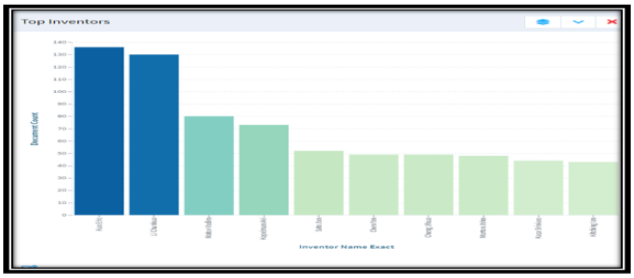

Figure 9. Top inventors

4. Discussion

The primary objective of this study was to perform a landscape analysis of patents filed with respect to clear aligners since 2000.The analysis accumulates data regarding innovations spanning more than two decades. With the help of such data it enables researchers involved in the field of clear aligners to proactively work on inventing novel concepts related to clear aligners which in turn will benefit users of clear aligners.

The present study gives us an insight into the patents not only granted but filed or even modified on a global level. While many believe clear aligners are becoming a commodity as the number of aligner companies is skyrocketing, this is a superficial understanding of the market. There is just one player who has the capability to provide high-quality treatment for complex cases with aligners at an industrial scale. Looking even deeper, we realize that all these newcomers use a pretty limited number of rather simple software solutions. Those solutions are

not robust enough and cannot fully assist doctors with planning treatment for crowded cases. Doctors end up turning to the established and trusted solution: Invisalign.

Align Technology has its own proprietary software (ClinCheck) for preparing aligners treatment plans. It is the most advanced solution for digital orthodontics, tested by millions of successful cases and hence is the major stake holder having maximum number of patents i.e., 500. Total number of publications were 213,205,170 in the year 2020, 2021 and 2022 respectively. Data shows that in legal status of the patents, 819 active and 386 pending patents were found with maximum jurisdiction of United States. Number of applied patents is more then 931 but the number of granted patents is barely 574 and design right is 8.

The significance of the CPC code is that it helps in identifying patent search to a particular technical domain and limits the number of patent search results. The CPC code analysis enables us to predict the product or technology with maximum commercial benefits for which the greatest number of patents have been filed. This landscape analysis depicts that the code A61C7/08 has the maximum potential hence shares the major chunk of patents filed in relation to clear aligners.

5. Conclusion

Patents and innovations provide the clinician the necessary impetus to surge forward and treat patients effectively, efficiently using cost effective measures. The benefits are manifold, the results are outstanding not only for companies involved in clear aligner patents but also to provide a competition to one another. Without patents, you may find yourself staring down the barrel of a gun in the rough landscape of the aligner industry with no way to defend your company or product.

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