

**August 30, 2004**

## **With Few Exceptions, the String Remains the Same**

**By RON DICKER**

In an era when scientists can land an unmanned spacecraft on Mars, no one has been able to quantify if a drop shot reacts better on kite string or piano wire.

Andrew Ashcroft, a doctoral student in engineering at the University of Cambridge in England, had an arsenal of data in his study of how the ball strikes the racket. His conclusion? "We don't understand how the ball interacts with racket strings," he said. "We can't correlate through mechanical tests what players perceive."

Players in a 15th-century version of tennis hit the ball with parchment stretched over their racket heads. Imagine swatting a ball with a cheap drum to understand why tennis players sought alternatives.

In the 16th century, they turned to animal intestine, or gut, to construct the string of choice. Unless moving from sheep innards to cow innards can be considered progress, the evolution of tennis strings remains in slow-motion.

Many of the elite players in the United States Open still play with gut. Synthetic materials like polyester may share the racket head with gut, but those, too, have been around for decades.

"String is not that big a deal to consumers," said Jay Schweid, who strings rackets for professional players. So companies, he said, will not pay for innovations. Nylon, Kevlar and polyester are used to make strings more durable, but gut has never gone out of style in the elite ranks. It is considered to have a softer feel, a greater cradling effect on the ball and more rebounding capacity, and it is supposed to be easier on the elbow.

Schweid, whose clients include Andre Agassi, said too many variables - racket angle, speed of the approaching ball, the player's arm speed, tension of the strings - make it impossible for a machine to make precise calculations. It comes down to player intuition.

"At this level, they're artists, like pianists," Schweid said. "Things they feel they can't explain."

Perhaps the one string attribute that could be measured throughout history was durability. When gut was at a premium during World War II because it was needed to stitch soldiers' wounds, sporting goods companies came up with a nylon alternative. The evidence that nylon lasted longer was overwhelming. The string became popular among recreational players.

Nylon was the first profound advancement in the industry since string makers began turning to slaughterhouses. Crawford Lindsey, the co-author of "The Physics and Technology of Tennis," called nylon the gold standard but does not recommend it for elite players.

Kevlar, which is used in bulletproof vests, and a more flexible polyester have made inroads in the elite ranks. Thirteen of the top 20 men, including No. 1-ranked Roger Federer, use polyester exclusively or in combination with gut, according to Lindsey. Agassi, an eight-time Grand Slam singles champion, once used Kevlar, which is supposed to create a truer ball strike because it is so rigid.

"The stiffer the string bed, the less string will deflect, so the ball will come off the racket at a more precise angle," Lindsey said.

But Agassi abandoned Kevlar because it contributed to a chronic wrist problem, Schweid said. Now Kevlar and polymer blends are mostly the domain of cost-conscious duffers. Steve Crandall, a spokesman for the polymer and Kevlar string maker Ashaway, said some lower-ranked pros use the stiffer synthetics because they cannot afford to replace gut often.

The percentage of upper-echelon women using synthetics is somewhat lower than the percentage of men. Nine of the top 20 women have some polyester in their racket head. Many players order rackets stitched with a synthetic on the main, or vertical, strings, and gut on the horizontal strings. They believe they are getting a blend of power and control, and less vibration to decrease the chance of injury.

Much of the evidence is anecdotal. Schweid, acting on the reports he collects from players at tournaments around the world, recommends that his clients use a hybrid string design. Lindsey has conducted tests on more than 350 strings on a pendulum-like device at his Racquet Sports Industry office in Vista, Calif.

"There's no good, there's no bad," he said. "Everybody has their personal opinion."

Sometimes, the proof is in the viewing. Ilie Nastase took the court against Guillermo Vilas in a 1977 match with a so-called "spaghetti string" racket made of nonintersecting strings on independent planes. It looked like a laughable novelty before Nastase began imparting wild spins on the ball. Vilas quit in disgust, ending his 50-match winning streak. The International Tennis Federation banned the string formation the following year. Nastase's bold stroke had threatened revolutionary change, but the sport's governing body would not allow it.

Tennis seems to have treated the development of raw materials with the same wary eye. Pierre Babolat

made what is believed to be the first mass-produced gut string in 1875, and the process has changed little since. The beef industry gets the meaty parts of the cow, and the tennis and medical industries share the part of the membrane called the serosa, which is dried, chemically treated and woven into strands.

(Cat gut, as players often refer to it, has never been made of actual cat gut. One theory on how it received that name was that troubadours from ancient England used a string instrument called a kit. The strings were known as kit gut, and that eventually became cat gut.)

Three cows are required for one racket. Even less economical was sheep intestine. Once commonly used, sheep intestine went out of vogue because its strands were not long enough, and string makers perhaps found themselves in direct competition with sausage makers, who used the membrane for their casings.

Professional and recreational players are unlikely to see major developments in string technology any time soon.

"I don't think you'll see anything too radical over the next few years," Schweid said.

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