

‘With 4-D printing we will be able to provide much more precise treatments’

Interview with Dr Sherif Kandil, experienced practitioner, CEO of K Line Europe GmbH

We all heard about 3-D printing, what does 4-D stand for?

Yes, that is true that we have been hearing lately only about 3-D printing, nowadays 4-D represents the dimension of time. 4-D refers to additive manufacturing or printing of special materials that have certain memory characterisation built in a specific layering system on a 3-D printer, yet was designed or using CAD on a software that dictates the material reshaping and response to stimuli by time.

Can you tell us more about your recent activities in concern to 4-D technology?

After I patented the idea of 4-D printing in orthodontics, I moved on to applying this technology in our R&D labs in K Line Europe in Düsseldorf, Germany. 4-D printing technology has been shifting engineers' opinions and even many in the medical field on the possibilities and chances that have been unleashed after the introduction recently of this technology. I have been focusing on

applying this science to clear aligners and also on orthodontic wires using advanced 3-D printers and re-engineered Meta-materials.

Since I would consider myself as an experimenter, I am currently applying the 4-D printing concept of therapy on my own teeth to manufacture clear aligners, I am strictly recording all details as I will be publishing results in a scientific study after treatment completion.

How does 4-D change medicine in general and orthodontics in particular?

I believe in the next two years 4-D printing will be changing many approaches we currently use to treat our patients. If you search online for 4-D you will find so many results and can even discover how medicine in particular will have the first and biggest impact with this technology. Bioengineers, for example, are trying to apply 4-D printing technology in replacing some tissue parts or even manufacturing implants and splints that are placed in our body. This could save many people's lives due to the fact that the 4-D printed objects can change their shape inside the body to conform to what exactly needs to be replaced without the need for multiple surgeries.

In orthodontics, we will be able to provide patients a much more precise treatment that exactly meets their needs through customising the clear aligners or the orthodontic wire to change its shape when placed in the oral cavity to the requested final result. So it is crafting the final result with much more precision and with a smaller amount of clear aligners or wires so that only 1-2 aligners or 1-2 orthodontic wires are needed for the whole treatment.

What are the challenges that current clear aligners and fixed braces face in the market?

Currently, I believe there are three main challenges we face in orthodontics when it comes to clear aligners or fixed orthodontics. First is the manufacturing process, as there are many steps



when manufacturing clear aligners, thus rendering the final result less accurate, more expensive, more time consuming and more control required. Second is the complexity of applying the exact designed forces on the software for manufacturing the clear aligners, you might need accessories, more attachments on the teeth, etc to overcome the limitations of clear aligners. Third, is the comfort of the patients as with clear aligners or braces patients need numerous amounts of aligners or wires to be changed throughout the treatment.

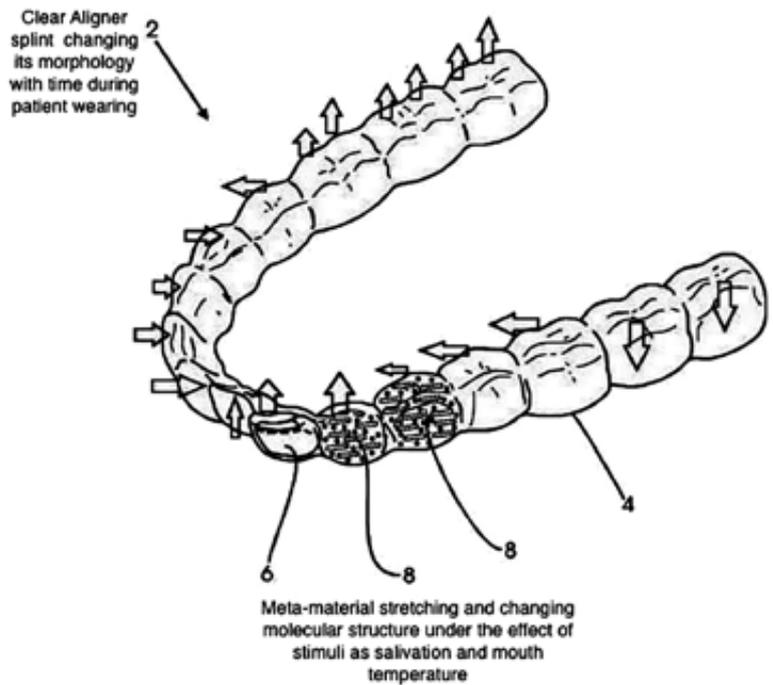
How will 4-D technology tackle these problems?

4-D technology promises to solve the aforementioned points and more. A short explanation of how this works is as follows. Teeth are normally 3-D scanned, then through the 3-D CAD software, aligners or orthodontic wire is made as a negative replica of the model stage representing the corresponding movement that shows where and how teeth need to be moved. The software allows you to put in joints and layers that allow contraction at one side and expansion on the other, and thus on the 3-D software we could stage all the aligner or wire shapes that will be self-morphed by the material. The object (i.e. aligner or wire) is 3-D printed using special Meta material that is responsive to the built-in software joints and layers. When the object is placed in the mouth there are fortunately the two most effective stimuli for the material to change its shape which is salivation (i.e. fluids) and 37 degree body temperature (i.e. heat).

So simply, the patient wears an aligner or wire on brackets that keeps changing its shape gradually to reach the final form through applying light continuous forces on teeth. Each aligner or orthodontic wire can be worn for over 5 months depending on the movements that were programmed on the software from the initial planning stage.

How would you describe the advantages that will be implemented in orthodontics using the 4-D concept?

The advantages are quite clear, as patients will enjoy a more friendly treatment where they don't have to visit their orthodontist as regularly as they used to as this coincides with the recent approaches of distant treatments applied in orthodontics nowadays. Also many treatments won't need the refinements as they did before, such as the clear aligner treatments, which has had negative experiences. Most of all, the precision of force application and distribution is way more precise as with the software, the exact force, amount and time will be controlled; furthermore the aligner thickness can be altered depending on the need



and can be controlled throughout the whole treatment to keep the force and anchorage distribution absolutely stable and avoid the variability that was experienced with previous clear aligners systems.

When do you think this technology will be available on the market?

We hope we can bring this technology into light very soon, yet a rational expectation would be to expect it to enter the market in 2019 and change many applied current treatment concepts in orthodontics.

Technology is shifting really quickly these days, how do you see it evolving in the next few years in orthodontics?

I see 4-D printing and augmented reality to be one of the game changers in medicine in the upcoming years.

How could we get more information and even follow up this upcoming high technology?

Currently, the internet contains many approaches in 4-D tech, yet for orthodontic application you could follow up more on the following webpage www.kline-europe.de/4dortho

Thank you for the valuable input and we hope to hear even more about the new inventions soon

Thank you for this opportunity and I hope that this advanced technology can bring more welfare to our patients. _

Editorial note: This interview has been prepared in collaboration with the K Line Europe GmbH dental coordination team.



Dr Sherif Kandil